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Review of Oral Nutritional Supplements in Malnutrition Management for Unlocking Nutritional Potential: A Review

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ABSTRACT

Malnutrition, stemming from inadequate or imbalanced diets, poses significant threats to physical health, mental well-being, and overall quality of life. Oral Nutritional Supplements (ONS) emerge as pivotal tools to address malnutrition and deliver precise amounts of essential nutrients often lacking in individuals' diets. This review synthesized findings from numerous studies exploring the efficacy of ONS in mitigating malnutrition and enhancing nutritional status, with a particular focus on elderly populations. ONS have emerged as cost-effective interventions to reduce complications, hospital readmissions, and mortality rates associated with malnutrition across healthcare settings, including hospitals and care facilities. Moreover, the versatility of ONS formulations, ranging from liquids to powders and varying energy density and nutrient composition, ensures suitability for diverse dietary needs. The accessibility, affordability, and palatability of these foods further demonstrate their usefulness for malnutrition management. Furthermore, ONS formulations include macronutrients that are essential for cellular integrity, energy production, and overall health, including proteins, fats, and carbohydrates. In conclusion, this review emphasizes the significance of integrating ONS into comprehensive malnutrition management strategies. Healthcare practitioners can effectively mitigate the adverse consequences of malnutrition by harnessing the nutritional potential of ONS, thereby promoting enhanced health and well-being for individuals across the lifespan.

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Introduction

Malnutrition

Malnutrition is a condition arising from an insufficient or imbalanced dietary intake, leading to either a deficiency or excess of essential nutrients. This imbalance can severely impact both physical and mental health and overall well-being. ONS plays a crucial role in addressing malnutrition by providing specific quantities of energy, protein, vitamins, and minerals that may be lacking in an individual's diet. The supplements are designed for individuals who struggle to consume enough food to meet their nutritional needs. ONS enhances nutrient intake, preserves body weight, and promotes overall health, particularly in cases where dietary modifications alone may not suffice. ONS is a valuable resource in managing malnutrition, particularly among older people and those at risk. Numerous studies have explored the effectiveness of ONS in alleviating malnutrition and enhancing nutritional status, particularly in older populations. Thus, integrating ONS into a comprehensive malnutrition management strategy, alongside dietary adjustments and nutrition education, is paramount for addressing this pervasive health concern (1-4).

Malnutrition is characterized by a state of inadequate absorption or intake of nutrients, resulting in alterations to the body's composition, including a decrease in body and body-cell mass. A decline in both mental and physical performance occurs as a consequence of this condition, making one more susceptible to a variety of illnesses. Malnutrition affects individuals regardless of their health status, resulting in a diminished quality of life and an increased risk of death. Malnourished patients discharged from acute care settings face elevated rates of readmission. A significant portion of hospitalized patients suffer from malnutrition, which is a pervasive challenge in hospital environments. Factors such as decreased appetite, reduced food intake, and medical procedures contribute to the deterioration of nutritional status during hospitalization. The

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clinical ramifications of malnutrition are substantial, manifesting as heightened medical complications and infection rates. Moreover, malnutrition carries significant economic implications, including prolonged hospital stays, delayed recovery, and increased risks of readmission and mortality. Consequently, patients with malnutrition or poor nutritional status incur substantially higher healthcare costs (5).

Disease-related malnutrition is widespread across various healthcare and social care settings, encompassing hospitals, care homes, and sheltered housing. More than three million people live with malnutrition or its risk in the UK alone, of which approximately 1.3 million are over 65. Despite these staggering figures, malnutrition often goes undiagnosed and untreated, resulting in a myriad of adverse effects that impose significant burdens on both individuals and the healthcare system (6).

In England alone, health and social care expenditures for malnutrition amount to approximately 15% of the health budget, which represents a prevalent and financially burdensome issue. The repercussions of malnutrition are multifaceted, encompassing heightened rates of complications, increased visits to general practitioners, and elevated risks of re-hospitalization (7). Currently, patient malnutrition is a paramount concern in hospital settings. On average, an estimated 30% of hospitalized patients experience malnutrition, specifically with rates fluctuating between 20% and 60% in geriatric wards. The ramifications of malnutrition extend beyond mere health implications, correlating with increased patient mortality and morbidity rates, prolonged hospital stays, and healthcare costs approximately 45% higher than those incurred for non-malnourished patients (8). The economic burden of disease-related malnutrition in the United States surpasses $15.5 billion annually. Furthermore, inadequate nutrition is intricately linked with prevalent chronic conditions in the country, including obesity, heart disease, stroke, and type 2 diabetes. This association contributes to a staggering economic toll, amounting to approximately $16 trillion between 2011 and 2020 (9).

Malnutrition remains a pressing global health concern, impacting millions of children worldwide. This multi-faceted issue encompasses a spectrum of conditions characterized by deficiencies, excesses, or imbalances in energy or nutrient intake. Underweight-related malnutrition, micronutrient-related malnutrition, and overweight and obesity are the common types of malnutrition (10, 11). Globally, acute malnutrition affects a staggering 19 million children and contributes to over half a million preventable child deaths annually. Alarmingly, only 20% of these affected children receive treatment. Malnutrition in children manifests through various indicators, including emaciation (low weight for height), short stature (low height for age), and underweight (low weight for age). Children with this condition are significantly more likely to suffer illness, succumb to common infections, and have a more difficult time recovering from infection (12, 13).

Chronic malnutrition arises from prolonged inadequate nutrient intake, compounded by a complex interplay of intergenerational and environmental factors, culminating in stunting. Malnutrition is primarily manifested by stunting in children, affecting 151 million under five years of age in 2017. More than 90% of these cases are concentrated in Africa and Asia. The World Health Organization (WHO) advocates the provision of nutrient-dense complementary foods to malnourished children in order to meet their heightened needs for weight and height gain, resulting in improved performance and development overall (14). The prevalence of overweight and obesity among children is increasing worldwide, along with undernutrition. Heart disease, stroke, diabetes, and certain types of cancer are all non-communicable diseases associated with dietary factors. Addressing the rising prevalence of overweight and obesity in children is crucial for mitigating the risk of these chronic health conditions and promoting overall well-being (10, 15). Malnutrition in children can exert lasting effects, extending into adulthood and impacting various aspects of life. Long-term consequences may include impaired cognitive development, diminished school performance, and reduced productivity in adulthood. A comprehensive, multisectoral approach is necessary to effectively address malnutrition due to its multifaceted nature. This approach should encompass healthcare interventions and broader societal factors such as poverty, food insecurity, and

inadequate access to healthcare. The underlying causes of malnutrition can only be adequately addressed by concerted efforts across multiple sectors, improving health outcomes and well-being for children globally (10, 16).

Vitamins and minerals play indispensable roles in maintaining the body's optimal function. As these nutrients are primarily obtained through a balanced and nutritious diet, deficiencies can arise, particularly in the context of certain pathologies like cancer or gastrointestinal diseases. Food supplements are commonly employed to address such deficiencies and uphold nutritional status. These supplements serve as concentrated sources of nutrients with specific nutritional or physiological effects, effectively replenishing deficiencies and supporting overall health (17). Reduced dietary intake stands out as a primary contributor to malnutrition. A number of authorities, including the National Institute for Health and Clinical Excellence (NICE), advocate for a multifaceted approach to addressing malnutrition. The use of supplements such as ONS and dietary counseling are among the strategies recommended to enhance oral nutrition. Providing targeted nutritional support to individuals at risk of malnutrition is a strategy aimed at mitigating the detrimental effects of reduced diets and improving nutritional status (6). A prevalent treatment modality for malnutrition involves the use of ONS. Supplements such as these are usually available in liquid form and provide essential nutrients such as energy, protein, vitamins, minerals, and trace elements. The ONS provides individuals at risk of malnutrition with a concentrated source of essential nutrients and supports their overall health (18).

Based on a comprehensive analysis of studies conducted in healthcare settings, ONS led to a significant 30% reduction in mortality rates. This reduction was primarily attributed to the beneficial effects of ONS in acute and hospitalized patients. Moreover, the impact of malnutrition and its associated consequences can be mitigated through proactive measures such as identifying, screening, and providing appropriate nutritional interventions (19). A systematic review and meta-analysis conducted by Cawood et al. further underscored the positive outcomes associated with the use of high-protein nutritional supplements, including ONS, across diverse patient populations and various healthcare settings. These findings highlight the significant potential of nutritional interventions, particularly the incorporation of ONS, in improving outcomes and enhancing overall patient well-being (6).

Bahramian et al. (2023), on designing blenderized tube-feeding diets for children, underscores the importance of precise nutrient formulation to meet specific dietary needs. A balanced nutrient composition is critical for addressing malnutrition in diverse populations in ONS. The principles of nutrient density and tailored macronutrient profiles, as highlighted in their study, can be directly applied to the development of ONS formulations. The ONS products are thus both nutritionally adequate and aligned with the specific requirements of vulnerable groups, such as older adults. Similarly, Toranj et al. (2024) investigated the nutrient content of enteral diets in hospitals to identify gaps in the nutritional adequacy of existing products. The findings highlighted the necessity for ONS formulations specifically designed to address the shortcomings in current nutritional interventions, particularly in clinical settings. OnS can be optimized to provide comprehensive nutritional support by incorporating insights from these studies, which can help bridge the gap between standard dietary intake and the elevated nutritional needs of malnourished people (20, 21).

The purpose of this study is to critically examine the role of Oral Nutritional Supplements (ONS) in managing malnutrition, particularly among vulnerable populations such as older adults. A review of various studies aims to assess whether ONS can improve nutritional status and reduce the odds of malnutrition-related complications by assessing its efficacy, versatility, and cost-effectiveness. This study seeks to provide healthcare practitioners with evidence-based insights into the integration of ONS into comprehensive malnutrition management strategies, ultimately contributing to better health outcomes and quality of life for individuals affected by malnutrition.

Definition of Dietary Supplement

ONS serve as valuable products designed to supplement additional nutrients, including protein and energy, to individuals whose dietary intake alone fails to meet their nutritional requirements adequately. Typically incorporated alongside a regular diet, ONS prove particularly

beneficial when dietary intake alone proves insufficient to fulfill daily nutritional needs. ONS is crucial for maintaining optimal health, especially during times of illness or heightened nutritional demands. Furthermore, ONS are instrumental in both preventing and treating malnutrition, a condition characterized by inadequate consumption of energy (calories) or protein. ONS helps address nutritional deficiencies and promote overall health by providing a concentrated source of essential nutrients. The versatility of these devices allows them to be used across a variety of clinical settings, providing a clinically and economically viable solution to the problem of malnutrition, especially among individuals with a low body mass index (BMI) (22, 23).

During periods of acute or chronic illness, many individuals face challenges in consuming sufficient energy and nutrients from food. In most cases, these difficulties are caused by two main factors: diseases themselves and issues surrounding food quality and availability. In such circumstances, ONS emerges as a valuable and efficient strategy for addressing deficiencies in nutrient intake. OnS provides a concentrated source of essential nutrients that mitigates the challenges associated with inadequate dietary intake during illness, thereby supporting optimal nutrition and promoting recovery (19). ONS serve as essential tools to augment the energy and nutrient intake of patients, particularly those who are malnourished or at risk of malnutrition. Dietary supplements are intended to be consumed in conjunction with a regular diet and serve specific medical purposes. As an additional source of nutrients, ONS assists in addressing nutritional deficiencies, supporting overall health, and managing several medical conditions (24).

ONS may be prescribed to address one or more nutrient deficiencies and facilitate the restoration of proper growth and bodily function. Supplements provide concentrated sources of nutrients or other substances with specific nutritional or physiological effects, either alone or in combination. ONS plays a vital role in supporting overall health and well-being, especially for individuals with specific dietary requirements or medical conditions (25). ONS typically contain 1.5 kilocalories per milliliter (kcal/ml) and are composed of approximately 14-20% protein, 25-35% fat, and 50-60% carbohydrate. Additionally, these supplements are fortified with vitamins and minerals to provide a portion of the recommended daily intake of essential nutrients. A standard 200ml package of ONS is designed to offer a balanced combination of macronutrients and micronutrients, thereby supporting optimal nutritional intake in individuals with increased dietary requirements or specific nutritional needs (26). ONS is highly regarded as a preferred nutritional intervention for individuals at risk of malnutrition, owing to its convenient and readily available benefits. Typically, ONS are formulated as multi-nutrient products containing a blend of macronutrients, such as protein, carbohydrates, and fats, alongside micronutrients, including vitamins, minerals, and trace elements. This comprehensive composition ensures that ONS effectively addresses nutritional deficiencies and supports overall health, making them a valuable component of malnutrition management strategies (6).

Ready and complete food supplements are abundant in energy, with most containing approximately 1.5 to 2.4kcal/ml, equating to roughly 300 kilocalories per serving of 150 to 200ml to provide a balanced combination of macronutrients and micronutrients, ensuring optimal nutritional intake. Their comprehensive composition provides essential nutrients in a convenient, easily consumable form, making them an effective way to address nutritional deficiencies and improve overall health (19). ONS encompasses a diverse array of products available in various forms, types, and energy densities to cater to individual nutritional needs and preferences. These supplements are offered in forms such as milk, juice, and yogurt and may be found in liquid, powder, pudding, or condensed forms. Additionally, ONS are categorized based on their nutritional composition, including high protein, high fiber, or low volume varieties. The energy density of ONS typically ranges from 1 to 2.4kcal/ml, offering flexibility in meeting varying energy requirements. Carbohydrates in ONS are commonly sourced from maltodextrin or glucose syrup, while proteins may derive from sources such as cow's milk, whey, soy, or animal protein. Fat sources typically include soybeans, corn, palm kernels, or seeds, although animal or fish-derived fats may also be utilized. This diverse range of ONS products ensures that individuals

can access tailored nutritional support to meet their specific dietary needs and preferences (27). Ensuring the effectiveness of dietary supplements hinges on patients adhering to the prescribed dosage and duration of use. Consequently, careful consideration of the sensory attributes of these products is imperative. The presence of active ingredients can influence taste perception, potentially eliciting negative emotions, which may impede supplement consumption and compromise treatment efficacy. Therefore, efforts to enhance palatability and minimize unpleasant sensory experiences are essential to promote compliance. Fortunately, dietary supplements are readily accessible, relatively affordable, and generally free of complications. Moreover, prioritizing palatability enhances their acceptability, facilitating consistent intake. Healthcare providers can optimize patient adherence to dietary supplement regimens by addressing sensory concerns and emphasizing palatability, thereby maximizing their therapeutic benefits and supporting overall health outcomes (28, 29). ONS exhibits characteristics of oil-in-water emulsions from a colloidal perspective. In this emulsion, the lipid phase comprises a blend of vegetable oils, such as sunflower and soybean oils, along with lipophilic bioactive compounds. Meanwhile, the aqueous phase is enriched with water-soluble vitamins. There may also be salts, polysaccharides, and proteins dispersed within the water phase. The specific ingredients chosen for the formulation of ONS play a pivotal role in determining their sensory attributes, including appearance, aroma, and texture. The sensory characteristics are instrumental in enhancing the patient's appetite, thus promoting consumption. ONS manufacturers strive to produce products that are nutritionally beneficial, palatable, and appealing to the senses, facilitating patient compliance and effectiveness (30).

Liquid ONS offers a distinct advantage in promoting faster gastric emptying, which facilitates greater overall caloric intake by mitigating the issue of early satiety. This characteristic allows individuals to consume more nutrients efficiently, supporting their nutritional needs. Various factors, including caloric content and timing of consumption, can also affect gastric emptying rates. In recent years, there has been a growing trend towards fortifying ONS products with omega-3 fatty acids, owing to their recognized anti-inflammatory properties. This fortification enhances the nutritional profile of ONS, potentially offering additional health benefits, particularly in individuals with inflammatory conditions. Additionally, ONS formulations can prevent muscle wasting, which is a major concern in cancer patients and other catabolic conditions, by adding amino acids such as arginine and glutamine. ONS fortified with these amino acids contribute to preserving muscle mass and supporting overall physical function by providing targeted nutritional support, thereby improving patient outcomes (31). Health economic assessments reveal that the extra expenditure on ONS is outweighed by the resulting savings in healthcare expenses, particularly through decreased costs associated with readmissions. Overall, there is a net cost benefit in favor of ONS, underscoring their cost-effectiveness in healthcare management (18).

The Amount of Macronutrients

ONS often contain macronutrients as energy and micronutrients as vitamins and minerals in varying concentrations (24). The amount of macronutrients and micronutrients in nutritional supplements for children one to four years old may vary depending on specific needs and recommendations. However, here are some general guidelines:

Macronutrients:

1. Carbohydrates: about 45 to 65% of the total daily caloric intake.
2. Protein: approximately 5-20% of total daily caloric intake.
3. Fats: almost 30-40% of total daily caloric intake (32, 33).

Food supplements for children should have a balance of macronutrients and micronutrients to ensure proper growth and development. Recommended macronutrient distribution ranges for children 4-8 years old are as follows:

- Carbohydrates: 45-65% of daily calories
- Protein: 10-30% of daily calories
- Fat: 25-35% of daily calories (34, 35).

Children's micronutrient requirements change as they grow. Some essential micronutrients for children are:

1. Vitamin D: Children who consume less than 32 ounces of vitamin D-fortified milk per day should supplement with ten mcg per day.
2. Vitamin A 400: micrograms per day
3. Vitamin: B6 0.6 mg per day

4. Vitamin B12: 1.2 micrograms per day
5. Vitamin 25: C mg per day (33, 35).

A nutrient-rich diet is essential to promoting healthy growth and development in children, ensuring they receive essential macronutrients and micronutrients at meals and snacks. However, it is equally important to avoid overfeeding children, as this can contribute to the risk of childhood obesity. Balancing nutrient intake with appropriate portion sizes is key to supporting children's nutritional needs while maintaining a healthy weight (33, 35).

The Energy Content of Food Supplements

Patients are frequently prescribed ONS based on a specific caloric intake or volume consumed. The higher energy density of these supplements enables patients to fulfill their nutritional requirements in smaller servings, which is particularly advantageous for individuals with swallowing difficulties. Research has suggested that ONS products formulated with higher energy density are associated with improved adherence. Therefore, there is growing interest in enhancing the energy density and nutritional composition of ONS products to deliver the necessary nutrients in the smallest prescribed volume possible. For instance, enriching ONS products with macronutrients (such as fats, proteins, or carbohydrates), micronutrients (including vitamins and minerals), or bioactive compounds (such as polyphenols or carotenoids) can help meet patients' nutritional needs more effectively. However, the recommended dietary allowance for micronutrients should not be exceeded through the consumption of ONS (31).

Children's energy requirements vary depending on factors such as age, breastfeeding status, and gender. For instance, breastfed babies aged 6-24 months have slightly lower energy needs compared to non-breastfed babies, typically around 4-5% less. These updated estimates represent a decrease of approximately 5-18% compared to previous figures published by the World Health Organization (WHO) in 1998 when considering age and about 5-13% lower when considering body weight. These adjustments reflect a more refined understanding of children's energy needs and underscore the importance of tailored nutrition recommendations for optimal growth and development (17). They are also about 20% less than the recommendations of FAO/WHO/UNU in 1985. The new required energy for ages 6 to 8, 9 to 11, and 12 to 24 months is 615, 686, and 894 kcal per day, respectively (

Table 1). The average energy intake from human milk varies by age group in developing countries. Infants 6 to 8 months old consume an average of 413kcal, while 9 to 11-month-olds consume 379kcal, and 12 to 23-month-olds consume 346kcal. Consequently, the energy required from supplementary food for these age groups is estimated at 202, 307, and 548kcal, respectively. Alternatively, following the suggestions of Davy and Brown, the recommended energy requirements are proposed as 200kcal for infants aged 6 to 8 months, 300 kcal for infants aged 9 to 11 months, and 550kcal for toddlers aged 12 to 23 months. Based on these revised energy requirements and assuming an energy density of 440 kcal per 100 g of dry product, the recommended daily rations correspond to 87%, 57%, and 48% of the energy requirements of infants aged 6 to 8 months, 9 to 11 months, and 12 to 23 months, respectively, from complementary foods. These revised guidelines aim to provide appropriate nutrition to support optimal growth and development in young children within these age groups (36). According to a study published in the National Center for Biotechnology Information (NCBI), low-volume pediatric oral nutritional supplements (ONS) with energy (2.4kcal/mL) can improve total nutrient intake and growth in pediatric patients with a need to increase nutrition (37).

Table 1. Energy intake from nutritional supplements based on longitudinal studies of U.S. Children (38)

age category	total energy required (kcal)	Energy received from milk (kcal)	Energy required from complementary foods (kcal)
6-8 months	615	413	202
9-11 months	686	379	307
12-23 months	894	346	548

Food Needs

The Amount of Protein

Proteins serve as vital building blocks for cells and are integral to the structure and function of the body. The amino acids in proteins serve as precursors to essential molecules, such as hormones and vitamins. Consequently, maintaining an adequate intake of dietary

protein is crucial for preserving cellular integrity, promoting overall health, and facilitating reproductive processes (38).

Diverse amino acid chains comprise proteins, which each adopt specific three-dimensional structures based on their sequences and lengths. Dietary protein serves as a source of amino acids essential for synthesizing body proteins and producing vital compounds like glutathione, creatine, and hormones. Amino acids are also integral to one-carbon metabolism, facilitating the generation of methyl groups and exerting influence over cellular processes, including gene expression, through mechanisms such as DNA and histone methylation (39). Children have an increased dietary requirement for protein to facilitate the growth of new tissues. Proteins are composed of amino acids, which are categorized as essential and non-essential. Unlike non-essential amino acids, essential amino acids cannot be produced by the body and must be obtained from food sources. This distinction underscores the importance of ensuring sufficient intake of essential amino acids through diet, particularly during periods of rapid growth and development in childhood (40).

Proteins derived from animal sources are generally more effective than those derived from plants. Animal sources such as meat, poultry, fish, eggs, dairy products, cheese, and yogurt provide all nine essential amino acids required by the body. On the contrary, plant-based proteins found in legumes, grains, nuts, seeds, and vegetables may lack one or more essential amino acids. For instance, cereal grains are deficient in lysine, while legumes lack methionine. A sufficient intake of "high-quality" protein is therefore recommended to support a child's growth. Animal proteins also boast higher digestibility compared to plant proteins, which aids in preventing protein-energy malnutrition. Achieving optimal nutrition entails striking a balance between protein and non-protein energy derived from carbohydrates and fats. Similarly, when amino acids are not present in the proper balance, it can impair the body's ability to utilize protein effectively. Thus, prioritizing a diverse diet that incorporates a variety of protein sources can help meet nutritional needs and promote optimal growth and development in children (38, 41, 42).

The protein content in food supplements for children may vary depending on factors such as age, weight, and specific nutritional requirements. However, according to the Dietary Reference Intakes for Protein, children aged 4 to 13 years typically require around 0.95 grams of protein per kilogram of body weight per day. For adolescents aged 14 to 18 years, the recommended protein intake is slightly lower, at approximately 0.85 grams per kilogram of body weight per day. These guidelines provide a framework for ensuring adequate protein intake to support growth and development during childhood and adolescence (43). For children aged 1 to 3 years, the suggested daily protein intake is approximately 1.08 grams per kilogram of body weight, translating to roughly 14 grams of protein per day. However, factors like age, weight, and activity level influence the protein requirement for children. Protein plays a fundamental role in growth and development, and ensuring adequate intake is vital to support muscle growth and overall developmental milestones in children. Parents and caregivers can contribute to promoting optimal health and well-being during the crucial early years of childhood by meeting recommended protein intake levels (44, 45).

The requirements for maintaining body protein balance and the optimal pattern of individual essential amino acids change little between the ages of 6 and 24 months (37). The assessment of dietary needs for complete protein suggests that maintaining a minimum protein-to-energy ratio of 6% in complementary foods is advantageous. The calculations reveal that sulfur-containing amino acids, such as cysteine and methionine, can be met by specific protein sources. For instance, providing approximately -0.18 to 0.48 grams of cow's milk protein or soy protein per kilogram of body weight per day can fulfill this need. Additionally, offering between 0.65 to 0.79 grams of cereal protein per kilogram of body weight per day can sufficiently supply the necessary amount of lysine. These calculations underscore the importance of selecting diverse protein sources to ensure comprehensive amino acid intake, contributing to overall nutritional adequacy in complementary feeding for infants and young children (36).

Amount of Fat

The incorporation of fat into ONS provides essential calories and delivers vital fatty acids. Fat stands as the primary energy source for infants and young children, with omega-6 and

omega-3 fatty acids playing pivotal roles in their normal growth and development. Moreover, fat enhances the taste and texture of food, influencing overall dietary acceptability. Furthermore, fatty acids affect gene expression and regulate transcription factors, regulating multiple genes and contributing calories. There are many functions dietary lipids fulfill within the body, including structural support for organs like the brain and retina, formation of cell membranes, and facilitation of lipid transport, which constitute the body's principal energy reservoir in the form of adipose tissue. Essential fatty acids are imperative for maintaining optimal fatty acid composition across all tissues and for the synthesis of eicosanoids and docosanoids, which are critical for various physiological processes (39).

Triglycerides, comprising three fatty acid molecules esterified to a single glycerol unit, constitute the predominant fraction of dietary fat. Additionally, dietary fats encompass phospholipids, free fatty acids, monoglycerides, and diglycerides, along with minor quantities of sterols and other non-consumable compounds. Natural fatty acids exhibit varying carbon chain lengths, ranging from 4 to 26 atoms, and can be categorized as saturated (lacking double bonds in the carbon chain), monounsaturated (possessing one double bond), or polyunsaturated (38).

Saturated fats are abundant in various food sources like whole milk, cream, butter, cheese, animal fats, coconut oil, and palm oil. Omega-9 fatty acids, which can be internally synthesized by the body, lack independent health benefits. Foods rich in monounsaturated fatty acids include canola oil, olive oil, high-oleic sunflower oil, high-oleic safflower oil, and animal-derived products, particularly meat fat. Approximately 50% of unsaturated fatty acids in the diet stem from animal products. Among the omega-3 fatty acids, alpha-linolenic acid is the only one that the body cannot produce on its own, making dietary intake necessary. Omega-3 fatty acids serve pivotal roles as structural components of cell membranes, especially in nerve tissue and the retina. Furthermore, omega-6 fatty acids compete with omega-3 fatty acids for enzymatic synthesis, thereby affecting the equilibrium of omega-3 and omega-6 eicosanoids. Foods abundant in omega-6 polyunsaturated fatty acids encompass nuts, seeds, and vegetable oils like sunflower, safflower, corn, and soybean oils. Linseed oil, rapeseed oil, and soybean oil exhibit substantial quantities of linolenic acid. Fatty fish, fish oil, and fish oil-enriched products serve as notable sources of longer-chain omega-3 fatty acids (24).

The composition of dietary fats could significantly influence infant growth and long-term health outcomes. Complementary foods for infants and toddlers typically have low-fat content, often relying on cereal sources. Generally, the recommended fat intake in complementary foods for infants aged 6 to 11 months varies from 0 to 24% of energy intake (for 30% of energy as lipids) or from 0 to 43% (for 45% of energy). Meanwhile, the suggested fat intake in complementary foods for children aged 12 to 23 months ranges from 0 to 28% (for 30% of energy as lipids) or from 34 to 44% (for 45% of energy). These ranges are influenced by human milk intake since it is a rich source of fat for both age groups. The total diet should provide infants with at least 3 to 4.5% of total energy from linoleic acid to fulfill essential fatty acid needs. In comparison, the intake of linolenic and other fatty acids (n-6) should be restricted to approximately 10% of energy, and total polyunsaturated fatty acid (PUFA) intake should be limited to about 15% of energy. The ratio of (n-6) to (n-3) fatty acids is ideally between 5:1 to 10:1, mirroring the proportions found in human milk (36).

Table 2. % of energy from dietary supplements received as fat in each age group and level of human milk intake

Percentage of energy intake from fat	Level of energy intake from human milk	age category 6-8 months	9-11 months	12-23 months
30	Low	19	24	28
	medium	0	5	17
	Much	0	0	0
45	Low	42	43	44
	medium	34	38	42
	Much	0	7	34

Nutritional supplements for children should align with recommended dietary guidelines concerning fat content. As per the American Heart Association, the total fat intake should fall between 30 and 35% of total calories for children aged 2 to 3 years and between 25 and 35% for children and adolescents aged 4 to 18 years. The acceptable macronutrient distribution range for fat for children aged 4 to 8 years is 25 to 35% of total calories. Thus, the fat content in these supplements should be within these specified ranges to ensure they contribute to a balanced diet for children (46, 47).

Amount of Carbohydrates

Nutritional supplements incorporate carbohydrates as a crucial component, available in various forms such as monosaccharides (like glucose and fructose), disaccharides (including lactose, sucrose, and maltose), and complex carbohydrates (such as starch). Dietary carbohydrates are classified according to their digestibility by salivary, stomach, or intestinal enzymes. Digestible and absorbable carbohydrates encompass monosaccharides (e.g., glucose and fructose), disaccharides (like lactose, sucrose, and maltose), and vegetable starch. In contrast, dietary fibers derived from grains, vegetables, fruits, and fructooligosaccharides such as inulin are considered non-digestible (39).

Carbohydrates serve as a crucial source of energy and play a role in sparing the metabolism of proteins and fats for energy production. In addition, carbohydrates are predominantly present in the diet in the form of sugars and starches. Besides providing energy, carbohydrates offer various potential benefits, including reducing cholesterol levels, enhancing calcium absorption, serving as a source of short-chain fatty acids in the colon, and increasing stool volume. Carbohydrates are generally well tolerated by the digestive system and typically have no adverse effects. Glucose, a type of carbohydrate, acts as a rapid energy source and is the primary carbohydrate circulating in the bloodstream and plays a pivotal role as the main fuel for brain function and fetal development. In response to metabolic stress, the production and availability of glucose are prioritized, particularly in children (48, 49). Carbohydrates should make up 45 to 65% of daily caloric intake in a typical diet. The main sources of carbohydrates are sugars and starches (40).

All kinds of Nutritional Supplements

Presently, four primary categories of ONS products are accessible: fruit juice-based, milk-based beverages, yogurt-based, and those derived from non-fat dry milk. These supplements are offered in both unflavored and flavored varieties, with a range of sweet options like vanilla, coffee, and chocolate, fruity flavors such as raspberry, strawberry, apple, peach, and kiwi, as well as savory options like tomato (31). Complementary foods are formulated to address the nutritional requirements of malnourished children and are available in various forms, such as ready-to-use liquids or powders. A potential approach involves decreasing the volume of ONS to enhance nutrient intake in children experiencing stunted growth while increasing their energy and nutrient density. This strategy may prove beneficial for underweight children and adolescents who are sensitive to volume or have reduced appetite (14).

High-protein Oral Nutritional Supplements

Malnutrition poses significant challenges, leading to prolonged recovery periods, heightened complications, and increased hospitalizations with extended stays. Given that insufficient dietary intake is a primary contributor to malnutrition, various authorities advocate for dietary improvements through interventions like dietary counseling, ONS (ONS), and artificial nutritional support. These interventions target energy and protein intake, recognizing the widespread inadequacy of protein consumption, particularly among older individuals, and the diminished appetite and protein intake observed in patients with disease-related malnutrition. Adequate protein intake is crucial for mitigating protein loss, promoting tissue repair, and supporting overall bodily regeneration. Consequently, there is a call for a modest protein boost in diets, achieved through methods like food fortification, protein supplements, or readily available protein-rich ONS. While the clinical efficacy of dietary interventions may lack robust evidence, systematic reviews and meta-analyses consistently demonstrate positive clinical outcomes associated with high-protein ONS usage (6).

A high-protein ONS was designed to provide a concentrated source of protein and essential nutrients for people who may have difficulty getting enough nutrients through regular food

consumption. These supplements can be used in a variety of situations, such as during illness, surgery, or periods of reduced food intake (50). Protein sources in dietary supplements encompass dairy options like casein or whey, as well as soy or pea protein. Aside from protein, these supplements can provide calories, vitamins, minerals, and sometimes additional fiber, omega-3 fats, prebiotics, and probiotics. High-protein food supplements are frequently formulated to be lactose and gluten-free, catering to individuals with food allergies or intolerances. Tube feeding and oral consumption are available, offering flexibility in administration to meet the needs of patients with diverse medical conditions (6).

There are numerous nutritional strategies aimed at boosting overall energy intake and at augmenting the proportion of protein in the total energy intake for several grounds. First, a notable portion of the general population experiences inadequate protein intake in their daily diets. Moreover, patients grappling with disease-related malnutrition often exhibit reduced appetite due to a spectrum of illnesses, ranging from infectious diseases to malignancies, which further exacerbates protein inadequacy. Secondly, individuals affected by disease-related malnutrition typically lead a less active lifestyle and consume less protein-rich foods, heightening the risk of nutrient deficiencies, including protein deficiency. Protein must constitute a larger proportion of the total dietary energy to maintain consistent protein intake despite reduced energy intake. In essence, dietary composition warrants careful consideration in the context of disease-related malnutrition. Thirdly, elevated protein intake may be warranted in patients with illnesses and disabilities, such as Crohn's disease and colitis, to counteract increased protein loss and the catabolic effects of inflammatory conditions (6).

High-fat Food Supplements

A high-fat ONS is formulated to offer a dense concentration of essential fats and nutrients, particularly targeting individuals facing challenges in meeting their nutritional requirements through regular dietary intake. These supplements find application in diverse scenarios, including periods of illness, post-surgery recovery, or during phases of diminished food consumption. High-fat nutritional supplements boast a higher proportion of calories derived from fat compared to standard nutritional products. The precise fat content varies depending on the product formulation and intended usage, typically exceeding 30% of the total energy provided by these formulations (51, 52).

Fat sources in food supplements encompass a range of options, including corn, soy, sunflower, safflower, coconut, palm oil, fish oil, and various other sources. Supplements can also provide calories, vitamins, and minerals, and, in some cases, fiber, omega-3 fats, prebiotics, and probiotics in addition to fats (53, 54). High-fat food supplements are frequently formulated to be lactose and gluten-free, catering to individuals with food allergies or intolerances. Moreover, these supplements are versatile in their application and suitable for both tube feeding and oral consumption. This flexibility in administration methods ensures adaptability to various patient needs and preferences (51, 55).

High-fat oral dietary supplements can be an excellent choice for people who need extra fat and nutrients due to medical conditions or other factors that affect their ability to get enough nutrients through regular food consumption (51, 52). ONS has proven effective in stimulating appetite, boosting energy intake, and promoting weight gain, particularly in individuals facing involuntary weight loss (56).

High-fat ONS are utilized across diverse patient demographics and healthcare environments, presenting potential advantages within specific clinical scenarios. Researchers have found that high-fat ONS can improve long-term health outcomes by promoting oral meal consumption, improving nutritional status, and regulating serum metabolites to support patient recovery (52). High-fat ONS offers potential benefits for individuals dealing with malnutrition by providing a concentrated source of energy packed with essential nutrients, particularly in cases where adequate nutrient intake is challenging through regular dietary means. Studies have demonstrated the effectiveness of these supplements in boosting appetite, augmenting energy intake, and facilitating weight gain, particularly among individuals grappling with undesired weight loss (56). Moreover, high-fat ONS with an energy density exceeding 1 kcal/ml have shown promise in reducing overall intake and fostering good

compliance, particularly among malnourished patients (52).

Standard Oral Nutritional Supplements

An ONS refers to a sterile liquid, semi-solid, or powder formulation containing macronutrients and micronutrients intended for oral consumption as an adjunct to regular meals. These supplements find extensive application in both acute care and community health contexts, catering to individuals unable to fulfill their nutritional requirements solely through oral dietary intake. ONS may be recommended for short durations during acute illness or for individuals managing long-term chronic conditions (57).

The majority of individuals in need of ONS can typically benefit from standard ONS formulations (1.5-2.4kcal/ml). These standard ONS are multi-nutrient products available in liquid or semi-solid form, offering a blend of macronutrients and micronutrients. The purpose of a supplement is to make up for nutritional deficits in the diet, not to replace it completely (27). ONS plays a role in averting and addressing malnutrition, a condition arising from insufficient energy (calories) or protein intake, resulting in weakened immunity, muscle loss, and diminished quality of life (58). People who struggle with undesired weight loss benefit from them because they enhance appetite, boost energy intake, and restore body weight. Additionally, ONS offers a cost-efficient means of managing malnutrition, especially for those with a low BMI (56).

Conclusion

In conclusion, the evidence presented underscores the pivotal role of ONS in the comprehensive management of malnutrition across diverse populations and healthcare settings. As elucidated through numerous studies, ONS offers a targeted approach to addressing nutritional deficiencies, enhancing nutrient intake, and improving overall health outcomes, particularly among vulnerable groups such as older adults. The versatility of ONS formulations, encompassing various energy densities and nutrient compositions, ensures their applicability in meeting diverse dietary needs and preferences. Their accessibility, affordability, and palatability further enhance their utility as cost-effective interventions in malnutrition management. Moreover, the inclusion of essential macronutrients, including proteins, fats, and carbohydrates, in ONS formulations supports cellular integrity and energy production and addresses the multifaceted nutritional requirements of individuals with malnutrition. Furthermore, the economic analyses highlight the potential cost savings associated with ONS implementation, stemming from reduced complications, hospital readmissions, and healthcare expenditures. Overall, this review emphasized the significance of integrating ONS into comprehensive malnutrition management strategies alongside dietary modifications and nutrition education. Healthcare practitioners can effectively mitigate the adverse consequences of malnutrition by harnessing the nutritional potential of ONS, thereby promoting enhanced health and well-being for individuals across the lifespan.

Declaratations

Strengths and Limitations

Strengths

1. **Comprehensive Integration of Evidence:** The review draws on a wide range of studies, including specialized research on tube-feeding diets and hospital-based enteral nutrition, providing a well-rounded understanding of ONS in various contexts.
2. **Targeted Focus:** The study provides relevant insights that are particularly beneficial for high-risk groups, emphasizing older adults and other vulnerable populations.
3. **Holistic Approach:** The review considers the nutritional content of ONS and evaluates their physicochemical, microbial, and anti-inflammatory properties, inspired by recent studies on specialized feeding solutions.
4. **Practical Relevance:** The findings offer practical guidance for healthcare practitioners, helping them to optimize ONS use in real-world settings.

Limitations

1. **Generalizability:** The specific findings from pediatric and hospital-based settings may not be fully applicable to the broader population using ONS, potentially limiting the generalizability of the conclusions.
2. **Variability of ONS Formulations:** The wide range of ONS products on the market, each with different formulations, can make it challenging to apply the findings universally across all ONS types.

3. **Focus on Developed Settings:** The study's reliance on research from developed healthcare environments may limit its applicability in less developed regions, where resource constraints might affect the availability and efficacy of ONS.
4. **Publication Bias:** The potential for publication bias in the studies reviewed may lead to an overestimation of the benefits of ONS while underreporting potential challenges.
5. **Lack of Long-Term Data:** While the short-term benefits of ONS are well-supported, there is a need for more research on the long-term impact of ONS use, particularly in elderly populations.

Implications for Future Studies

1. **Long-Term Impact:** Future research should focus on the long-term effects of ONS use, particularly in elderly and chronically ill populations, to better understand the sustained benefits and potential risks over time.
2. **Personalized Nutrition:** There is a need for studies that explore the development of more personalized ONS formulations tailored to the specific nutritional and health needs of different population groups, including those with specific dietary restrictions or chronic conditions.
3. **Global Applicability:** Research should be expanded to include diverse healthcare settings, particularly in low-resource environments, and the efficacy and feasibility of ONS in different socioeconomic and cultural contexts should be assessed.
4. **Comparative Studies:** Future studies should conduct comparative analyses of different ONS formulations to determine which combinations of nutrients and energy densities are most effective in specific populations.
5. **Inflammatory and Microbial Properties:** Further research is required to understand the anti-inflammatory and microbial safety aspects of ONS, ensuring that formulations are both effective and safe over the long term.

Data Availability

The datasets used and/or analyzed during the current study are available from the corresponding author upon reasonable request.

Conflict of Interest

There is no conflict of interest.

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