Malnutrition and obesity

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Contents

1 Introduction

Food and nutrition are basic indispensable needs of humans. Nutrition plays a critical role in maintaining the health and well-being of individuals and is also an essential component of the healthcare delivery system. The nutritional status of individuals affects the clinical outcomes. Essential nutrients are classified into six groups, namely carbohydrates, proteins, lipids, minerals, vitamins, and water.

Nutritional requirements of healthy individuals depend on various factors, such as age, sex, and activity. Hence, recommended values of dietary intakes vary for each group of individuals.

An imbalance in nutritional intake leads to malnutrition. The word *malnutrition* is defined in multiple ways, and there is still no consensus. Traditionally, the term malnutrition has been used in the context of lack of energy intake or deficiencies of nutrients.

However, the term malnutrition now includes conditions caused by both insufficient as well as excess intake of macronutrients and micronutrients. As per WHO guidelines, malnutrition encompasses three categories:

1. Undernutrition (low weight-for-height, low height-for-age, and low weight-for-age),
2. Micronutrient (vitamins and minerals) deficiency or excess, and

3. Overnutrition (overweight, obesity, and other diet-related health conditions such as type 2 diabetes mellitus, cardiovascular disorders, etc.).

Also, diagnosis of malnutrition in adults can be categorized as

(i) starvation-related malnutrition (chronic, non-inflammatory),

(ii) acute disease or injury-related malnutrition (mild to severe inflammation), or

(iii) chronic disease-related malnutrition (chronic mild to moderate inflammation).

2 Nutrient Requirements as a Basis for Dietary Evaluation

Nutrition profoundly impacts health status across all stages of life, and unhealthy dietary habits represent one of the most important causes of disability and premature death. While an optimal diet is essential for maximizing health and longevity, what constitutes an optimal diet remains controversial. Macronutrient intake is one of the most important aspects of any diet because of its significant and direct influence on energy balance, body composition, and health outcomes. Nutrients are essential compounds required to sustain physiological processes and are classified into two broad categories: macronutrients and micronutrients. Macronutrients are compounds required in large amounts that play a critical role in energy provision, synthesis of structural molecules, hormone production, and regulation of metabolic pathways. Micronutrients, such as vitamins, minerals, and antioxidants, are essential compounds needed in smaller amounts for biochemical processes such as the modulation of gene transcription, catalyzing enzymatic reactions, and protection against oxidative stress.

The three macronutrients are proteins, carbohydrates, and lipids. Alcohol is sometimes included as the fourth macronutrient, but its overall consumption is strongly discouraged, and it is not recommended as an energy source under any circumstances. All macronutrients are considered sources of energy, but each one has unique biochemical properties and different effects on body composition and health.

2.1 Proteins

Proteins are large molecules comprising varying amounts and combinations of amino acids linked via peptide bonds. Although dietary proteins contain 4 kcal of energy per gram, they are considered a less efficient energy source than lipids or carbohydrates. Rather, the most important function of dietary proteins is to supply amino acids, which provide nitrogen, hydrocarbon skeletons, and sulfur. In the human body, amino acids are used for mechanical and structural purposes and help synthesize enzymes, hormones, antibodies, cytokines, transporters, and neurotransmitters. The ingestion of dietary protein increases amino acid availability, stimulates protein synthesis, inhibits protein catabolism, and helps regulate whole-body protein balance.

2.2 Carbohydrates

Carbohydrates are an important dietary energy source and provide 4 kcal of energy per gram. Carbohydrate intake raises blood glucose levels and stimulates insulin secretion, promoting glucose uptake into tissues and glucose storage as glycogen. Additionally, carbohydrates play an important role in gut health and immune function. Fiber, a type of nondigestible carbohydrate with multiple subtypes, is important in promoting satiety, improving gastrointestinal function, and reducing cholesterol levels.

2.3 Lipids

Lipids or dietary fats are the most energy-dense macronutrient and provide 9 kcal of energy per gram. In human physiology, lipids are essential for the production of sex hormones, maintenance of cellular structure, energy storage as body fat, regulation of body temperature, protection from physical trauma, and the absorption of fat-soluble vitamins A, D, E, and K. Additionally, fats enhance the taste, texture, and palatability of foods.

Dietary fats can be separated into triglycerides (fats and oils), phospholipids, sterols (cholesterol), and fatty acids. Fatty acids in the diet can be further distinguished according to the presence of double bonds; saturated fats have no double bonds, and unsaturated fats have one or more double bonds.Finally, unsaturated fatty acids can be distinguished by the position of the first double bond counted from the methyl end of the carbon chain into omega-3, omega-6, and omega-9 fatty acids, with the first double bond occurring at the third, sixth, and ninth position, respectively. Different groups of dietary lipids have been known to have distinct physiological properties and health effects.

2.4 Micronutrients

Micronutrient intake is vital for maintaining health and preventing diseases throughout life. While whole foods should be the primary source of micronutrients, supplementation is necessary in certain cases. Both deficiencies and excess intake of micronutrients can have adverse effects. Maintaining a healthy, varied dietary pattern rich in whole, nutrient-dense foods in adequate quantities is imperative for maintaining health and preventing disease throughout the lifespan. The body needs micronutrients in small amounts to support biochemical processes and cellular function. To achieve the best outcomes, micronutrient needs should be primarily met through various whole foods, recurring to supplementation only when clinically necessary. Both deficient and excessive micronutrient consumption can have adverse health consequences and should be avoided. Vitamin A, folate, iodine, iron, and zinc are the most common micronutrient deficiencies worldwide and contribute to perinatal complications, poor growth, cognitive impairment, and increased morbidity and mortality.

3 Nutritional Assessment

While performing nutritional assessment, it is important to understand that there is no single best test to evaluate nutritional status. Information should be collected systematically and additional clinical examinations or diagnostic tests may be necessary for different groups of populations and individuals with specific underlying pathology.

It is important to inquire about the patient's usual weight and ask if there have been any weight changes. Weight loss of

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10% of body weight can signify underlying pathology. Weight gain can be suggestive of various underlying endocrine pathologies. Weight gain can also lead to insulin resistance contributing to metabolic syndrome. Loss of appetite should also be asked for. There are skin-related symptoms suggestive of malnutrition other than weight changes, such as rashes, or sores in the mouth.

Imbalanced nutritional status adversely affects the health and wellness of individuals. By evaluating the nutritional status of individuals early on, nutritional screening and assessment allow for timely intervention and thus help maintain the health and wellness of individuals and improve quality of life. Timely interventions, especially in specific groups of individuals, such as infants, growing children, pregnant and lactating mothers, etc., help prevent long-term complications.

Nutritional assessment and intervention together break the vicious cycle between malnutrition and various diseases or conditions, in which malnutrition aggravates a disease/condition, and the disease/condition, in turn, precipitates malnutrition. Breaking this cycle helps in improving clinical outcomes. Nutritional and clinical management based on comprehensive nutritional assessment results in positive healthcare outcomes by reducing the recovery period, hospital length of stay, risk of complications, susceptibility to infections, and mortality associated with clinical and surgical illnesses. The use of standardized, systematic nutrition risk screening and assessment in the clinical setting also helps in reducing overall healthcare costs.

Also, eating habits and dietary preferences should be collected: the number of meals eaten in a day, approximate portion sizes, whether they are following any restrictive diets, whether they are vegan or vegetarian, or if they are allergic to any food items. This can help in diagnosing a possible nutritional deficiency. For example, a vegan diet may be associated with vitamin B12 (cobalamin) deficiency.

The next component of the nutritional assessment is physical examination. The physical examination aims to identify signs of malnutrition and factors affecting nutritional status. The physician should assess general condition, vital signs, height and weight, skin, hair, oral cavity and perioral region, and so on.

There are some anthropometric measurements to bear in mind:

Height, weight, and BMI Measure the weight and height of the patient, as mentioned above. BMI (weight in kilograms divided by height in meters squared) is also calculated using these parameters, and the state of nutrition can be assessed. In adults, BMI $<$ 18.5 kg/m^2 : $underweight$; BMI= 18.5 to 24.9 kg/m^2: within normal range; BMI $>$ 24.9to29.9kg/m^2: overweight; and BMI $\geq$ 30kg/m^2: obesity. BMI cannot differentiate between muscle mass and adipose tissue/fat mass. And BMI does not take into account micronutrient deficiencies.

Other anthropometric measurements Circumference (arm, abdomen, and thigh) measurements and skinfold (biceps skinfold, triceps skinfold, subscapular skinfold, and suprailiac skinfold) thickness measurements can also help with the evaluation of nutritional status. Skinfold thickness measurements are considered indicators of energy stores (mainly lipid stores). Circumference measurement, namely midarm circumference (MAC), can be used to derive midarm muscle circumference (MAMC=MAC-3.1414 $\times$ triceps skinfold thickness), which is an indicator of protein stores. While these tests can quickly be done at the bedside without additional cost, subjectivity in terms of measurements and the applicability of results across various populations can make these tests less reliable.

Routine clinical tests Routine clinical tests can help evaluate the patient's overall status (as well as nutritional status): serum electrolytes, blood urea nitrogen, creatinine, blood glucose levels, lipid profile, liver enzymes, and complete blood count. Low cholesterol levels can be seen in undernourished individuals. Low hemoglobin is suggestive of anemia. Lymphocyte functioning and proliferation are affected in chronic malnutrition and may manifest as decreased lymphocyte count. Undernutrition and protein deficiency, in general, lead to impaired immune response.

Visceral proteins Levels of visceral proteins such as albumin, prealbumin, transferrin, and retinol-binding protein can help evaluate nutritional status. Prealbumin is the preferred parameter and allows for the detection of acute alterations in nutritional status. Retinol-binding protein can be used for monitoring changes in nutritional status.

Micronutrient levels If specific micronutrient deficiencies are suspected, individual micronutrient levels can be measured. For example, levels of B vitamins (thiamine, riboflavin, niacin, pyridoxine, folic acid, B12), vitamins A, C, D, E, and K, iron, zinc, selenium, homocysteine, etc., can be measured.

Other non-nutrition-specific markers For example, C-reactive protein (CRP) can be used to indicate inflammation.

4 Marasmus and Kwashiorkor

To maintain the physiological requirements of the body, it is essential to take a sufficient amount of micro and macronutrients; however, the overconsumption of micronutrients and macronutrients can also be harmful. As defined by the World Health Organization (WHO), malnutrition is an inadequate or excess intake of protein, energy, and micronutrients such as vitamins, and the frequent infections and disorders that result. The excess intake would be known as overnutrition, whereas an insufficient intake would be known as undernutrition.

Undernutrition can be further classified according to the cause and presentation. The term 'protein-energy malnutrition' refers to acute malnutrition as a result of an insufficient intake of protein and calories. This includes the conditions of kwashiorkor and marasmus.

Acute malnutrition is an inadequate weight relative to vertical height. Severe acute malnutrition is further divided into two main categories: marasmus and kwashiorkor.

Kwashiorkor is a severe manifestation of protein-energy malnutrition. It is associated with a poor-quality diet high in carbohydrates but low in protein content such that the child may have a sufficient total energy intake. Severe protein insufficiency leads to characteristic bilateral pitting pedal edema and ascites. Therefore, Kwashiorkor is a disease marked by severe protein malnutrition and bilateral extremity swelling. It usually affects infants and children, most often around the age of weaning through age 5. The disease is seen in very severe cases of starvation and poverty-stricken regions worldwide.

Marasmus is a severe manifestation of protein-energy malnutrition. It occurs as a result of total calorie insufficiency. This leads to overt loss of adipose tissue and muscle. The child may have a weight-for-height value that is more than 3 standard deviations below the average for age or sex. So, while kwashiorkor is a disease of edematous malnutrition, marasmus is similar in appearance. Marasmus is known as the wasting syndrome (malnutrition without edema).

5 Obesity

Obesity is the excessive or abnormal accumulation of fat or adipose tissue in the body that impairs health via its association with the risk of development of diabetes mellitus, cardiovascular disease, hypertension, and hyperlipidemia. It is a significant public health epidemic which has progressively worsened over the past 50 years. Obesity is a complex disease and has a multifactorial etiology. It is the second most common cause of preventable death after smoking. Obesity has become an epidemic which has worsened for the last 50 years. In the United States, the economic burden is estimated to be about $100 billion annually. The body mass index (BMI) is used to define obesity, which is calculated as weight (kg)/height(m).

5.1 Etiology

Obesity is the result of an imbalance between daily energy intake and energy expenditure, resulting in excessive weight gain. Obesity is a multifactorial disease caused by a myriad

of genetic, cultural, and societal factors. Various genetic studies have shown that obesity is extremely heritable, with numerous genes identified with adiposity and weight gain. Other causes of obesity include reduced physical activity, insomnia, endocrine disorders, medications, the accessibility and consumption of excess carbohydrates and high-sugar foods, and decreased energy metabolism.

5.2 Pathophysiology

Obesity is associated with cardiovascular disease, hypertension, dyslipidemia, and insulin resistance, causing diabetes, stroke, gallstones, fatty liver, obesity, hypoventilation syndrome, sleep apnea, and cancers.

The association between genetics and obesity is already well-established by multiple studies. Some genes are associated with adiposity and might harbor multiple variants that increase the risk of obesity.

Leptin is an adipocyte hormone that reduces food intake and body weight. Cellular leptin resistance is associated with obesity. Adipose tissue secretes adipokines and free fatty acids, causing systemic inflammation, which causes insulin resistance and increased triglyceride levels, subsequently contributing to obesity.

Obesity can cause increased fatty acid deposition in the myocardium, causing left ventricular dysfunction. It has also been shown to alter the renin-angiotensin system, causing increasing salt retention and elevated blood pressure. Also, adipocytes have been shown to have an inflammatory and prothrombotic activity, which can increase the risk of strokes.

6 Treatment and Management

Obesity causes multiple comorbid and chronic medical conditions, and physicians should have a multidisciplinary approach to the management of obesity. Practitioners should individualize treatment, treat underlying secondary causes of obesity, and focus on managing or controlling associated comorbid conditions. Management should include dietary modification, behavior interventions, medications, and surgical intervention if needed.

The dietary modification should be individualized with close monitoring of regular weight loss. Low-calorie diets are recommended. Low calorie could be carbohydrate or fat restricted. A low-carbohydrate diet can produce greater weight loss in the first months compared to a low-fat diet. The patient's adherence to their diet should frequently be emphasized.

Behavior Interventions Several psychotherapeutic interventions are available, which include motivational interviewing, cognitive behavior therapy, dialectical behavior therapy, and interpersonal psychotherapy. Behavior interventions are more effective when they are combined with diet and exercise.

Medications Antiobesity medications can be used for BMI greater than or equal to 30 or BMI greater than or equal to 27 with comorbidities. Medications can be combined with diet, exercise, and behavior interventions. Antiobesity medications include phentermine, orlistat, liraglutide, semaglutide, diethylpropion, topiramate, bupropion, setmelanotide, and phendimetrazine. All the agents are used for long-term weight management. Orlistat is usually the first choice because of its lack of systemic effects due to limited absorption.

Surgery Indications for surgery are a BMI greater or equal to 40 or a BMI of 35 or greater with severe comorbid conditions. The patient should be compliant with post-surgery lifestyle changes, office visits, and exercise programs. Patients should

have an extensive preoperative evaluation of surgical risks. Commonly performed bariatric surgeries include adjustable gastric banding, Rou-en-Y gastric bypass, and sleeve gastrectomy. Rapid weight loss can be achieved with a gastric bypass, and it is the most commonly performed procedure. Early postoperative complications include leak, infection, postoperative bleeding, thrombosis, and cardiac events. Late complications include malabsorption, vitamin and mineral deficiency, refeeding syndrome, and dumping syndrome.