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Omega-3 effect on Language learning below the age of Five

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Abstract

Background: Language learning is an essential part of a child's development in the early years. Substantial compromise in the child's language learning ability results in inability on the part of the children to communicate with the world and, therefore, may result in disability. Omega-3 is a fatty acid essential for a child's normal neurological development. The objective of this narrative review was to find out the role of omega-3 in early language development among children less than five years of age in light of the published scientific literature.

Methods: To identify the articles relevant to the role of omega 3 in early language development among children less than five years of age, an exhaustive literature search using PubMed and Google scholar has been used. The articles published between January 2022 and May 2022 in English, was included for this literature search.

Results: There is a scarcity of literature to give a conclusive statement about the relationship between omega-3 and language learning ability of children below the age of five years. There is some evidence of the relationship between omega-3 and other morbidities like Attention Deficit Hyperactivity Disorder (ADHD) and Autism which can compromise a child's language learning ability. In these conditions, it is not clear that giving omega-3 will improve the child's ability to learn new languages.

Conclusion: Due to the lack of relevant literature, it is important to conduct adequately powered randomized controlled trials to determine the role of omega-3 in children's language learning ability in the first five years. Additionally, researchers need to use novel research methods to use observational data for causal inference to investigate the relationship between omega-3 and language learning abilities in children below five years of age.

Keywords: Omega-3; Language; learning; child's development, Five years age.

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1. Introduction

Language learning is an essential aspect of the child's development, and toddlers learn language effortlessly as they grow [1]. Language development varies substantially, and compromised language development is an important criterion that makes the child eligible to be enrolled for special educational services [1]. Substantial compromise in language learning that interferes with daily activities and functioning, including social interactions and communication, can amount to a disability [2]. Delay in language learning is observed in around 16% of the children, and half of these children continue to have problems with language learning for an extended period [3]. It is essential to be aware of the child's language development pattern to identify any delay in language learning [4]. Language development is linked to neurological development, including myelination of language pathways [5]. Detailed clinical assessment that includes history, physical examination, and observation is required to ensure effective surveillance of children to detect red flags pertinent to language delay. It is recommended to screen children for language delay at the age of 9, 18, 24, and 30 months to ensure identification of any language learning problems so that timely intervention can be used to prevent persistent problems with language learning [6], [7].

Omega-3 is a group of fatty acids, an essential ingredient of cell members, and has recently been the focus of multiple scientific inquiries [8]. Different types of omega-3 fatty acids include docosahexaenoic acid (DHA), eicosapentaenoic acid (EPA), and alpha-linolenic acid (ALA) [9]. Omega-3 is needed to continue regular functionality at the cellular level [10]. Literature shows that rather than the absolute value of omega-3, the ratio of omega-3 to omega-6 is more important to ensure the effective continuation of different processes at the cellular level [11]. To maintain optimal functionality of neural membranes, DHA is quite important, [12] as it ensures the transfer of neural signals and maintains a hydrophobic core of the neural membranes [12]. Omega-3 is required to make important hormones during processes like inflammation, relaxation of arterial walls, and regulation of blood clotting [13]. It has also been reported to be related to important health outcomes that include fetal development, attention deficit hyperactivity disorder (ADHD), and problem-solving skills in the infant [14]–[16]. It can also influence the central nervous system's functioning [17]. Although many researchers have explored the role of omega-3 in neurological disorders, the role of omega-3 in cognitive development at an early age is a relatively new area of research. Human beings cannot make omega-3 fatty acids; therefore, it must be taken in food to ensure its continuous supply [13]. Omega-3 can be found in leafy vegetables, flaxseed oil, flax seeds, walnuts, vegetable oils, and fish [13]. Through this narrative review, we intend to

identify existing literature pertinent to the role of omega-3 in language learning among children below the age of five years..

2. Subjects and Methods

To identify the articles relevant to the role of omega 3 in early language development among children less than five years of age, an exhaustive literature search using PubMed and Google scholar has been used. The articles published between January 2022 and May 2022 in English, was included for this literature search. Considering this review's narrative nature, any article published in the specified duration, which can give us insight into the topic under discussion were included. It was because a very small number of articles have directly done work on this topic. Therefore, to retrieve the relevant literature, search terms used were "omega-3" OR "language learning," which resulted in retrieving 25,041 articles. Additionally, the bibliography of the included articles was also explored to identify articles pertinent to the specified topic. After reviewing the retrieved articles, we found the need to review 869 relevant abstracts resulting in the retrieval of 57 articles used to synthesize this narrative review.

3. Early Childhood stages of language development

Different checklists are used to track a child's development, and each of these checklists pertains to a specific domain [4]. Language development is one important domain used to monitor the child's development [4]. At each age bracket, different aspects of language development are routinely monitored during regular physical examination of the child [4]. Any deviation from the expected normal language development may indicate a cognitive or neurological disorder that requires attention. Therefore, any cognitive or neurological development problem is expected to affect the child's ability to develop language skills.

4. Role of Omega-3 in neurological development

The child's cognitive development in the early ages depends on neurological development [5]. Omega-3, especially DHA and EPA, plays a critical role in this development [18]. DHA plays a significant role in developing areas in the central nervous system like the hippocampus and cerebral cortex, which are critical for learning and memory [19]–[21]. DHA plays an essential role in neuronal processes like membrane fluidity, synaptogenesis, neurite outgrowth, neurogenesis, and neuroplasticity [22]–[26]. While performing a cognitive task, there is a need to increase the blood flow to the relevant part of the brain. DHA regulates the tone of the vessels in the relevant area of the brain to ensure the provision of requisite glucose and other nutrients, therefore facilitating cognitive activity (9). DHA also helps to transfer glucose across the blood-brain barrier (7,10). In

situations where DHA is consistently not taken in the diet, especially over an extended period and across generations, there is a chance of depleting DHA in the brain, resulting in sub-optimal cognitive functionality [18, p. 3]. Studies have shown that this deficiency can be repleted after getting DHA in diet (14). An efficient way to get the requisite DHA for neural development is the use of fish and seafood [18, p. 3]. This requirement is not met mostly among children as a survey in Australia showed that only 21% of the children consumed either fish or seafood [27]. Some diets, like the vegan diet, lack DHA [28]. From conception to early childhood, omega-3 is essential for neurocognitive development [29]. DHA is quite important for normal neurological development during the last trimester of pregnancy and during the first month of the newborn, as a lot of synaptogenesis, differentiation, neuroblast migration, and neurogenesis occur during this period [30].

5. Language learning and Omega-3

Omega-3 is related to neurological development [22]. Normal neurological development of the child in the early ages is critical for ensuring that the child gets the needed cognitive abilities. Therefore, with this background, omega-3 becomes an essential component of the regular diet that affects different learning abilities, including language learning [25]. During pregnancy, fish intake by the mother improves cognition in infants and children in the early years [31]–[34]. Another study found that eating fish by the mother during pregnancy enhanced children's language comprehension between 15 to 18 months [32]. On the other hand, one study failed to report a positive relationship between omega-3 and cognitive functions [35]. Though many studies reported a positive correlation between omega-3 intake and improved children's cognitive ability, this reported relationship was not causal [36]. Further, many of these studies did not adjust for potential confounders, and therefore, findings from these studies must be interpreted with caution [36, p. 25].

6. Omega-3 as an intervention to the mother, infant, or child

Randomized controlled trials (RCTs), which checked the effect of omega-3 given to mothers for improving child's cognitive ability, showed inconsistent results [36, p. 25]. Some RCTs found no effect of omega-3 administration on the cognitive ability of 6 to 9 months infants [37]. One study that assessed the effect of maternal intake of fish oil rich in DHA during pregnancy on language development among infants and toddlers compared to vegetable oil showed that DHA could not improve cognitive and language development [38]. These studies focused their analysis on the levels and intake of omega-3, but one important aspect which was not analyzed or assessed was the ratio of omega-3 to omega-6, which is quite important. Decreased ratio of omega-

3 to omega-6 has been advocated to have a relationship with bad cognitive outcomes and may result in problems in language learning in early childhood [36, p. 25].

Another approach was to add omega-3 to the diet of the infant or the child during the early years of development [36]. Supplementing infant's milk with DHA and AA for 2.25 months improved recognition memory and problem-solving skills compared to infants fed on milk that did not contain DHA and AA [39]. Enhanced language development was reported in one study when DHA was given to infants compared to the control formula [40]. Supplementation of fish oil in the early ages resulted in more gestures on MacArthur Communicative Development Inventory than olive oil [41]. An important finding was that DHA within red blood cells was negatively correlated with child's vocabulary and vocabulary comprehension [36, p. 25]. Due to the conflicting nature of the available literature and the fact that most of the studies were conducted by selecting a cognitive outcome, to provide conclusive evidence on pertinent to effect on omega-3 on child's language development below the age of five, there is a need to conduct an adequately powered randomized controlled trials to understand the true nature of this relationship. Alternatively, advanced statistical methods like the use of instrumental variables can be used to derive causal inferences from observational studies. Because conducting randomized controlled trials is quite expensive, working towards efficient data systems to capture the child's language learning ability and intake of omega-3 and other relevant variables can lay the foundation of drawing causal inference from observational data. In such cases, the choice of the instrumental variable is critical as the intention is to choose a variable that can almost emulate the randomization process in a randomized controlled trial.

7. Disorders that impede learning and their relationship to omega-3

Several disorders manifest in early childhood, and they impede the child's ability to learn languages. These disorders include Attention-Deficit Hyperactivity Disorder (ADHD), Autism, Depression and Schizophrenia [42, p. 28]. Additionally, it has also been reported that there is a negative correlation between mental retardation and plasma DHA level [42]. According to one study, one unit increase in the DHA reduces the odds of mental retardation by 74% [42, p. 28], [43]. Such relationships between different omega-3 variants and the specified disorders are important to understand as this relationship will be important in developing a conceptual framework explaining the relationship between omega-3 and language learning in the early years.

7.1 Attention-Deficit Hyperactivity Disorder and omega-3

Several observational studies have shown a relationship between ADHD symptoms and low

omega-3 levels [44]. Children who suffer from ADHD report having problems with learning and linguistic communication [45]. To be more specific, some of these children have difficulties in formulating sentences, disturbed ability to engage in word structuring, and problems with properly structuring the morphemes for nouns and verbs [46], [47]. These children face difficulty in comprehension and grammatical constructions that include compromised ability to give order to words, inability to recall, and problem with interpreting relative and passive clauses [46]–[48]. Apart from the issues specified, compromised ability to correctly articulate the sound and missing segments when they are repeating the words is because of affected and compromised phonological processing ability among children with ADHD [45], [47], [48]. Similarly, phonological problems in these children also translate into compromised reading ability [49]. It was found that boys having ADHD showed a deficiency of some polar lipids that include 22:6n-3, 20:5n-3, and 20:4n-6 [50]. Similarly, some erythrocyte lipids i.e., 20:4n-6 and 22:4n-6 were also deficient in these children [50]. It was further explored in some other studies that those subjects who had lower omega-3 levels had compromised learning [51]. Some studies have tried to see the effect of omega-3 administration to treat ADHD. It was shown that omega-3 with higher doses of EPA had a modest effect in treating ADHD [16]. Though the effectiveness of omega-3 is low compared to other well-known treatment options for ADHD, it has been proposed that omega-3 can be given to subjects add-on to the existing treatment because of the benign nature of omega-3 [16]. Additionally, omega-3 can also be considered when subjects or their families decline psychopharmacological treatment [16]. Another important and expected outcome will be that we may expect language learning to improve with the improvement in ADHD symptoms. Though we can make this hypothesis theoretically based on the published literature but to comment on this point conclusively, we will have to conduct randomized controlled trials on children below the age of five who have ADHD and check omega-3 as an intervention compared to treatment as usual to check improvement in language learning abilities in the specified children population.

7.2 Autism and omega-3

Autism is a condition in which the subject has pervasive impairments and severe deficits in several brain areas, including compromised communication ability [42, p. 2]. At times autistic children may have compromised structural language ability like problems with vocabulary, grammar, and phonology [52]. Additionally, delayed language development is an important early sign of autism spectrum disorder [53]. The ratio of AA to EPA may be raised in children who have autism [54], [55]. A small pilot study reported that omega-3 and omega-6 supplementation reduces

autism symptoms and, therefore, recommended conducting a large scale adequately power randomized controlled trial to test this hypothesis [56]. Another pilot study also reported that when children with Autism spectrum disorder were given omega-3 and omega-6 as compared to placebo for three months, it was found that gesture use was improved among these children, but there was no effect on word production [53]. To the best of our knowledge, one limitation of the published literature is that none of the study was designed to check the effect of omega-3 on language performance among children under the age of 5 years having autism. This presents an opportunity for future research work, although this will not be without several methodological and operational challenges. An important challenge will be to gather an adequate number of patients who have autism; therefore, such a study will require collaboration between different centers to ensure recruiting an adequate number of children to generate generalizable data.

8. Methodological Challenges for checking the effect of omega-3 on language development

There are several methodological challenges to check the effectiveness of omega-3 on language development among children less than five years of age. First, the outcome assessment, i.e., assessment of linguistic development or any pertinent problem, depends on a combination of psychological and educational skills. Therefore, such an assessment will require detailed working that includes training relevant professionals to assess the outcome by developing validated and culturally appropriate tools that have an acceptable level of validity. One way is to engage in translation, cultural adaption, and validation of a tool made in a different part of the world. If that is not possible, researchers will need to make their own tools. Similarly, a validated tool is also needed to assess the intake of omega-3 fatty acids during a randomized controlled trial [57]. There is a need to find the correlation between self-reported intake of omega-3 and plasma levels of different omega-3 variants in such validation studies [57]. Randomized controlled trials are expensive to conduct. Due to limited funding for such research, it is also important to develop methodological expertise to use observational data for causal inferences for such situations.

9. Machine Learning, omega-3, and language learning

Machine learning can potentially be used to identify specific types of omega-3 fatty acids related to adverse language-related outcomes among children. Some algorithms are used to rank the variables according to their relative importance with respect to the outcome. Additionally, these models can be engaged right from pregnancy to predict adverse language-related outcomes among newborns for possible intervention. Risk stratification of mothers based on such models will guide public health practitioners and policymakers to make interventions to prevent language

learning problems in these children using an adequate dose of omega-3 along with other indicated treatments.

To actualize any of these ideas, there is a need for large datasets integrated across multiple systems to ensure effective translation of data into evidence followed by the translation of evidence into public health intervention or policy. Though the use of machine learning algorithms to prevent language learning abnormalities among young children seems to be quite attractive, caution is required to be exercised to avoid wrong decisions because of such algorithms. Though, while coming up with a dataset, it is important to ensure the collection of generalizable data, researchers need to keep in mind that biases in the underlying data will get exaggerated when predictions are made; therefore, maximum possible effort is needed to reduce such biases.

10. Conclusion

Children's normal linguistic development at an early age is an important parameter to assess children's normal growth and development. Omega-3, an essential ingredient for some critical cellular processes, is advocated to play a role in cognitive and neurological development and, therefore, is expected to contribute to the child's normal language development. Our review showed that there is very little evidence supporting the claim that omega-3 can directly improve the child's linguistic development. With that background, literature has reported a relationship between omega-3 with conditions that compromise intellectual capacities like ADHD and Autism. There is a need for conducting adequately powered randomized controlled trials to see the effect of omega-3 on children's language learning abilities. Considering Different methodological and operational challenges in RCTs, researchers need to use observational data to draw a causal inference in this area.

11. Declarations

11.1 Conflict of Interest Statement

The authors have no conflict of interests to declare.

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12. References

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