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PROTEIN AND MALNUTRITION: BIOLOGICAL BASIS, CLINICAL CONSEQUENCES, ASSESSMENT AND PREVENTION

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ABSTRACT

Protein is required for tissue growth and repair, maintenance of skeletal muscle, synthesis of enzymes and hormones, transport of substances, and immune function. Inadequate protein intake can contribute to malnutrition; however, protein deficiency rarely occurs in isolation in populations affected by undernutrition. Insufficient energy intake, micronutrient deficiencies, recurrent infection, impaired absorption, chronic disease and household food insecurity frequently coexist. This narrative review examines the physiological role of dietary protein, the causes and manifestations of protein-energy malnutrition, current approaches to nutritional assessment, and evidence-informed strategies for prevention and management. Particular attention is given to childhood wasting and nutritional oedema, chronic growth restriction, and disease-related malnutrition in adults. Contemporary diagnostic frameworks emphasise the combined assessment of phenotypic features, such as weight loss and reduced muscle mass, and aetiological factors, including reduced intake, impaired assimilation and inflammation. Management must be tailored to age, clinical stability and underlying cause; severe acute malnutrition requires protocol-based medical and nutritional care rather than unsupervised protein supplementation. Sustainable prevention depends on access to diverse nutrient-dense foods, appropriate infant and young-child feeding, infection prevention, early screening and social measures that improve food security. A multisectoral approach is therefore essential to reduce the burden and long-term consequences of malnutrition.

KEYWORDS: Protein; malnutrition; protein-energy malnutrition; wasting; stunting; kwashiorkor; marasmus; nutritional assessment

1. INTRODUCTION

Protein is one of the three major macronutrients and provides amino acids required for the synthesis and maintenance of body proteins. These include structural proteins in muscle and connective tissue, enzymes, peptide hormones, transport proteins and components of the immune system. Unlike carbohydrate and fat, the body has no specialised storage depot for protein; amino acids are continuously recycled, synthesised into proteins or oxidised when required. Dietary protein must therefore be supplied regularly, with requirements varying according to age, body size, physiological state, activity, illness and recovery [1,2].

Malnutrition is a broad clinical and public-health condition resulting from deficiencies, excesses or imbalances in energy and nutrients. Undernutrition includes wasting, stunting, underweight and micronutrient deficiencies, while malnutrition in clinical practice also includes disease-related loss of muscle and body reserves. Protein-energy malnutrition (PEM) describes inadequate availability or utilisation of protein and energy, often accompanied by deficiencies of vitamins and minerals [3,4].

The term PEM is useful for describing the overlap between protein and energy inadequacy, but it should not imply that a single nutrient explains all cases. A child may have an apparently adequate protein intake yet remain at risk because total energy intake is insufficient, infections are frequent, or essential micronutrients are lacking. Similarly, adults with inflammatory disease may lose muscle despite apparently reasonable food intake because inflammation alters metabolism and increases catabolism [5,6]. The present review discusses protein in the wider biological, clinical and social context of malnutrition.

2. REVIEW METHODOLOGY

This article is a narrative review of established and contemporary literature on dietary protein, undernutrition and clinical malnutrition. Relevant material was drawn from peer-reviewed research, consensus statements and technical guidance published by the World Health Organization (WHO), the Food and Agriculture Organization of the United Nations (FAO), UNICEF and professional nutrition organisations. Priority was given to authoritative guidance and reviews addressing protein requirements, child undernutrition, adult malnutrition diagnosis and nutritional care. The review is not a systematic review; it did not use a registered protocol, duplicate independent screening or formal risk-of-bias assessment.

3. Physiological importance of dietary protein

3.1 Amino acids and protein turnover

Dietary proteins are digested into peptides and amino acids, which are absorbed primarily in the small intestine. Amino acids enter a dynamic metabolic pool used for synthesis of new proteins and other nitrogen-containing compounds. Nine amino acids are indispensable in the human diet because endogenous synthesis cannot meet physiological requirements. Protein quality is influenced by

indispensable amino-acid composition and digestibility; both the quantity and quality of protein should therefore be considered when evaluating a diet [1,2,7].

Protein turnover occurs continuously. Muscle and other tissues undergo simultaneous synthesis and breakdown, with net balance determined by food intake, physical activity, hormones, age and disease. During growth, pregnancy, lactation, recovery from injury and some illnesses, requirements may increase. Inadequate energy intake can lead to oxidation of amino acids for energy, reducing their availability for tissue synthesis. Adequate dietary energy is consequently necessary for efficient utilisation of protein [1,8].

3.2 Functional roles

Proteins provide structural support, maintain muscle mass and contribute to skin and connective tissue integrity. Enzymes catalyse metabolic reactions, while transport proteins carry molecules such as oxygen, lipids and minerals. Immunoglobulins and other immune mediators depend on protein synthesis. Plasma proteins contribute to oncotic pressure, although oedema in severe malnutrition is multifactorial and should not be explained solely by low circulating albumin. Protein is also needed for wound healing and recovery from infection or surgery [6,9].

4. Dietary sources and protein quality

Animal-source foods—including milk, yoghurt, cheese, eggs, fish, poultry and meat—generally provide highly digestible protein containing all indispensable amino acids. Plant sources include lentils, chickpeas, beans, peas, soy foods, nuts, seeds and cereals. A well-planned vegetarian or vegan diet can provide adequate protein when energy intake is sufficient and a range of foods is consumed. Legumes are relatively rich in lysine, whereas many cereal proteins are comparatively limited in lysine; combining different plant foods across the day can improve the overall amino-acid pattern [7,10].

Protein quality should not be judged from protein concentration alone. Digestibility, amino-acid availability, portion size, food processing, antinutritional factors, age and physiological needs influence the nutritional contribution of a food. The FAO recommends the Digestible Indispensable Amino Acid Score (DIAAS) as a method for evaluating protein quality, while recognising that practical dietary adequacy depends on the complete diet rather than a single ingredient [7].

For resource-constrained households, pulses, beans, soy products, groundnuts, seeds, milk or eggs where acceptable and locally available can contribute to dietary protein. These foods also provide varying amounts of iron, zinc, calcium, fibre and other nutrients. Counselling should be culturally appropriate and should account for food cost, availability, cooking facilities, storage and food safety. A protein supplement may be useful in selected clinical circumstances, but it cannot correct food insecurity, untreated infection or deficiencies of other nutrients.

5. Causes and determinants of protein-energy malnutrition

The immediate causes of undernutrition are inadequate dietary intake and disease. Low intake may result from insufficient food availability, poor appetite, feeding difficulties, nausea, swallowing problems, restrictive diets or dependence on caregivers. Impaired digestion or absorption can occur in gastrointestinal disease, while chronic illness and inflammation can increase metabolic demands and accelerate tissue breakdown. Diarrhoeal disease and other infections reduce appetite, increase nutrient losses and may impair absorption; undernutrition in turn weakens host defence, creating a reinforcing cycle [3,5,11].

Underlying determinants include household poverty, food insecurity, low dietary diversity, poor maternal nutrition, inadequate breastfeeding support, inappropriate complementary feeding, unsafe drinking water, inadequate sanitation and limited access to healthcare. These factors interact rather than act independently. For example, a household may understand appropriate feeding practices but lack the resources to obtain eggs, dairy products, pulses or fresh produce. Climate shocks, displacement, conflict and food-price volatility can further undermine access to nutritious diets [4,12].

In adults, disease-related malnutrition may develop in hospitals, long-term care settings or the community. Cancer, chronic obstructive pulmonary disease, heart failure, chronic kidney disease, neurological disorders and gastrointestinal conditions may reduce intake or increase inflammatory catabolism. Older adults are at particular risk when poor appetite, dental problems, social isolation, functional limitations and multimorbidity occur together. Malnutrition can also coexist with overweight or obesity; body weight alone may therefore fail to identify clinically important muscle loss [6,13].

6. Clinical manifestations and consequences

6.1 Wasting and marasmus

Wasting is defined by low weight relative to height or length in children and generally reflects recent or ongoing weight loss or failure to gain weight. Severe wasting is associated with marked depletion of fat and muscle and increased risk of infection and death. Marasmus is the traditional clinical term for severe energy deficiency with pronounced wasting and without nutritional oedema. Affected children may have prominent ribs, reduced subcutaneous fat, weakness, irritability or lethargy. Clinical assessment must also identify infection, dehydration and other complications [3,14].

6.2 Nutritional oedema and kwashiorkor

Kwashiorkor is the traditional term for severe acute malnutrition characterised by bilateral pitting nutritional oedema. Oedema may obscure the degree of weight loss and can occur with skin and hair changes, poor appetite, apathy or fatty liver. The pathophysiology is complex and involves interactions among diet, infection, inflammation, oxidative stress, metabolic adaptation and other factors. It is inaccurate to attribute the condition simply to isolated dietary protein deficiency.

Bilateral pitting oedema in a child requires prompt clinical assessment and management according to established protocols [3,14].

6.3 Long-term effects

Undernutrition during pregnancy and early childhood can impair fetal growth, linear growth, immune function and neurodevelopment. Childhood stunting is associated with poorer developmental and educational outcomes and may have consequences for adult health and economic productivity [4,15]. In adults, inadequate energy and protein intake can lead to loss of muscle mass, reduced strength, impaired mobility, delayed wound healing and longer recovery from illness. In older people, loss of muscle may contribute to falls, frailty and loss of independence. The severity of consequences depends on duration, age, underlying disease and the timing and effectiveness of nutritional intervention [6,13,16].

7. Assessment and diagnosis of malnutrition

Assessment should combine nutritional history, clinical examination, anthropometry and evaluation of underlying disease. Relevant history includes usual food intake, recent changes in appetite, unintentional weight loss, gastrointestinal symptoms, swallowing or chewing difficulties, medication use, physical function and food access. In children, weight, length or height, mid-upper-arm circumference (MUAC), bilateral pitting oedema and growth trajectory are interpreted using age- and sex-specific standards. WHO growth standards provide reference values for assessing child growth and identifying wasting, stunting and underweight [17,18].

For adults, screening tools can identify risk, but diagnosis requires a more complete assessment. The Global Leadership Initiative on Malnutrition (GLIM) framework recommends screening followed by assessment of phenotypic criteria—non-volitional weight loss, low body mass index (BMI) and reduced muscle mass—and aetiological criteria, including reduced food intake or assimilation and inflammation or disease burden. At least one phenotypic and one aetiological criterion are required for diagnosis. The 2025 GLIM update reviewed evidence accumulated over five years and retained the central structure of the framework [13,19].

Laboratory investigations may help identify complications or underlying causes, but no single biochemical marker diagnoses malnutrition. Serum albumin and prealbumin are influenced by inflammation, fluid balance, hepatic function and illness; they should not be interpreted as direct measures of dietary protein intake. Depending on clinical circumstances, tests may include blood count, glucose, electrolytes, renal and liver function, inflammatory markers and selected micronutrient measurements. Severe wasting, bilateral pitting oedema, inability to feed, altered consciousness, hypothermia, hypoglycaemia or signs of serious infection require urgent medical assessment [3,13,14].

8. Prevention and management

8.1 Maternal, infant and young-child nutrition

Prevention begins before conception and during pregnancy through adequate maternal nutrition, antenatal care and attention to maternal health. WHO recommends exclusive breastfeeding for the first six months, followed by the introduction of safe and nutritionally adequate complementary foods at around six months while breastfeeding continues. Complementary feeding should provide sufficient energy, protein and micronutrients and should progress in texture and variety according to the child's developmental stage [20,21].

Appropriate complementary foods include pulses, eggs, dairy products, fish or meat where culturally acceptable, and other locally available nutrient-dense foods. Feeding advice should also address responsive feeding, hand hygiene, safe water, food preparation and avoidance of choking hazards. Infection prevention through immunisation, sanitation and timely treatment of illness supports nutritional recovery and healthy growth [20,21].

8.2 Community and household strategies

Community interventions should improve access to diverse foods and strengthen the conditions that support healthy diets. Options include nutrition counselling, breastfeeding support, school meals, food fortification where indicated, social-protection programmes and links between health services and food-security initiatives. Programmes should be designed around local dietary patterns and should avoid assuming that education alone can overcome financial barriers. Monitoring should assess food access, dietary diversity, growth, morbidity and programme reach, particularly among vulnerable households [4,12,22].

8.3 Clinical management

Management depends on age, severity, medical stability and the cause of malnutrition. In adults, care may include treatment of the underlying disease, symptom control, food fortification, oral nutritional supplements, enteral feeding or parenteral nutrition when clinically indicated. Protein and energy targets should be individualised, especially in patients with renal, hepatic or metabolic disorders. In patients at risk of refeeding syndrome, nutritional rehabilitation requires careful clinical monitoring and correction of electrolyte and fluid abnormalities [6,23].

Children with severe acute malnutrition require structured, evidence-based management. Clinically unstable children may need inpatient stabilisation, treatment of infection and metabolic complications, cautious nutritional rehabilitation and close monitoring. Selected children with uncomplicated severe wasting may be managed through outpatient services using ready-to-use therapeutic food and regular follow-up, according to national protocols and WHO recommendations. Therapeutic foods are medical nutrition products and should not be replaced by routine high-protein snacks or unsupervised supplementation [3,14].

9. Protein nutrition across the life course

Protein needs are not identical throughout life. Infants and children require protein to support rapid growth; pregnancy and lactation require additional nutrients to support maternal and fetal or infant needs. Adults generally require adequate intake to maintain tissue and metabolic function, while older adults may be vulnerable to inadequate intake and muscle loss because of reduced appetite, disease, inactivity or functional limitations. Illness, injury and rehabilitation can alter requirements and tolerance. Accordingly, a single high-protein recommendation should not be applied indiscriminately to all individuals [1,2,8,16].

A practical dietary pattern should distribute protein-containing foods across meals and include sufficient total energy. In vegetarian diets, combinations of pulses, cereals, soy foods, dairy, nuts and seeds can contribute to adequacy. For individuals with clinical disease or significant weight loss, dietetic assessment is preferable to self-prescribing supplements. Excessive supplementation may be costly, displace other nutrient-rich foods and be inappropriate for some patients.

10. Table 1. Summary of common forms and assessment priorities

Pattern / condition	Common features	Assessment priorities	General management principle
Inadequate protein-energy intake	Poor intake, fatigue, reduced muscle mass or growth faltering	Dietary history, weight trend, growth measures, food access and illness	Improve total dietary adequacy and address underlying causes
Wasting / marasmus pattern	Low weight-for-height, loss of fat and muscle; possible weakness or lethargy	Anthropometry, MUAC, oedema, appetite and danger signs	Protocol-based assessment; therapeutic nutrition and medical care when indicated
Nutritional oedema / kwashiorkor	Bilateral pitting oedema; weight may underestimate severity	Check both feet for pitting oedema and assess clinical stability	Urgent clinical assessment and structured treatment
Chronic undernutrition / stunting	Low height-for-age and possible developmental consequences	Growth trajectory, dietary quality, recurrent infection and social context	Maternal-child nutrition, food security and infection prevention
Disease-related malnutrition	Reduced intake, inflammation, weight loss or low muscle mass	Weight history, BMI, muscle status, intake and disease burden	Treat underlying disease and provide individualised nutrition support

11. Figure 1. Conceptual relationship between dietary inadequacy and malnutrition

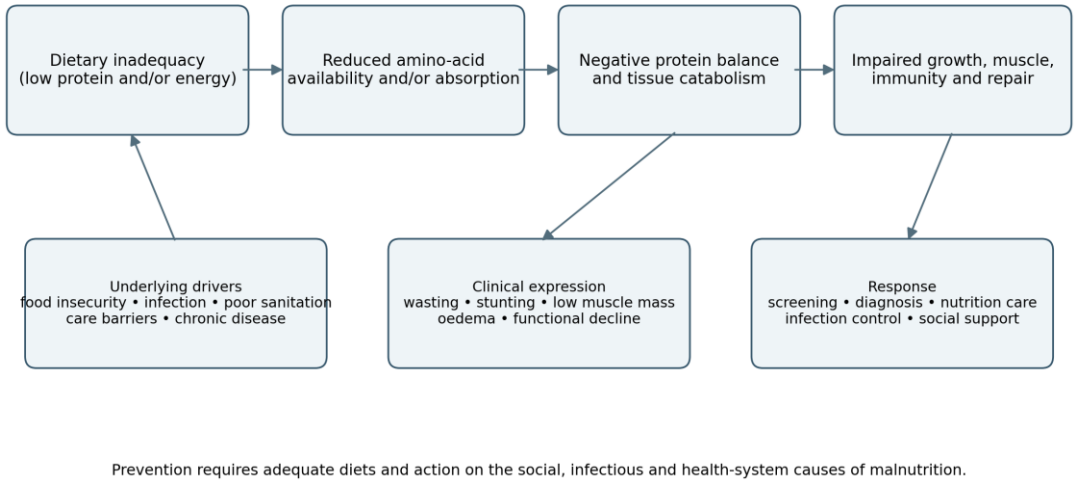


Figure 1. Simplified conceptual pathway linking inadequate dietary intake and underlying determinants to clinical consequences and opportunities for intervention.

12. Current challenges and future perspectives

A major challenge is that malnutrition is often identified late, after weight loss, growth faltering or functional decline has become established. Screening should be incorporated into primary care, hospital admission, maternal-child health services and community programmes, with clear referral pathways for people who require treatment. Screening without access to effective intervention is insufficient. Health systems must connect nutrition assessment with treatment of infection and chronic disease, counselling, food assistance and follow-up [3,13,22].

Future research should evaluate interventions in real-world settings and consider dietary quality, energy intake, infection burden, household resources and clinical outcomes together. Studies of protein supplementation should avoid treating protein as the only potentially limiting nutrient. Outcomes should include growth, muscle function, development, morbidity, quality of life, relapse and cost-effectiveness. The 2025 GLIM update also identifies continuing needs in screening, muscle assessment and application of diagnostic criteria in specialised clinical settings [19].

Sustainable action requires collaboration among healthcare professionals, public-health agencies, educators, food systems, community organisations and policymakers. Interventions are more likely to succeed when they are affordable, culturally acceptable, locally available and linked to reliable health services. In this context, protein adequacy is one component of a broader strategy to improve nutrition and health.

13. CONCLUSION

Protein is essential for tissue growth and repair, muscle maintenance, immune function and normal metabolism. Nevertheless, protein-energy malnutrition is rarely a problem of protein alone. Inadequate energy intake, micronutrient deficiencies, infection, inflammation, impaired absorption and social determinants frequently interact. Clinical manifestations range from growth faltering and wasting to severe wasting with or without nutritional oedema, while disease-related malnutrition in adults may occur even when body weight is not obviously low. Accurate diagnosis requires a combination of dietary history, anthropometry, physical examination and assessment of underlying disease. Prevention depends on adequate maternal and child nutrition, diverse and affordable diets, infection control, food security and early identification. Severe acute malnutrition requires protocol-based clinical care. A coordinated, context-sensitive approach is therefore essential to reduce the burden and long-term consequences of malnutrition.

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