Effects of Omega-3 for children’s health: an integrative literature review

Efeitos do Ômega-3 na saúde infantil: uma revisão integrativa da literatura

Efectos del Omega-3 para la salud infantil: una revisión integradora de la literatura

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ABSTRACT
Background: Omega-3 is a set of essential fatty acids, related to brain development and is beneficial to adult health. It is necessary to understand whether the benefits of these fatty acids extend to children because they have low omega-3 consumption, not reaching the daily recommendations established by public health dietary guidelines. The knowledge about the benefits of omega-3 for children can help to identify the necessity to increase the consumption of omega-3 by this population, encouraging the promotion of dietary interventions for child health. This integrative review aimed to gather the main scientific findings that describe the benefits of omega-3 consumption by preschool and school-age children.

Methods: The terms: “Fatty Acids, Omega-3, AND Child” were investigated in four databases: PubMed, Web of Science, Cochrane, and Virtual Health Library. Subsequently, the inclusion and exclusion criteria were applied. Results: 53 scientific articles that responded to this investigation were selected. They reported several benefits from omega-3 to children's physical, mental, and cognitive health.

Conclusion: The results highlight the importance of omega-3 for this age group's health and development, encouraging adequate consumption.

Keywords: fatty acids, health, nutrition, pediatrics.

RESUMO
Introdução: O ômega-3 é um conjunto de ácidos graxos essenciais, relacionados ao desenvolvimento do cérebro e benéficos à saúde do adulto. É necessário entender se os benefícios desses ácidos graxos se estendem às crianças por apresentarem baixo consumo de ômega-3, não atingindo as recomendações diárias estabelecidas pelas diretrizes alimentares de saúde pública. O conhecimento sobre os benefícios do ômega-3 para crianças pode ajudar a identificar a necessidade de aumentar o consumo de ômega-3 por esta população, incentivando a promoção de intervenções dietéticas para a saúde infantil. Esta revisão integrativa teve como
objetivo reunir os principais achados científicos que descrevem os benefícios do consumo de ômega-3 por crianças em idade pré-escolar e escolar. Métodos: Os termos: “Fatty Acids, Omega-3, AND Child” foram investigados em quatro bases de dados: PubMed, Web of Science, Cochrane e Biblioteca Virtual em Saúde. Posteriormente, foram aplicados os critérios de inclusão e exclusão. Resultados: foram selecionados 53 artigos científicos que responderam a esta investigação. Eles relataram vários benefícios do ômega-3 para a saúde física, mental e cognitiva das crianças. Conclusão: Os resultados destacam a importância do ômega-3 para a saúde e o desenvolvimento dessa faixa etária, incentivando o consumo adequado.

Palavras-chave: ácidos graxos, saúde, nutrição, pediatria.

RESUMEN
Antecedentes: El omega-3 es un conjunto de ácidos grasos esenciales, relacionados con el desarrollo del cerebro y beneficiosos para la salud del adulto. Es necesario comprender si los beneficios de estos ácidos grasos se extienden a los niños por tener un bajo consumo de omega-3, no llegando a las recomendaciones diarias establecidas por las guías dietéticas de salud pública. El conocimiento sobre los beneficios del omega-3 para los niños puede ayudar a identificar la necesidad de aumentar el consumo de omega-3 por parte de esta población, incentivando la promoción de intervenciones dietéticas para la salud infantil. Esta revisión integradora tuvo como objetivo recopilar los principales hallazgos científicos que describen los beneficios del consumo de omega-3 en niños en edad preescolar y escolar. Métodos: Los términos: “Ácidos grasos, Omega-3 y Niño” se investigaron en cuatro bases de datos: PubMed, Web of Science, Cochrane y Virtual Health Library. Posteriormente se aplicaron los criterios de inclusión y exclusión. Resultados: Se seleccionaron 53 artículos científicos que respondieron a esta investigación. Informaron varios beneficios del omega-3 para la salud física, mental y cognitiva de los niños. Conclusión: Los resultados resaltan la importancia de los omega-3 para la salud y el desarrollo de este grupo de edad, fomentando un consumo adecuado.

Palabras clave: ácidos grasos, salud, nutrición, pediatría.

1 INTRODUCTION

The body does not produce essential fatty acids that need to be acquired through food, as they play important roles in the body, acting on the cardiovascular, pulmonary, immune, and endocrine systems. Fish oil is the main natural food source that provides omega-3 (Grazioli et. al., 2019; Øyen et. al., 2018), also known as PUFAs (“polyunsaturated fatty acids”), which are composed of alpha-linolenic acid (ALA), stearidonic acid (SDA), Eicosatetraenoic acid (ETA), and docosahexaenoic acid (DHA) (Shahidi and Ambigaipalan, 2018). These fatty acids have anti-inflammatory properties and function as efficient regulators of biological processes (Grazioli et. al., 2019; Ricker e Haas, 2017), acting for example, in modulating the integrity of the erythrocyte membrane and lipid dosages (Khan et. al., 2022).
The DHA is important for the structure of the cerebral cortex, especially for the frontal lobe, the region responsible for executive functions and behavioral and emotional regulation. Besides that, it favors the signaling of neurotransmitter pathways, affecting, for example, the cholinergic system, which is fundamental in developing memory and learning. In turn, the ETA acts on regulating endocrine and immune systems, obtaining relevant participation in cardiovascular functions. Its deficiency may indicate inflammation and has been associated with several mental disorders, as well as impaired attention and learning ability (Grazioli et al., 2019).

In healthy adults, higher levels of DHA and ETA are associated with greater and better brain flow (Del-Río-Navarro et. al., 2019; Lee-Sarwar et. al., 2019; Trebatická et. al., 2020) and increased gray mass volume with positive effects under cognitive tasks (LEE-Sarwar et. al., 2019; Teisen et. al., 2021a). Other benefits of consumption of omega-3 by adults have been reported, among them efficiency in treatment against hypertriglyceridemia (Del-Río-Navarro et. al., 2019), improvement of immune function, reduction of risk of allergic diseases (Lee-Sarwar et. al., 2019), improvement of depressive disorder (Fidelix et al., 2024; Trebatická et al., 2020), reduction of blood pressure and heart rate (Teisen et. al., 2021a) and improvement of cardiovascular health (El Amrousy et. al., 2022; Lee, Sang et. al., 2006; VUHOLM et. al., 2019). However, according to Stark et al. (2016) (Stark et. al., 2016), low serum levels of DHA and ETA in most of the world increase the overall risk of chronic diseases.

According to Teisen et al. (2020) (Teisen et. al., 2021b), omega-3 accumulates in the brain during childhood and affects its development, influencing, for example, neuronal growth (Trebatická et. al., 2020). For Mulder et al. (2022) (Mulder et. al., 2022a) this period is of fast brain development, with increased synapses rich in omega-3 that continue throughout life. In addition, omega-3 has functional and structural importance for the development of the human brain (El Amrousy et. al., 2022; Teisen et. al., 2021a; Trebatická et. al., 2020). However, it has been reported in several countries that the consumption of omega-3 by children does not meet the daily omega-3 recommendations established by public health dietary guidelines (Al-Ghannami, S.S. et. al., 2018a; Burns et. al., 2022a; Fuentes-Albero et. al., 2019a; Vuholm et. al., 2020; Yang et. al., 2021).

Whereas omega-3 influences brain development and is beneficial for adults’ health (Øyen et. al., 2018; Yang et. al., 2021) we hypothesize that these benefits extend to the child population, which has a below-ideal omega-3 intake. Thus, this integrative review aimed to investigate and describe the possible benefits of the health of omega-3 consumption by children. This research contributes to the knowledge of health-related changes through the consumption...
of this essential fatty acid by the child public and may serve as an incentive for the application of interventions that aim to improve the intake of omega-3 by this population, either through food consumption or supplementation (Al-Ghannami, Samia S. et. al., 2019a; Al-Ghannami, S.S. et. al., 2018b; Burns et. al., 2022b; Fuentes-Albero et. al., 2019b).

2 METHODS

This review followed the methodology for integrative reviews proposed by Whittemore and Knafl (2005) (Whittemore and Knafl, 2005) composed of five steps: problem identification, literature search, data evaluation, data analysis, and presentation. We investigated databases relevant to the health field: PubMed, Web of Science, Cochrane, and Virtual Health Library (VHL). The search strategy was used in all databases and consisted of the use of the MeSH (Medical Subject Headings) terms: “Fatty Acids, Omega-3” and “Child” using the Boolean operator “AND” selecting the period from January 2018 until March 2023. Subsequently, filters of type of article were applied selecting clinical trials, controlled trials, randomized trials, and not reviews. The articles in duplicate with another database were excluded.

After this screening, the titles and abstracts were read, and the inclusion and exclusion criteria were applied. The inclusion criteria were to have the descriptors in the title or abstract, refer to the child population, and investigate the benefits of using omega-3. The exclusion criteria were not having the full text available and being research in progress or inconclusive. The articles that meet the inclusion and exclusion criteria were included in this investigation and read entirely to be discussed in this integrative review. The reading and selecting articles process was made by peers.

3 RESULTS

In total, 2459 potential articles were identified in the databases. After the automated types of manuscript filter application, 1049 publications remained for titles and abstract screening. Of these, 62 were selected and read completely. After reviewing the full text, nine articles were excluded according to exclusion criteria, leaving 53 articles that met the eligibility criteria and were included in the data extraction process. A flowchart of the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) (Page et. al., 2021) shows in detail the process of searching and selecting articles for this integrative review (Figure 1).
Table 1 shows the main characteristics of the included studies. After the data extraction process, the benefits presented by each of the articles selected to compose this integrative review are discussed below to elucidate the contributions of omega-3 to the child population.

Table 1. Description of the articles selected to compose the review.

<table>
<thead>
<tr>
<th>Authors</th>
<th>Year</th>
<th>N</th>
<th>Age of children (years old)</th>
<th>Mode of ingestion</th>
<th>Intervention groups</th>
<th>Intervention duration (weeks)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abdelhalima et al.</td>
<td>2022</td>
<td>150</td>
<td>7 to 18</td>
<td>Supplementation</td>
<td>Omega-3 + standard therapy group vs vitamin D + standard therapy group vs standard Therapy only (control group)</td>
<td>40</td>
</tr>
<tr>
<td>Al-Ghannami et al.</td>
<td>2018</td>
<td>285</td>
<td>9 and 10</td>
<td>Alimentation and supplementation</td>
<td>Fish oil vs oily fish vs control</td>
<td>12</td>
</tr>
<tr>
<td>Al-Ghannami et al.</td>
<td>2019</td>
<td>55</td>
<td>9 and 10</td>
<td>Alimentation and supplementation</td>
<td>Fish oil supplement vs grilled fish</td>
<td>12</td>
</tr>
<tr>
<td>Authors</td>
<td>Year</td>
<td>Sample Size</td>
<td>Intervention</td>
<td>Outcome</td>
<td>Study Type</td>
<td></td>
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<tr>
<td>Bahagat et al.</td>
<td>2019</td>
<td>50</td>
<td>5 to 15</td>
<td>Diarrhoeal symptoms (intervention) vs control</td>
<td>Cross-sectional</td>
<td></td>
</tr>
<tr>
<td>Bonafini et al.</td>
<td>2018</td>
<td>66</td>
<td>5 to 17</td>
<td>Diarrhoeal symptoms (intervention) vs control</td>
<td>Cross-sectional</td>
<td></td>
</tr>
<tr>
<td>Boone et al.</td>
<td>2022</td>
<td>29</td>
<td>1 to 3 Supplementation</td>
<td>Omega-3-6-9 vs Canola oil</td>
<td>Cross-sectional</td>
<td></td>
</tr>
<tr>
<td>Borasio et al.</td>
<td>2022</td>
<td>30</td>
<td>8 to 13 Supplementation</td>
<td>Developmental dyslexia vs normally reading children</td>
<td>Cross-sectional</td>
<td></td>
</tr>
<tr>
<td>Brigham et al.</td>
<td>2019</td>
<td>135</td>
<td>5 to 12</td>
<td>Base line, 12 weeks and 24 weeks</td>
<td>Cross-sectional</td>
<td></td>
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<tr>
<td>Carucci et al.</td>
<td>2022</td>
<td>160</td>
<td>6 to 12 Supplementation</td>
<td>Omega-3/6 vs placebo</td>
<td>Cross-sectional</td>
<td></td>
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<tr>
<td>Chang et al.</td>
<td>2019</td>
<td>92</td>
<td>6 to 18 Supplementation</td>
<td>High-dose eicosapentaenoic acid vs placebo</td>
<td>Cross-sectional</td>
<td></td>
</tr>
<tr>
<td>Checa-Ros et al.</td>
<td>2019</td>
<td>40</td>
<td>7 to 15 Supplementation</td>
<td>Pre and post intervention</td>
<td>Cross-sectional</td>
<td></td>
</tr>
<tr>
<td>Crippa et al.</td>
<td>2019</td>
<td>50</td>
<td>7 to 14 Supplementation</td>
<td>Docosahexaenoic acid vs placebo</td>
<td>Cross-sectional</td>
<td></td>
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<tr>
<td>De Cosmi et al.</td>
<td>2022</td>
<td>73</td>
<td>6 to 14 Supplementation</td>
<td>Omega-3 + vitamin D3 vs vitamin D3 + wheat germ oil</td>
<td>Cross-sectional</td>
<td></td>
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<tr>
<td>Del-Río-Navarro et al.</td>
<td>2019</td>
<td>130</td>
<td>10 to 16 Supplementation</td>
<td>Omega-3 vs placebo</td>
<td>Cross-sectional</td>
<td></td>
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<tr>
<td>Demmelmair et al.</td>
<td>2019</td>
<td>205</td>
<td>4 to 6 Alimentation</td>
<td>Farmed Atlantic salmon vs meat</td>
<td>Cross-sectional</td>
<td></td>
</tr>
<tr>
<td>Dosei et al.</td>
<td>2021</td>
<td>54</td>
<td>5 to 15 Supplementation</td>
<td>Omega-3 vs Placebo</td>
<td>Cross-sectional</td>
<td></td>
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<tr>
<td>Döpfner et al.</td>
<td>2021</td>
<td>40</td>
<td>3 to 6 Supplementation</td>
<td>Omega-3/Omega-6 fatty acids vs control</td>
<td>Cross-sectional</td>
<td></td>
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<tr>
<td>El Amrousy et al.</td>
<td>2022</td>
<td>60</td>
<td>6 to 11 Supplementation</td>
<td>Omega-3 + traditional treatment vs traditional treatment</td>
<td>Cross-sectional</td>
<td></td>
</tr>
<tr>
<td>Flannagan et al.</td>
<td>2020</td>
<td>636</td>
<td>1 to 16 Supplementation</td>
<td>1 year vs 16 years</td>
<td>Cross-sectional</td>
<td></td>
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<tr>
<td>Fristad et al.</td>
<td>2021</td>
<td>38</td>
<td>7 and 19 Supplementation</td>
<td>1 year vs 16 years</td>
<td>Cross-sectional</td>
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<tr>
<td>Grazioli et al.</td>
<td>2019</td>
<td>46</td>
<td>8 to 14 Supplementation</td>
<td>Attention deficit hyperactivity disorder VS typically developing</td>
<td>Cross-sectional</td>
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<tr>
<td>Izadi et al.</td>
<td>2020</td>
<td>514</td>
<td>7 to 12 Alimentation</td>
<td>Seafood</td>
<td>Cross-sectional</td>
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<tr>
<td>Jutomo et al.</td>
<td>2020</td>
<td>24</td>
<td>1 to 3 Supplementation</td>
<td>Omega-3 vs placebo</td>
<td>Cross-sectional</td>
<td></td>
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<tr>
<td>Kasemy et al.</td>
<td>2020</td>
<td>62</td>
<td>8 to 14 Supplementation</td>
<td>Patients vs control</td>
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<tr>
<td>Katrenčiková et al.</td>
<td>2020</td>
<td>58</td>
<td>11 to 17 Supplementation</td>
<td>Fish oil emulsion with omega-3 vs sunflower oil emulsion with omega-6 vs control</td>
<td>Cross-sectional</td>
<td></td>
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<tr>
<td>Keim et al.</td>
<td>2018</td>
<td>31</td>
<td>1 to 3 Supplementation</td>
<td>Omega-3-6-9 vs Canola oil</td>
<td>Cross-sectional</td>
<td></td>
</tr>
<tr>
<td>Khan et al.</td>
<td>2022</td>
<td>43</td>
<td>5 to 16 Supplementation</td>
<td>Pre and post intervention</td>
<td>Cross-sectional</td>
<td></td>
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<tr>
<td>Kozić et al.</td>
<td>2022</td>
<td>61</td>
<td>7 to 16 Supplementation</td>
<td>Asperger's syndrome / high functioning autism vs healthy siblings</td>
<td>Cross-sectional</td>
<td></td>
</tr>
<tr>
<td>Lee &amp; Lee</td>
<td>2021</td>
<td>120</td>
<td>6 to 12 Supplementation</td>
<td>Omega-3 and Korean red ginseng vs placebo</td>
<td>Cross-sectional</td>
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<tr>
<td>Lee et al.</td>
<td>2020</td>
<td>40</td>
<td>6 to 12 Supplementation</td>
<td>Omega-3 and Korean red ginseng</td>
<td>Cross-sectional</td>
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<tr>
<td>Lee-Sarwar et al.</td>
<td>2019</td>
<td>83</td>
<td>3 Supplementation</td>
<td>Food allergic vs food sensitive vs control</td>
<td>Cross-sectional</td>
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<tr>
<td>Mazahery et al.</td>
<td>2020</td>
<td>73</td>
<td>2 to 8 Supplementation</td>
<td>Omega-3 vs vitamin D vs omega-3 + vitamin D vs placebo</td>
<td>Cross-sectional</td>
<td></td>
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<tr>
<td>Mazahery et al.</td>
<td>2019</td>
<td>73</td>
<td>2 to 8 Supplementation</td>
<td>Omega-3 vs Vitamin D vs Omega-3 + Vitamin D vs Placebo</td>
<td>Cross-sectional</td>
<td></td>
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<tr>
<td>Mulder et al.</td>
<td>2022</td>
<td>285</td>
<td>5 and 6 Alimentation</td>
<td>Omega-3 vs Vitamin D vs Omega-3 + Vitamin D vs Placebo</td>
<td>Cross-sectional</td>
<td></td>
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<tr>
<td>Omar et al.</td>
<td>2019</td>
<td>49</td>
<td>10 to 16 Supplementation</td>
<td>Pre and post intervention</td>
<td>Cross-sectional</td>
<td></td>
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<tr>
<td>Oyen et al.</td>
<td>2018</td>
<td>218</td>
<td>4 to 6 Alimentation</td>
<td>Fish vs meat</td>
<td>Cross-sectional</td>
<td></td>
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<tr>
<td>Paduchová et al.</td>
<td>2021</td>
<td>78</td>
<td>13 to 16 Supplementation</td>
<td>Fish oil emulsion with omega-3 vs sunflower oil emulsion with omega-6 vs control</td>
<td>Cross-sectional</td>
<td></td>
</tr>
<tr>
<td>Papamichael et al.</td>
<td>2019</td>
<td>64</td>
<td>5 to 12 Alimentation</td>
<td>Cooked fatty fish (intervention) vs usual diet (control)</td>
<td>Cross-sectional</td>
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<tr>
<td>Petrova et al.</td>
<td>2019</td>
<td>119</td>
<td>8 to 14 Alimentation</td>
<td>Fortified milk group vs regular full milk control group</td>
<td>Cross-sectional</td>
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<tr>
<td>Rahmani et al.</td>
<td>2018</td>
<td>180</td>
<td>7 to 15 Supplementation</td>
<td>Omega-3 vs Vitamin D vs Omega-3 + Vitamin D vs Placebo</td>
<td>Cross-sectional</td>
<td></td>
</tr>
</tbody>
</table>
4 DISCUSSION

The studies included in this integrative review refer to research on the benefits of omega-3 consumption by children, which are discussed in topics: Physical Health, Mental Health, and Cognitive Performance.

4.1 PHYSICAL HEALTH

In healthy children, a diet focused on the consumption of omega-3 was associated with a reduction of BMI (body mass index) (De Cosmi et. al., 2022; Izadi et. al., 2020; Vuholm et. al., 2019), reduction of total cholesterol and LDL cholesterol (low-density lipoprotein), and increased HDL cholesterol (high-density lipoprotein) (Izadi et. al., 2020; Vuholm et. al., 2019). Besides that, omega-3 consumption from diet or supplementation enables the reduction of plasma triglycerides (Al-Ghannami, S.S. et. al., 2018a; Izadi et. al., 2020; Vuholm et. al., 2019) being a safe and effective supplementation option in the treatment of hypertriglyceridemia in obese children (Del-Río-Navarro et. al., 2019).

Still, on the relationship between obesity and omega-3 consumption, it has been reported that high omega-3 content in children can significantly reduce cardiovascular risk factors, often related to obesity (Izadi et. al., 2020) such as higher heart rate (Vuholm et. al., 2019), blood pressure (Al-Ghannami, S.S. et. al., 2018a; Bonafini et. al., 2018) and fat mass (De Cosmi et. al., 2022). Higher levels of omega-3 were shown to be relevant to preventing inflammatory
complications associated with childhood obesity (De Cosmi et al., 2022). For Flannagan et al. (2020) (Flannagan et. al., 2020) the supplementation of omega-3 was inversely associated with central adiposity, suggesting being a protective factor against it, commonly related to the development of metabolic syndrome and cardiovascular disease. And, according to See et al. (2018) (SEE et. al., 2018) children who received omega-3 supplementations have lower waist circumference and better insulin concentrations than those who did not, and these factors may influence later health.

Omega-3 supplementation is also related to the reduction of inflammatory biomarkers. This change occurs in children with depression (Paduchová et al., 2021), cancer (El Amrousy et. al., 2022), renal failure (Omar et. al., 2019) and autism spectrum disorder (Mazahery et. al., 2020). Among the beneficial changes observed in children, some biomarkers stand out like interleukin-6 and C-reactive protein, which were reduced after the supplementation (Omar et. al., 2019) and BDNF ("Brain-derived Neurotrophic factor") levels, related to neuroprotection and cell growth, which increased after the supplementation (Paduchová et. al., 2021).

In addition to these benefits, positive changes are reported about omega-3 consumption in other specific health conditions, for example, the same changes in cholesterol observed in healthy children appear in studies reporting omega-3 intakes through supplementation in children with kidney failure, with depressive symptoms (Katrenčíková et. al., 2020; Omar et. al., 2019) and with sickle cell disease, influencing directly in consequences of the disease (Abdelhalima et. al., 2022; Khan et. al., 2022). Omega-3 supplementation has also been effective in protecting against early cardiac toxicity in children with leukemia (El Amrousy et. al., 2022) and against asthma (Brigham et. al., 2019). The consumption of fish twice a week may be a potential strategy to reduce airway inflammation in childhood asthma (Papamichael et. al., 2019), this increase is associated with a lower risk of asthma incidents (Talaei et. al., 2021), being the plasma omega-3 levels inversely associated with asthma, recurrent wheezing, and predisposition to allergic reactions in children aged 3 years (Lee-Sarwar et. al., 2019).

Other studies indicate other benefits of omega-3 supplementation such as having an important role in the adequacy of treatment and quality of life of children on dialysis (Kasemy et. al., 2020), being able to improve nocturnal enuresis in children with this common complication of the urinary bladder (Rahmani et. al., 2018) and motor and sensory capacity in children with autism spectrum disorder (Mazahery et. al., 2019). Omega-3 consumption also influences the height of children with growth deficits, a problem that influences morbidity and infant mortality (Jutomo et. al., 2020).
4.2 MENTAL HEALTH

Omega-3 also has an influencing role in child mental health (Teisen et. al., 2020). Healthy children who received omega-3 supplementations improved in difficulties reported by the Strengths and Difficulties Questionnaire assessed by the parents. The results showed a reduction in the internalization of problems and a decrease in socioemotional problems (Teisen et. al., 2020). Equivalent results were found in children with problems related to behavior, the omega-3 supplementation for 12 weeks described improvements in the scores of the Strengths and Difficulties Questionnaire, with significant reductions in all subscales of the test, health, and quality of life of the participants (Rodríguez-Hernández et. al., 2020).

In individuals aged 7 to 16 years with externalization behaviors or antisocial behaviors and psychopathic personality, the use of omega-3 enabled a reduction of reactive aggression and antisocial behavior (Raine et. al., 2019, 2021). In addition to behaviors directed to emotions, several authors have shown that in children and adolescents, the consumption of omega-3 modulates and improves depressive symptoms being effective in the treatment of this disorder (Katrenčíková et. al., 2020; Paduchová et. al., 2021; Trebatická et. al., 2020). In children and adolescents suffering from depressive disorder, there was a significant reduction in scores on the scale of childhood depression after 6 and 12 weeks of supplementation (Trebatická et. al., 2020). In addition, in young people with depression or bipolar disorder, supplementation improves mood, emotional regulation skills, and family communication (Fristad et. al., 2021).

The omega-3 supplementation also improved levels of hyperactivity (Carucci et. al., 2022), internalization, and externalization (Döpfner et. al., 2021), impulsivity (San Mauro Martin et. al., 2022), psychosocial functioning, emotional (Crippa et. al., 2019) and behavioral problems (Al-Ghannami, Samia S. et. al., 2019b) in children with ADHD (attention deficit hyperactivity disorder). Even in children with just symptoms of ADHD, without a diagnosis, the supplementation improved ADHD Assessment Scale scores, as well as behaviors, including attention and hyperactivity problems (Lee, Jeewon and Lee, 2021).

Besides that, in children with autism spectrum disorder, supplementation with Omega-3 enabled the improvement of stereotyped behaviors, the severity of autism (Bernabé e colab., 2023; Doaei e colab., 2021), irritability, and social communication (Mazahery et. al., 2019) promoting clinically significant improvements in symptoms (Keim et. al., 2018). In this population, the concentrations of omega-3 were inversely correlated with the index of ADHD, inattention, and behavioral problems (Kozielec-Oracka et. al., 2022). In addition, children with only symptoms of autism have also improved in anxious behaviors, internalization, and...
interpersonal relationships when they receive supplementation of omega-3 (Boone et. al., 2022).

4.3 COGNITIVE PERFORMANCE

The consumption of omega-3 has a fundamental role in brain functions (Teisen et. al., 2020). Investigating brain activity in healthy children through a computerized test Sittiprapaporn et al. (2022) (Sittiprapaporn et. al., 2022) showed that supplementation with omega-3 promoted a consistent improvement in attention and cognitive processing capacity, changes in brain activity during working processes, and long-term memory. In turn, Grazioli et al. (2019) (Grazioli et. al., 2019) investigated in children with and without ADHD the association between serum concentrations of omega-3 and metabolism of the cerebral cortex measured by near-infrared functional spectroscopy (fNIRS). As a result, associations between changes in frontoparietal regions and fatty acid profiles have been reported, suggesting that omega-3 plays an important role in typical and atypical neurological development.

Moderate to strong correlations between plasma levels of omega-3 and reading, writing, and scores in neuropsychological tests in healthy children were found, suggesting that as higher the concentrations of omega-3, the better the cognitive performance (Borasio et. al., 2022). Corroborating with these findings, plasma levels of DHA were associated with scores in neurodevelopmental tests, including language and short-term memory (Mulder et. al., 2022b). According to Demmelmaier et al. (2019) (Demmelmaier et. al., 2019) there is an association between a diet rich in Omega-3 and cognitive performance in tests that evaluate fluid intelligence. Besides that, children who received a diet rich in omega-3 improved overall scores in cognitive performance, obtaining fewer errors in attention tasks and better cognitive flexibility (Teisen et. al., 2020). Moreover, the omega-3 supplementation provided improvement in cognitive function in younger children (from 4 to 6 years of age) (Øyen et. al., 2018) and in older children (from 8 to 14 years of age) (Petrova et. al., 2019). The increase in serum levels of DHA provided better processing speed, cognitive flexibility, and working memory performance (Petrova et. al., 2019; Teisen et. al., 2020; Yang et. al., 2021). According to Roach et al. (2021) (Roach et. al., 2021) omega-3 consumption promotes the improvement of executive functions and self-regulation. In turn, Yasseen et al. (2020) (Yasseen et. al., 2020) investigated the impact of Omega-3 consumption on speech development and showed that the supplementation group improved their language quotient significantly about the control group, who went to speech therapy. In addition, the consumption
of omega-3 also promotes cognitive improvement in children with epilepsy (Bahagat et. al., 2019) and with autism (Kozielec - Oracka et. al., 2022). Furthermore, in children with depression or bipolar disorder the consumption of omega-3 improves executive and global function (Fristad et. al., 2021) while in children with ADHD, besides improving executive function (Lee, Jeewon et. al., 2020), it also promotes memory improvement (Al-Ghannami, Samia S. et. al., 2019b; Lee, Jeewon et. al., 2020), attention (Al-Ghannami, Samia S. et. al., 2019b; Carucci et. al., 2022; CHANG et. al., 2019; Checa-Ros et. al., 2019; Crippa et. al., 2019; Döpfner et. al., 2021; Lee, Jeewon et. al., 2020) and, state of surveillance (Chang et. al., 2019).

5 FINAL CONSIDERATIONS

This integrative literature review investigated the benefits of consuming omega-3 by children. The findings reported benefits to the physical, mental, and cognitive health of children who consumed omega-3. The main benefits to physical health were improvement of the anthropometric measures, heart rate, blood pressure, insulin, cholesterol, and triglycerides levels. In addition, the reduction of inflammatory biomarkers, the increase of neurotrophin associated with neural protection and cell growth, the decrease in the risk of cardiovascular diseases, protecting against obesity and cardiovascular disease, and helping in treatments for this and other diseases, such as nocturnal enuresis and asthma, for example.

Regarding the benefits of mental health, improvements in communication, relationship, emotional regulation, behavior, hyperactivity, bipolar disorder, anxiety, and depression were related, influencing the improvement of quality of life. The benefits related to cognitive performance described improvements in executive and global function, self-regulation, surveillance, and speed of information processing. It highlighted the improvement of cognitive flexibility, working memory, language, and intelligence. In addition, improvement of brain activity and association with changes in brain metabolism.

In conclusion, the intake of omega-3 was beneficial to the health of children of different ages, and health conditions influencing positively the physical, mental, and cognitive health of this age group. The diverse benefits reported in healthy children and in children with different health problems, as well as the low consumption of omega-3 by this population and the recommendations of the authors, encourage the increase of consumption of omega-3 through diet or supplementation. The implementation of dietary interventions that include omega-3 as an important nutrient for children's health is encouraged and necessary.
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