Narrative review

Relationship between lipid-based nutritional supplements and psychomotor and anthropometric development in malnutrition

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Relación entre suplementos nutricionales basados en lípidos y el desarrollo psicomotor y antropométrico en desnutrición

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Abstract
Malnutrition affects a significant proportion of children aged six to 24 months, causing low weight and shorter height for their age, as well as a predisposition to multiple diseases. It is important because it is during these ages that the greatest changes in children's early brain development occur. When this occurs, delays in motor and language development may result, hindering children from achieving their optimal developmental outcomes. This literature review provides a summary of the evidence on the effect of lipid-based nutritional supplements. The objective was to analyze the effect of lipid-based nutritional supplements on anthropometric, motor, and language development in malnourished children between six and 24 months of age. Original articles and literature reviews in Spanish and English, published from 2019 to August 2024, were included. Databases such as Google Scholar, SciELO, HINARI, and PubMed were consulted. This review demonstrates that lipid-based nutritional supplements improve length and weight for age, as well as motor and language development scores, making them a valuable tool for addressing the described problem.

Keywords
Dietary Supplements, Child Development, Malnutrition.

Resumen
La desnutrición afecta una importante proporción de los niños en edades de seis a 24 meses, ocasiona bajo peso y menor longitud para la edad, así como predisposición a múltiples enfermedades. Presenta importancia ya que es en estas edades donde se produce el mayor cambio en el desarrollo cerebral temprano de los niños. Cuando este se afecta, se enlentece el desarrollo motor y de lenguaje, evitando que los niños alcancen su máximo potencial. Esta revisión bibliográfica ofrece un resumen sobre la evidencia del efecto de los suplementos nutricionales basados en lípidos. El objetivo fue analizar el efecto de suplementos nutricionales basados en lípidos en el desarrollo antropométrico, motor y lenguaje en niños desnutridos, entre seis a 24 meses de edad. Se incluyeron artículos originales y revisiones bibliográficas en idioma español e inglés, publicadas de 2019 hasta agosto de 2024. Se consultaron bases de datos como Google Académico, SciELO, HINARI y PubMed. Esta revisión evidencia que los suplementos nutricionales basados en lípidos incrementan la longitud y el peso para la edad, como también los puntajes del desarrollo motor y de lenguaje, esto los convierte en una herramienta útil para afrontar la problemática descrita.

Palabras clave
Suplementos Nutricionales, Desarrollo Infantil, Desnutrición.

Introduction

Child malnutrition encompasses clinical, biochemical, and anthropometric alterations of multifactorial origin, among which the following stand out: inadequate diet, presence of infections, poverty, poor sanitary conditions, and food insecurity.[i]

It manifests as low weight for height and low weight for age, affecting more than 50 million and 149 million children, respectively, which makes it a public health problem that remains prevalent because, in the long term, it can impact the development of children's learning skills and their productivity as productive adults.[ii,iii]

Malnutrition predisposes to acute diseases, mainly of respiratory and gastrointestinal origin, by compromising the immune system. In addition, there is evidence of a lack of adequate growth, as indicated by anthropometric measurements, a deficit in cognitive development, and impairment in motor and language development, primarily during the first two years of life. This is because proper functioning depends on obtaining macromolecules in the diet, such as proteins, lipids, and carbohydrates.[iv,v]

For this reason, in recent years, lipid-based nutrient supplements (LNS) have been studied, which are a fortified and individually packaged paste, generally made with a base of peanuts, cereals, vegetable oils and powdered milk, intended to supplement the diet of children from six months of age, depending on their needs and nutritional status.[vi] In addition, their formulation also includes foods based on wheat or corn, water fortified with vitamins and minerals. There are also prepared foods intended for children from six to 59 months, which are consumed in small quantities and prepared with a lipid base that provides proteins and micronutrients.[vii]

Regarding their effects, an increase in the concentration of essential fatty acids has been observed in children with malnutrition who received LNS. These acids are involved in multiple processes in the body, such as protection of the gastric mucosa, hemostasis, maintenance of endothelial function, reduction of the risk of developing allergies, and improvement of the immune system.[viii]

Furthermore, LNS also increases high-density lipoprotein (HDL) levels and their ability to scavenge excess cholesterol from tissues;[ix] in addition, LNS has been shown to decrease the prevalence of anemia and iron deficiency.[x] Additionally, improvements in growth and reduction of underweight have been observed in children aged six to 24 months.[xi]

The previously described effects enable us to highlight the role of LNS in preventing infant malnutrition, positioning it as a potential therapeutic and preventive approach to mitigate short- and long-term alterations related to infant malnutrition.[xii-xvi]

This work consists of a narrative review of original and review articles dated from January 2017 to August 2024. Google Scholar, SciELO, HINARI, and PubMed databases were consulted in Spanish and English language, the Boolean operators AND, OR, and NOT were used, and the descriptors: Child Nutrition Disorders, Child Developmental Deviations, Childhood Malnutrition, Growth Disorders, Lipid-based Nutritional Supplements were used and combined in different ways together with the Boolean operators. This review aimed to analyze the effect of lipid-based nutritional supplements on the development of anthropometry, motor skills, and language in malnourished children aged six to 24 months.

Discussion

Composition and generalities of lipid-based nutritional supplements

LNS is formulated with basic foods such as skim milk powder, peanut, soy, vitamin and mineral premix, and carbohydrates such as lactose, maltodextrin, and sucrose. Among the main energy sources are lipids, such as essential fatty acids, obtained from vegetable sources.[xv]

They are nutritional support strategies for home use aimed at populations at nutritional risk in low- and middle-income countries. They are targeted as a supplement to the daily diet to increase caloric and protein intake.[xvi]

There are currently three LNS formulations, each with a different daily portion, nutritional value, and energy content. These include: Small Quantity LNS (SQ), designed to supplement the regular diet, which provides 3 g of protein and 10 g of fat in 20 g of product; Medium Quantity LNS (LNS-MQ), traditionally used to treat moderate acute malnutrition in children, which provide 6 g of protein and 16 g of fat in 45-90 g of supplement; while Large Quantity LNS (LNS-LQ), used in the treatment of severe acute malnutrition in children, provide 15 g of protein and 28 g of fat in 180-280 g of product.[xvii]

Okronipa *et al.* reported in Mexico that even sugar-free LNS are well accepted by caregivers and children, thanks to their pleasant taste and the possibility of being consumed directly from the packaging or mixed with water or other foods.[xviii]

In other parts of the world, their acceptability is limited; however, Merrill *et al.* evidenced in Bangladesh that designing and manufacturing an LNS with locally and culturally appropriate products improves its acceptability compared to imported nutritional products.[xix]

Lipid-based nutritional supplements and anthropometric development

Anthropometry is the study of measuring the human body in terms of its dimensions, including bone, muscle, and adipose tissue[xx,xxi]. For children under two years of

age, the Ministry of Health of El Salvador recommends assessing nutritional status by weight and length for age.[xxii]

Mbabazi *et al.*, conducted a randomized, double-blind trial in children aged 12 to 59 months with growth retardation, using four formulations of LNS enriched with milk protein, permeated whey, soy protein, or maltodextrin, compared to a reference group that did not receive any supplementation. In the children who did not receive the intervention, there was no growth, and they gained body fat, unlike those who received an LNS, regardless of their formulation, who presented an increase of 0.56 cm in height, which reflects a recovery of 0.17 of the Z value of height and an increase in fat-free mass deposits.[xxiii]

In a study by Griswold *et al.*, in Sierra Leone, 2691 children aged 6-59 months with moderate acute malnutrition, defined by a Mid-upper arm circumference (MUAC) of ≥ 11.5 cm and < 12.5 cm, were studied. They were divided into four study arms: the first, a soybean blend; the second, a soybean blend with oil; the third, Super cereal Plus amylase; and the fourth arm, LNS. Anthropometric measurements were taken every 14 days. During their development, the participants gained an average of 13.1 ± 17.5 g/kg/day and an average MUAC of 0.4 ± 0.03 cm/day. Recovery, defined in the study as a MUAC ≥ 12.5 cm in 12 weeks, was achieved by 63 % of the children, with no significant difference between interventions.[xxiv]

In a longitudinal study conducted by Fazid *et al.*, in Pakistan in children aged 6-23 months, participants were divided into two arms: a treatment arm that received Ready-to-Use Supplementary Food (RUSF) and health counseling and a control arm that received counseling only. Of the 1680 children included in the study, 810 were assigned to the treatment arm, of whom 256 had low height-for-age, 72 had low weight-for-age; 870 were assigned to the control group, of whom 362 had low height-for-age, and 80 had low weight-for-age. They performed monthly follow-ups for one year, during which anthropometric measurements were taken, and counseling was provided. It was observed that in the intervened arm, the participants presented an increase in average height, from 73.4 cm to 82.1 cm (a total of 8.52 cm difference), an increase in height-for-age from -1.13 to -0.93 standard deviations (SD), and a total of 0.19 SD compared to the control arm, in which no statistically significant increase in height-for-age was observed.[xxv]

Huybregts *et al.*, conducted a longitudinal, cluster-randomized, controlled trial in 1132 children aged six to 23 months who were free of acute malnutrition at enrollment and were divided into two arms. One received the Innovative Approaches for the Prevention of Childhood Malnutrition (PROMIS) intervention plus SQ-LNS supplementation, while the other received no intervention. The intervention arm showed a 29 % reduction in the incidence of acute malnutrition, mainly between six to ten months of age, attributing the preventive effect to the consumption of SQ-LNS.[xxvi]

In 2019, Das *et al.*, conducted a systematic review of the effect of LNS in children aged six to 23 months, including 17 studies with a sample of 23 200 previously healthy or at-risk children for prevalent diseases such as malaria, diarrhea, and malnutrition at baseline. In the groups using LNS, there was evidence of a 7 % reduction in the prevalence of moderate stunting and a 15 % reduction in the prevalence of severely stunted children. In addition to improving measures such as mean arm circumference and serum hemoglobin, greater effectiveness was achieved using LNS for a longer period, recommending a minimum use of 12 months of LNS to obtain a more significant recovery of anthropometric measures.[xxvii]

A meta-analysis by Dewey *et al.*, included 14 randomized clinical trials of children between six and 24 months at risk of malnutrition from countries with low or medium economic income, where LNS was used. In the groups that used the SQ-LNS, there was evidence of a reduction in the prevalence of stunting, ranging from 9 % to 16 %, compared to children who did not receive the intervention. Additionally, a greater benefit was observed in children with a higher degree of malnutrition.[xxviii]

Khan *et al.*, evaluated the impact of LNS-MQ in 870 children aged 6-23 months at risk of stunting in Thatta and Sujawal districts of Sindh, Pakistan, divided into two groups: one receiving the intervention and the other serving as the control. The initial rates of stunting and wasting were comparable in the two groups studied. There was evidence of a reduction in the risk of stunting, especially in children under 12 months of age, by approximately 9 % and in wasted children by 22 %. This supports the recommendations of a greater benefit at ages of nutritional vulnerability.[xxix]

Dewey *et al.*, conducted a two-stage meta-analysis in 2022 that included 14 studies, which were conducted on 37 066 children aged six to 24 months at risk of undernutrition in low- and middle-income countries. In which the same participants were measured at baseline and the end

of the study; in some cases, longitudinal post-intervention follow-up was performed, ranging from six to 18 months. Those who received SQ-LNS showed reductions in the prevalence of severe wasting and stunting of 31 % and 17 %, respectively.[xxx]

According to the document "The Double Burden of Malnutrition," RUTF (Ready-to-Use Therapeutic Food) is an effective strategy for treating severe acute malnutrition, which has been shown to reduce mortality. In food-insecure contexts, LNS with lower energy density, fat, and sugar content are used to improve nutritional status, promote growth in young children, and treat moderate acute malnutrition.[xxxi]

Lipid-based nutritional supplementation and motor and language development

The brain is a heterogeneous organ composed of multiple processes, neuronal connections, neurotransmitters, and specific anatomical areas that each have different functions. Due to its high functional and structural complexity, brain development extends from birth through the first years of life, a period during which it undergoes the most significant number of changes, culminating in adulthood, when its development is considered complete.[xxxii] During the first years of life, a critical stage for neuronal plasticity, the brain requires a constant supply of nutrients to facilitate its proper development.[xxxiii] That is why malnutrition has been associated with multiple cognitive, social, and motor deficiencies during childhood development.[xxxiv]

LNS has been used in several studies conducted in low- to middle-income countries as a measure to improve motor and language development. In a study conducted in the Democratic Republic of Congo, children aged six to 18 months with malnutrition and at risk of malnutrition belonged to two geographic areas of interest to the researchers. Participants were divided into two arms according to area; one arm received intervention with the government's infant and young child feeding (IYCF) program plus an LNS, while the control arm received only the government's IYCF program without LNS. Motor and language development were assessed using the ASQ-3 tool in the Communication and Gross Motor Development modules (Ages and Stages Questionnaire, 3rd edition). The results showed that children in the treatment group scored higher in communication and motor response compared to those in the control group. In addition, LNS decreased the likelihood of motor developmental delay by 18 % and the likelihood of language developmental delay by 19 %, highlighting its preventive role in language development.[xxxv]

Not only have LNS been observed to prevent developmental delay in children at risk of malnutrition, but studies have also been conducted looking at the efficacy of LNS in acutely malnourished children. In a study by Olsen *et al.*, conducted in five hospitals in Burkina Faso, 1613 malnourished children were divided into 12 groups. Six groups received a soybean-based supplement, and six groups received an LNS. Using the Malawi development assessment tool (MDAT), which assesses four developmental domains (fine motor, gross motor, language, and social skills), it was found that at the end of the 12 weeks of intervention, children who received LNS increased their scores assessed with the tool in the language and fine motor domains.[xxxvi]

In another study conducted by Mbabazi *et al.*, in Uganda, 1950 children with low weight for height were divided into four groups, depending on the composition of the LNS administered to them, comparing those containing milk protein, soy protein, both or none of the above; it was found, through an evaluation with the MDAT tool, that all children who received the LNS, after 12 months of intervention, increased their scores in the four domains of the evaluation, with a greater increase observed in children who consumed LNS with milk protein.[xxxvii]

In addition, in a meta-analysis conducted by Prado *et al.*, in which 14 studies were evaluated from nine countries, with a total population of more than 30 000 children between six and 24 months of age, with different nutritional status (incorporating both healthy and malnourished children) who received LNS, their results in language, motor, and socio-emotional development were compared mainly using tools such as Extended Ages and Stages Questionnaire (EASQ), Developmental milestones checklist (DMC), MDAT and Kilifi Development Inventory (KDI). Increases in scores in the areas of language, social-emotional, and motor development were reported in all the studies reviewed, corresponding to each of the tests used. In addition, these increases were found to be greater in children with low height-for-age at the beginning of the interventions. Individually, the increases were more significant in those with acute malnutrition.[xxxviii]

In a 6-month follow-up study by Cornelius M *et al.*, in a northern province of South Africa in undernourished children aged 6-12 months,

a population of 750 children was divided into three study groups, one with LNS-SQ, one with LNS-SQ plus four additional nutrients (phosphorus, magnesium, potassium, and manganese) and a control group that received no intervention. Each group underwent anthropometric and psychomotor development measurements at six and 12 months of age, using the "Kilifi Developmental Inventory (KDI)" tool, which includes the assessment of skills such as movement in space, motor coordination, dynamic balance, and static balance. It was observed that, when measured at 12 months of age, children who received LNS-SQ plus four additional nutrients scored 25 % higher on the KDI than children in the control group.[xxxix]

Currently, LNS is now considered one of the most promising interventions to improve language and motor development in children with malnutrition due to its ease of administration, which leads to good adherence to indicated treatment. More research is needed to support this intervention as a primary tool to benefit children affected by this condition, exploring possible health effects.

Conclusion

The effectiveness of LNS in improving anthropometric measures such as weight-for-age and length-for-age in malnourished children has been clearly demonstrated. Regarding motor and language development, the studies reviewed indicate that children who receive LNS achieve better results on standardized tests assessing these developmental areas. Likewise, LNS is attributed with having a preventive effect against delays in motor and language development.

It is important to note that more significant improvements were observed when LNS administration was combined with interventions that promote good feeding practices—such as the IYCF program and the PROMIS strategy—along with food security and proper handwashing.

Therefore, it should be emphasized that using LNS as a standalone intervention may not produce the same benefits in development and anthropometric measures as when it is combined with the aforementioned strategies. Additionally, the formulations of lipid-based nutritional supplements can differ depending on the region where they are produced. This review considers the results of studies that used various types of lipid-based nutritional supplements, recognizing that outcomes may vary depending on the specific formulation.

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