Review Article

Subclinical Kwashiorkor in Adults: A New Age Paradigm

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Abstract

Childhood protein-energy undernutrition (PEU) is a well-recognized problem and therefore a lot of work has been done to identify and manage paediatric PEU. Though there have been several reports of low protein consumption in adults from developing countries, PEU and its subtle forms (subclinical PEU) are not yet recognized as adult disorders. Physicians and public perception do not favour easy recognition and action. In this review, the authors provide a scoping review of the existing literature on this entity providing insights into its recognition, pathogenesis and management. Adult subclinical PEU is an enormous under-recognized challenge that can have detrimental consequences if not recognized and corrected in time. PEU has grave health and economic impact on the patient and society. Therefore, it is important to recognize subclinical PEU and prevent its progression to full-blown form.

Keywords: Adults, kwashiorkor, obesity, severe protein malnutrition, subclinical, undernutrition

Introduction

Malnutrition continues to be a major global public health problem in children and adults.[1] Malnutrition covers two spectrums of opposing nutrition status, that of undernutrition and over nutrition.[1] In this review, we will cover the undernutrition aspect in adults.

Undernutrition in developing countries is multifactorial and the programmes to counter it need to consider the demographic, socioeconomic, physiological and behavioural aspects of nutrition.[2-5] Social welfare programmes in countries like India, aimed at improving nutritional status, have been ineffective.[6] This confirms that the multifactorial dynamics of adult undernutrition are poorly understood.[7]

Childhood undernutrition is usually well-identified and perceived as a magnitude of a huge problem.[8-13] Childhood protein-energy undernutrition (PEU) or protein-energy malnutrition (PEM) is a widely discussed and accepted global problem.[8-16] However, though PEU is reported in adults,[17-19] it continues to be an under-recognized entity that does not receive the attention it should.[20]

Adult undernutrition includes both PEU and deficiency of micronutrients (vitamins and minerals).[1] It is associated with higher morbidity, mortality and disability, reduced productivity, lower intelligence quotient (IQ) and impaired economic growth and development.[7,21-27] While mineral and vitamin deficiency is a well recognized and accepted concern in adults, PEU is not.[20,28]

Chronic energy deficiency (CED), characterized by lean body mass with low energy storage, is one of the hallmarks of adult undernutrition.[29] CED decreases work capacity and if the earning member is affected, then CED can result in food insecurity, compromised economic capability, poverty and poor access to adequate healthcare.[30-33] The aetiology of the unique thin fat phenotype in South Asian countries, often prevalent in lean diabetes, is also linked to CED.[34-36]

Protein deficiency is an under-recognized and serious concern in Asian and African adults.[20] The recommended dietary

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allowance (RDA) for protein for healthy Indian adults as per the Indian Council of Medical Research (ICMR) and National Institute of Nutrition (NIN) is 0.8 g per kg reference body weight (for India: 60 kg for men and 50 kg for women).[37] However, an Indian adult's dietary protein intake usually falls short of RDA to about 0.6 g per kg reference body weight.[20] The 2015 Protein Consumption in Diet of Adult Indians: A General Consumer Survey (PRODIGY) found that nine out of 10 Indian adults consume an inadequate amount of proteins.[38] PRODIGY brought to the limelight that protein consumption was very low in Indian adults. Though the RDA of protein is well delineated in India, and the protein sources are usually available and accessible, adult protein deficiency continues to pose a challenge to the public as well as the individual health of Indians.[7,20,30]

Just like PEU, subclinical PEU is largely under-recognized, under-diagnosed and therefore rarely reported. Adult subclinical PEU needs early detection and rectification to prevent its progress to PEU. There is an urgent need to infuse adult subclinical PEU awareness among the public and healthcare professionals.

Kwashiorkor

Epidemiology

Kwashiorkor is a type of PEU that is prevalent and amply reported across countries and societies in children from resource-challenged backgrounds.[8-13] Kwashiorkor has been reported in sub-Saharan Africa, Southeast Asia including India and Central America and affects 6% to 25% of children depending on food availability and famine conditions.[39,40] According to the 2019 United Nations Children's Fund (UNICEF)/World Health Organization (WHO)/World Bank Group report, more than two-thirds of wasted and more than half of the stunted under-five children in the globe lived in Asia. Of the 49.5 million under-five wasted children in Asia, 16.6 million were severely wasted in 2018.[41] As per India's National Family Health Survey-4 (NHFS-4) data, under-five stunting and underweight children are most prevalent in the poorest and least in the richest sections of the society (51% vs. 22% for stunting and 49% vs. 20% for underweight).[42] Kwashiorkor has also been reported in children from other well-off regions of the world.[14-16]

The 2019 Food and Nutrition Security Analysis initiated jointly by the Government of India and the World Food Programme found that the average protein consumption in rural and urban India was 47.5 g/day and 47 g/day, respectively, which was lower than the 48 g/day and 50 g/day recommended by ICMR for rural and urban areas, respectively.[43] A 2017 survey by Indian Market Research Bureau (IMRB) conducted in seven Indian cities, reported that 73% of urban rich were protein deficient and 93% were unaware of their RDA.[20] These data show that PEU is also seen in the rich, highlighting the fact that the aetiology is more deep-rooted than just affordability.

Aetiology

Inability to afford a protein diet due to poverty or ignorance regarding the composition of food is the main cause of PEU in low-income countries.[20,44] However, in India, often the cause of deficiency goes beyond affordability and ignorance to include issues like the gender gap with males in the family getting more nutrition than females.[20,30,45]

The aetiology of PEU in children from well-off families is not related to affordability. Frequent modifications in milk diet, perceived milk allergies, food faddism, unorthodox diets, malabsorptive syndromes and parental ignorance leading to predominantly cereal-based protein-poor weaning diet are common causes of kwashiorkor in children from an affluent background.[14-16] Children brought up in an environment of significantly chaotic social environment were also found to be at risk of kwashiorkor.[14]

Kwashiorkor usually starts during the weaning age and usually presents when the child is under five years.[46] However, adult kwashiorkor has also been described in the literature.[17-19] Kwashiorkor has been reported post bariatric surgery and/or short-gut syndrome.[17,19] Zhu (2019) reported kwashiorkor in a 60-year-old alcohol-dependent male.[18]

Adults following fad diets, starving to lose weight or having chronic illness or inflammation in the body are also at risk of developing PEU. Conditions, such as infections, trauma, burns, surgery and hyperthyroidism, that increase metabolic demands, can precipitate PEU.[47,48]

Apart from medical causes and dieting/starving or following fad diets, dietary preferences and habits play a major role in causing adult PEU. The majority of Indians are vegetarians with a predominantly rice-based diet.[5] Though the Indian diet across states is generally low in proteins,[49] vegetarians consume lower protein than non-vegetarians.[50] Up to 60% of the protein in Indian diets comes from cereals which are of relatively low quality and digestibility.[49,51] The Study To Assess the dietaRy CarboHydrate content of Indian type-2 diabetes population (STARCH) survey from India found that 64.1% of all energy requirements were met by consuming starchy food, which was approximately 4.1% higher than the upper limit of RDA of 60%.[52] Another nutrition survey from Asia found carbohydrate consumption exceeded the RDA in 58.0% of men and 60.0% of women.[53] High carbohydrate intake was associated with low energy and protein intake.[53] Dietary preference for high carbohydrates has also been reported in Africa and other parts of the world as well.[54,55]

Additionally, all causes of PEU, including reduced intake, absorption and assimilation, do coexist and are important from a clinical viewpoint. Hence, it is important to understand the factors leading to undernutrition in adults. A case-control study from Bangladesh in the 18–45 year age group found that having more siblings [adjusted odds ratio (aOR), 1.39], higher score for mental health and psychological symptoms (aOR, 1.12), anaemia (aOR: 3.63) and high α-1 antitrypsin in stools (aOR 4.82) correlated positively with adult undernutrition.[29]

Undernourished adults had iron and zinc deficiency.[29] On the other hand, older age (aOR, 0.90), having a low dietary

diversity score (aOR, 0.75), having low inflammatory markers such as C-reactive protein level (aOR, 0.82), not having Helicobacter pylori infection (aOR, 0.11) and proper hand hygiene before eating, cooking or serving food (aOR, 0.33) correlated with reduced odds of adult undernutrition.[29] Other factors associated with adult undernutrition in the Asian population are female gender, lower education level, having no permanent employment, low family income and smoking.[56-58]

There are many other clinical situations where physicians may encounter PEU. Psychiatric disorders such as depression and anorexia result in poor food intake and can therefore precipitate PEU.[59,60] PEU can be a presenting feature of undetected malignancy or can precipitate in patients undergoing treatment for malignancy (cancer cachexia).[59-61] Other than these, critically ill patients being managed in intensive care units (ICUs) or those hospitalized for a prolonged period are more likely to develop PEU.[62] Secondary endocrine causes such as endogenous Cushing's syndrome, chronic adrenal insufficiency, chronic steroid use, uncontrolled diabetes, hyperthyroidism and hypogonadism should be ruled out in patients where no other obvious cause can be identified.[48]

PEU is increasingly being seen in patients infected with severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) and developing coronavirus disease 2019 (COVID-19).[63,64] COVID-19 causes malnutrition in many ways. ICU admissions, prolonged hospital stays, loneliness during home isolations or hospitalizations in COVID wards and stress of the disease resulting in poor food intake during the disease can precipitate PEU.[63-68] The increased viral load and infection and inflammation associated with COVID-19 increase metabolic demand on the body and can therefore precipitate PEU.[69] The risk of PEU is higher in patients who have obesity and diabetes.[69] Obesity, an inflammatory state, is associated with increased COVID-19 risk and severity, and diabetes often becomes uncontrolled, thereby increasing inflammation and metabolic demand.[70,71]

Symptoms

The word kwashiorkor often elicits vivid imagery of a severely undernourished child. The clinical presentations in children include the characteristic erosive crusting rash giving the flaky paint sign image with overall peripheral oedema.[14] On the other hand, an adult with PEU may just be irritable, weak, fatigued, have low work capacity and apathy.[72]

Sometimes, PEU in adults may be severe enough and mimic the classic presentation seen in children. There may be muscle shrinking, fat wasting with cachexia, most prominent in areas of fat deposit and protrusion of bones.[72-75] Patients may complain of dry skin, which looks pale, is thin and inelastic, and cold to touch.[72] Dry hair and profuse hair loss may be a complaint in subclinical PEU, and on examination, there is thinning of the scalp.[72]

Prolonged PEU may present as amenorrhoea (women), or gonadal atrophy and loss of libido in both sexes.[72,76,77] More severe cases may impair cognition; decrease blood pressure, pulse rate and cardiac output; and cause hypothermia which if unattended may cause death in rare cases.[72,75] Anaemia, oedema, jaundice and petechiae may develop if there is organ failure affecting the kidney, heart or liver.[72,75] This phenotype also explains the high prevalence of normal weight obesity and its associated metabolic complications in the Indian subcontinent.[78,79]

Signs

Physicians have many tools at their disposal to elicit physical deficits in PEU. These tools test muscle mass, muscle strength and muscle function as a reflection of PEU.[80] Various tools for diagnosing PEU and for eliciting underlying subclinical PEU are strength, assistance with walking, rising from a chair, climbing stairs, and falls (SARC-F) questionnaire, gait speed, grip strength, Timed Up and Go test (TUG) and short physical performance battery (SPPB). Imaging studies like dual-energy X-ray absorptiometry (DEXA) and bioelectrical impedance analysis (BIA) can be used to assess body composition and muscle mass. Anthropometric measures such as mid-arm circumference (MAC), body mass index (BMI), waist circumference, hip circumference, triceps skinfold and calf circumference are useful in assessing PEU.[81,82]

DEXA and BIA are costly tests, not available at all centres and not routinely used in clinical practice for assessing PEU. Questionnaires are difficult to administer, especially in busy clinics. Instead, physicians rely on easy-to-use tools such as gait speed, grip strength and anthropometric measures. A patient who has three low anthropometric measures, viz., BMI, waist circumference and waist-to-height ratio, is likely to have PEU.[83] MAC and calf circumference are other useful clinical tools to assess PEU.[84]

Subclinical Kwashiorkor

Despite the availability of reliable diagnostic tools, it would be a disservice to humanity to wait for the onset of kwashiorkor before diagnosing and treating it. The right approach is to screen, diagnose and manage protein deficiency before it causes clinical dysfunction. A way to paraphrase this would be to state that subclinical protein deficiency should be tackled, to prevent clinical protein deficiency. This thought process suggests that the term subclinical kwashiorkor may be used, to drive home the point that if unchecked, protein deficiency may lead to kwashiorkor-like symptoms and signs.

The definition of subclinical disease

The subclinical disease is the time period from exposure to a causative agent/factor to the appearance of clinical symptoms.[85] It is a stage where all pathological and biochemical changes are occurring.[85,86] Though the word 'subclinical' has a connotation of being symptom-free, many subclinical diseases can be identified clinically. Subclinical hypothyroidism,[87] and hypomania,[88] for example, may have

subtle symptoms and signs which facilitate early diagnosis. A similar condition applies to subclinical adult kwashiorkor.

Subclinical PEU is rarely reported. However, considering that adult PEU has grave consequences, physicians and the public should understand that it is important to identify subclinical PEU. A history of deficient protein intake in a healthy or sick adult should raise a suspicion of subclinical PEU. Adults having malabsorption syndromes,[89] kidney[90,91] or liver disease[92] and those with prolonged illness or cancer[93,94] are likely to have subclinical PEU before the symptoms actually manifest. Adults presenting with mild oedema, loss of muscle strength and inability to gain muscle mass in spite of appropriate exercise may have adult subclinical kwashiorkor, even in the face of normal biochemistry.[73,95] Subclinical PEU may coexist in adults with mineral, vitamin or other nutrient deficiency.[92,96]

Public Perception

There is very low priority and importance attached to adult protein malnutrition in the community. PRODIGY showed that the public was generally unaware that protein deficiency is as major a concern as iron and calcium deficiency.[38] Additionally, 93% of the Indian population was unaware of recommended daily protein requirement.[38] The survey also showed that 97% of pregnant women, 96% of lactating mothers and 95% of adolescents were unaware of their recommended daily protein requirement.[38] The recent 'Right to Protein', a nationwide public health awareness survey conducted across 16 cities in India found that misinformation led to low protein consumption.[20] The majority of Indian women/mothers are unable to identify easily available protein-rich foods. About 78% of mothers believed that protein is only required for strenuous exercises and that lack of protein in the diet does not affect overall health.[20]

Additionally, though physicians understand the importance of nutrition, they do not feel confident enough to address the nutritional aspect of patient management. A survey of 114 resident physicians found that majority agreed that routine primary care visits should include nutrition assessment (77%) and that they are obligated to discuss nutrition with their patients (94%).[97] However, only 14% of them felt they had adequate training to provide nutrition counselling. Physicians who had previous exposure to nutrition assessment and counselling training had significant doubts regarding their effectiveness to provide nutritional support to their patients ($P = 0.03$).[97] This shows that continued medical education (CME) covering nutrition assessment and counselling is required to improve physicians' confidence to manage the nutritional requirement of their patients.

A qualitative study from Saudi Arabia showed that while the nurses felt that they could promote proper nutrition among the patients they care for, they do not have enough independence and power to provide nutritional support and counselling.[98] This is worrying because the hospital and community nurses/social workers spend the maximum time with chronically ill hospitalized and discharged patients, respectively.[25,98] Hence, they can provide an important link to screen, detect and manage subclinical PEU in this vulnerable population.

Another survey of older adults and dieticians showed that older adults were significantly unaware of the possibility that they are under-nourished.[99] They failed to correct their nutritional deficit despite the efforts of their dieticians. This was because the dieticians usually recommended incorporating regular food products that the older adults were familiar with.[99] They worked on providing diversity and palatability. Instead, those older adults who were prescribed protein-enriched food products improved their nutritional deficit without much coaxing.[99] The survey showed that older adults may not be able to benefit from dietary recommendations usually provided to adults as they may have difficulty arranging wholesome meals for themselves. Hence, nutrient-rich food supplements are more likely to help this population.

Provider Discordance and Tools

The situation is compounded by the lack of consensus seen amongst healthcare professionals regarding the diagnosis and management of subclinical PEU. At least 22 malnutrition screening tools are available, all of which give widely varying estimates of PEU risk.[100] There is no diagnostic tool for subclinical PEU. In such a situation, it is important to use available tools judiciously to identify the subclinical disease at the earliest. These diagnostic tools include history, physical examination and laboratory findings.

History

Diagnosis of subclinical PEU can usually be suspected from a carefully elicited history showing reduced intake due to poverty, starvation, following a fad diet, dieting for weight loss, chronic illness or due to eating disorders such as anorexia nervosa. Amenorrhoea in a non-pregnant woman of child-bearing age should raise a suspicion of undernutrition.

Physical examination

Anthropometric measures such as height, weight and BMI (BMI = weight in kg/height [m^2]), along with inspection of body fat distribution may aid in the diagnosis of subclinical PEU [Table 1]. BMI may need to be substantiated with other tools such as waist-hip ratio and waist circumference, even

Table 1: Physical examination values commonly used to grade the severity of protein-energy undernutrition[72,101,102]

Measurement	Normal	Subclinical PEM
Normal weight (%)	90-110	85-90
Body mass index (BMI)*	18.5-22.9	<18.5
Waist circumference*		<90 cm in men and <80 cm in women
Waist-hip ratio*		<0.9 in men and <0.8 in women
Body fat percentage**		<25% in men and<30% in women

*Asian values. ** by dual-energy X-ray absorptiometry (DEXA) scan

though they may be more obvious in clinical PEU.[101,102] Other than this, there may be signs of muscle wasting, cachexia, other vitamin deficiencies, pale, inelastic and cold skin, profuse hair loss, dry hair, anaemia and oedema. Assessing hand-grip strength may be a useful tool in diagnosing muscle weakness.[95]

Laboratory tests

Laboratory tests may not be routinely performed to diagnose subclinical PEU. However, if dietary history does not show inadequate protein intake or if the physical examination is inconclusive, then laboratory tests may be required for diagnosis. Various laboratory parameters such as serum albumin and proteins, total lymphocyte count, serum cholesterol, various vitamin levels (especially vitamin D and vitamin E), mineral levels, urine creatinine, haemogram urine routine and microscopy, urine culture, delayed hypersensitivity and 3-methylhistidine may aid in the diagnosis of subclinical PEU [Table 2].[72,103] Immune response involving CD4+ and CD8+ T lymphocytes may be decreased in subclinical PEU.[104] Poor immune responses in subclinical PEU may be assessed by checking the values of C-reactive proteins and interleukins.[103] Though initially serum compliments have been reported to be low in children with PEM, this has not been shown in more recent studies. Leptin levels may provide insight into the fat metabolism of a given individual [Table 2].[103]

Bringing Objectivity to Evaluation

Subclinical PEU is difficult to identify and diagnose. Loss of muscle mass, easy fatiguability and reduced exercise capacity may be ignored or labelled as being due to other causes. Subtle changes in skin, hair and nail health may be missed, or ascribed to micronutrient deficiency. History, physical examination and anthropometric measurements are highly subjective tools as they rely heavily on the ability of the evaluator to assess and correlate.[103] Though routine laboratory tests for nutritional assessment may provide the much-needed objectivity to evaluation, their incorporation into routine clinical practice is difficult. A single value/level of a biochemical test is often inconclusive and may require repeat serial evaluations to be able to correlate with subclinical PEU. This adds to the cost of treatment and may be difficult to implement in a country like India.

The Global Leadership Initiative on Malnutrition (GLIM) has recently published a consensus-based framework of phenotypic and causative criteria for evaluating adult malnutrition.[105] International guidelines on adult malnutrition and GLIM agree that the aetiology of PEU can be classified under discrete criteria such as decreased intake; faulty absorption and assimilation of protein and energy intake; and inflammation due to any cause precipitating lean tissue catabolism.[105,106] Inflammatory causes can be further categorized as severe inflammation caused by acute disease/injury; sustained inflammation caused by chronic diseases/conditions; chronic disease with no or minimal perceived inflammation; and chronic starvation unrelated to any disease.[105-107]

This is a welcome step towards bringing objectively to protein malnutrition diagnosis and evaluation. Based on the above criteria, Table 3 enumerates the groups of adults at risk of subclinical PEU. Adults falling into any of the above

Table 2: Common laboratory values that may help assess adult subclinical protein-energy undernutrition[72,103]

Laboratory parameter	Relation to prognosis
Serum albumin (g/dL)	Each 2.5 g/L decrease in value increases mortality risk by 24-56%
Serum transferrin (mg/dL)	Role is controversial but if albumin is decreasing, decreasing tranferrin value is indicative of worsening morbidity and mortality
Insulin growth factor-I	Hospitalized patients: Inverse correlation with life-threatening complications
Total lymphocyte count (per mL)	Values <1500/mL correlated with four times increased mortality risk
C-reactive protein	Hospitalized patients: Decreased levels predict short-term survival
Interleukins (IL)	Increase in soluble IL-2 receptors increases mortality risk
Urine creatinine	Decrease in muscle mass may be suspected of low levels
Cholesterol	Values <120 are associated with 10-fold increased risk of mortality
Delayed hypersensitivity reaction	Absence of normal response is associated with increased 3-year mortality
Leptin	Association with prognosis is unknown

Table 3: Adults at risk of subclinical protein-energy malnutrition

Category	Conditions
Starvation	Poverty
	Fad diets
	Remaining hungry to lose weight
Chronic conditions	Chronic obstructive pulmonary disease (COPD)
	Cancer
	Chronic inflammatory gastrointestinal disease
	Renal or liver disease
	Inflammatory conditions such as rheumatoid arthritis
	Palliative/end of life care
	Stroke
	Parkinson's disease
	Motor neurone disease
Acute illness	Diarrhoea
	Intensive care unit
	Burns
Debility/Age	Dementia
	Old age
	Frailty
	Immobility
Psychological/ Neurological issues precipitating poor intake	Depression
	Living alone
	Alcohol/substance abuse
	Learning disabilities

categories should be diligently scrutinized for subclinical PEU through meticulous history taking and comprehensive physical examinations and, if required, serial laboratory investigations.

The Need for Motivation

Irrespective of the screening and diagnostic criteria used for the identification of protein malnutrition, an important barrier to action is the diagnosis. To be effective, a public health strategy should sensitize the community towards the need for early diagnosis, prevention and management. This can be done by a variety of social marketing methods. Multiple motivational theories try to explain why health interventions have mixed impacts on the public. One of the simplest theories is a binary construct, which describes two opposing motivational strategies: the need for achievement, and fear of failure. The need to achieve protein sufficiency may carry less importance in an individual's mind if he or she has not experienced the advantages of sufficiency. On the other hand, fear of protein malnutrition may be a greater driving force, if vivid imagery is used to portray the ill effects of this condition.

Management and Call to Action

Physicians should understand that PEU screening is just the tip of the iceberg in PEU management. Screening has to be followed up with proper evaluation, replacement of deficit, supplementation if required, monitoring and creating awareness. It requires acceptance and compliance from both the patient and the physician. Both must understand that if subclinical PEU is not halted in time, it can have a devastating effect on the health and quality of life (QoL) of the patient.[25]

PEU can be typically corrected by supplementing the protein-energy requirement in proportion to the need to meet the deficit.[108] However, this is often not enough because when PEU is caused by disease-related poor nutrition, then the therapeutic effect of supplementation is blunted.[109] Judicious management of the deficit and strict monitoring is required in many patients to correct the deficit and prevent over-supplementation and its adverse outcomes.[109] Hence, individualized or personalized nutrition support is often required to meet the nutrition deficit.[108,110] Individualized nutrition support can help reduce the risk of progression to PEU, and improve muscle strength and QoL.[111]

Every effort should be made to monitor the diet of such patients, make them aware of the affordable and easily available protein options[112,113] [Table 4], teach them portion size to be taken and give necessary supplementation if required.[25] Protein portion sizes will vary daily with the dish and other accompaniments; and also vary with gender and family size,[114] and therefore these parameters need to be considered when helping patients assess the portion size. Despite these differences in portion sizes, on the whole, protein should provide 10–15% of the total calorie requirement of the patient.[115] Rough portion size for different proteins for sedentary adults[115] as listed in Table 4 can act as a guide during a discussion with the patient.

The healthcare professional may also need to understand the patient's socioeconomic condition, resources available, ability to cook, access to food, ability to self-feed, mental state, functional limitations and other such factors to individualize the nutrition support programme and plan supplementation.[25] Dieticians and nutritionists can play a strong role in individualizing nutrition support and should be an integral part of the medical team managing the patient.

The Protein Paradox study shows that protein awareness is very poor in India. Therefore, social media and other health platforms, right from public health centres to tertiary care centres, need to run protein awareness programmes. These programmes should include knowledge about RDA in terms of portion size and highlight the easily accessible[112,113] [Table 4] and affordable protein options. The programmes should generate awareness to self-diagnose subclinical PEU. Patients should be able to recognize common symptoms (e.g. fatigue, hair fall, dry skin and hair), and understand that they are likely to have subclinical or clinical PEU if being treated for a chronic illness. They should be able to assess if they are taking the RDA or falling short of it and be able to add the required protein quantity to their meals and see if their symptoms are improving. However, simultaneously they should be encouraged to reach out to their physicians, dieticians and nutritionists to assess if they have subclinical PEU. Needless to say, it is important to stress that prevention is better than cure and it is important to detect and correct subclinical PEU to prevent its progression to detrimental PEU.

As with the loss of fat, that may increase the potential toxicity of fat-soluble molecules, even albumin plays a very important role in binding to several hormones and drugs. The presence of low albumin as may be found in patients with PEU may have implications in interpreting albumin-bound hormones, understanding the toxicity profile of albumin-bound drugs and also understanding these changes after improvement of albumin.

There is an unmet need to provide nutritional education, maybe in form of nutritional CME, to physicians as there is substantial providers' discordance and varying perceptions regarding adult undernutrition.[116] Additionally, nurses, dieticians, social workers and nutritionists should be integrated into patient care to provide nutrition support and counselling.

Addressing subclinical PEU will require a cohesive and multidimensional effort of all key players such as the government, media, nutritionists, doctors, food industry, food experts and public and educational institutions.[20] Moreover, further studies are needed to know the precise impact of treating subclinical PEU in preventing rapid deterioration during a crisis. A very similar analogy is poor dietary calcium intake in postmenopausal Indian women, which despite having

Table 4: Easily available protein options and their portion sizes for adult Indians[112,113,115]

Pulses (a major source of protein for most Indians)			
Peas	**Chickpeas**	**Lentils**	**Beans**
Green peas (split or whole, harvested dry), yellow peas (split or whole, harvested dry), pigeon peas	Desi or Kabuli	Green, red, yellow (split or whole)	Adzuki, Bambara, Cowpeas and black-eyed peas, Cranberry, Faba or fava, Great Northern, Kidney, Lima, Lupin, Mung, Navy, Mungo, Pink, Pinto, Yellow, Vetch
Pulses portion size sedentary adult 30 g×2 portions for vegetarians 30 g×1 portion for non-vegetarians			
Other vegetarian sources	Tofu		
	Soy milk, almond milk		
	Soy nuts		
	Nuts and seeds (almonds, pistachios, walnuts, cashew nuts, peanuts, pine nuts, pumpkin seeds, sunflower seeds, watermelon seeds)		
Milk and dairy/egg	Milk		
	Cottage cheese: tikka, grilled, scrambled (burjee), sautéed		
	Curd/unflavoured yogurt		
	Cheddar cheese, Mozzarella cheese, Parmesan cheese		
	Egg: boiled, scrambled, poached or omelette		
Milk portion size Sedentary adult 100 g × 3 portions			
Non-vegetarian	Chicken: salad, grilled, sautéed, baked or tikka without cornflour/flour/breadcrumbs		
	Fish: rohu, Indian salmon (ravas), kingfish (surmai) or pomfret tikka, baked without cornflour/flour/ Breadcrumbs		
	Meat curry, kofta, kebabs		

For non-vegetarians – Substitute one pulse portion with one. portion of egg/meat/chicken/fish.

normal serum calcium may predispose to the development of fragility fracture and can be prevented by prophylactically supplementing adequate calcium.

The Association with Sarcopenia, Sarcopenic Obesity and Osteoporosis

The association between low protein intake and low muscle mass and strength is well established. Sarcopenia, a condition referred to as a combination of either low muscle mass, low muscle strength and/or poor muscle function is commonly seen in the elderly population. Sarcopenia is part of the spectrum encompassing PEU and is more commonly seen in the elderly. Moreover, sarcopenia may also be associated with underlying osteoporosis and osteoarthritis together known as the MOAN syndrome (musculo-osteo-arthro-neuropathic).[117] In the Indian thin fat phenotype, this may further be associated with increased visceral adiposity despite having a lower BMI.[118] This entity will then be called sarcopenic obesity. The above-mentioned various phenotypes highlight the importance of evaluating different body composition components in people suspected of PEU, which are often interlinked.

Moreover, the association of PEU along with low muscle mass may further be linked to poor bone strength. This triad is commonly seen in the elderly population, together referred to as the MOAN syndrome.[117] This highlights the close link between these four organ systems and their contribution to the poor health-related QoL in these individuals. Furthermore, a higher body fat percentage, which is often commonly present in people with poor muscle mass, was initially thought to be protective against bone fragility. However, more recent literature has suggested that this does not hold true in those with morbid obesity.[119]

Summary

PEU is thought to be a childhood problem. However, it can occur in adults. Protein undernutrition is very common in Indian adults. And hence subclinical PEU is also likely to be very common. Adult subclinical PEU and protein undernutrition is a surprising find and is largely preventable and treatable because the cause is not affordability but basic ignorance regarding RDA and easily accessible protein sources. Hence, every effort should be made to generate awareness in the public, physicians and other healthcare workers regarding the existence of subclinical PEU, detect it at the earliest, treat it and prevent its progression to clinical PEU.

Ethics compliance

Not required as it is a review article.

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Conflicts of interest

There are no conflicts of interest.

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