Nutrition 31 (2015) 935–940

Contents lists available at ScienceDirect

Nutrition

journal homepage: www.nutritionjrnl.com

Applied nutritional investigation

Protective effects of dietary supplementation with natural ω-3 polyunsaturated fatty acids on the visual acuity of school-age children with lower IQ or attention-deficit hyperactivity disorder

Qiaoling Wu Ph.D. [a], Tingting Zhou M.D. [a], Liping Ma M.D. [b], Dongjuan Yuan Ph.D. [c], Yongmei Peng M.D., Ph.D. [a,*]

[a] Department of Child Health Care, Children's Hospital, Fudan University, Shanghai, China
[b] Centre for Disease Control, Yuyao, China
[c] Department of Biochemistry and Molecular Biology, Guangdong Medical College, Zhanjiang, China

ARTICLE INFO

Article history:
Received 3 March 2014
Accepted 17 December 2014

Keywords:
ω-3 polyunsaturated fatty acids
School-age children
Visual acuity
Dietary supplementation
Lower IQ
Attention-deficit hyperactivity disorder

ABSTRACT

Objective: Little attention has been paid to the possible protective role of ω-3 polyunsaturated fatty acids (PUFAs) on the visual acuity of school-age children with lower IQs or attention-deficit hyperactivity disorder (ADHD). The aim of this study was to evaluate the effect of dietary ω-3 PUFAs on the visual acuity and red blood cell (RBC) fatty acid compositions of these children.
Methods: We randomly assigned 179 children with lower IQs or ADHD to receive ordinary eggs (control group, n = 90) or eggs rich in C18:3 ω-3, eicosapentaenoic acid (EPA, 20:5 ω-3) and docosahexaenoic acid (DHA, 22:6 ω-3) for 3 mo (study group, n = 89). Before and after the intervention, distance visual acuity was tested using an E chart and the RBC fatty acid composition was determined using capillary gas chromatography.
Results: Three months later, 171 children completed the follow-up with the exception of 8 children who were unavailable during follow-up. Both groups of children showed a significant improvement in visual acuity ($P < 0.05$), however, visual acuity in the study group was significantly better than that of the control group ($P = 0.013$). The C18:3 ω-3 ($P = 0.009$), DHA ($P = 0.009$) and ∑ω-3 ($P = 0.022$) levels of the intervention group were significantly higher than those of the control group, while the C20:4 ω-6 ($P = 0.003$), C22:4 ω-6 ($P = 0.000$), ∑ω-6 ($P = 0.001$), ∑ω-6/∑ω-3 ($P = 0.000$) and arachidonic acid/DHA ($P = 0.000$) of the study group were significantly lower than those of the control group. No significant differences in the levels of C18:2 ω-6 ($P = 0.723$), C20:2 ω-6 ($P = 0.249$), C20:3 ω-6 ($P = 0.258$), C20:5 ω-3 ($P = 0.051$), or C22:5 ($P = 0.200$) were found between the two groups.
Conclusions: Dietary supplementation with ω-3 PUFAs improves both visual acuity and the RBC fatty acid profile in school-age children with lower IQs or ADHD.

Introduction

The ω-3 polyunsaturated fatty acids (PUFAs), especially eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA), mediate a wide variety of functions in the body. There have been numerous studies demonstrating that ω-3 PUFAs play important roles in many aspects of health, such as cardiovascular diseases [1], inflammatory responses [2], neurodevelopmental conditions, [3] and visual function [4]. DHA is the principal ω-3 fatty acid in the brain and retina, comprising 40% of the PUFAs in the brain and 60% of the PUFAs in the retina [5]. EPA, which plays a

This study was supported by the National Natural Science Foundation of China (grant no. 30972475). QLW was responsible for statistical analysis, drafting and editing of the manuscript. TTZ was involved in the participant recruitment and data collection. LPM was involved in the participant recruitment. DJY performed fatty acid analysis. YMP designed and supervised the study. All authors read and approved the final manuscript. The authors have no conflicts of interest to declare.
* Corresponding author. Tel.: +86 021 64931229; fax: +86 021 64043900.
E-mail address: ympeng@fudan.edu.cn (Y. Peng).

http://dx.doi.org/10.1016/j.nut.2014.12.026
0899-9007/

more minor structural role but is essential for normal brain function, was found in trace amounts in the brain and the majority of other tissues [6]. Moreover, ω-3 PUFAs and their derivatives help to regulate blood flow, neurotransmitter uptake, synaptic transmission, apoptosis, gene expression, ion channels, and immune functions during their biological processes [7]. However, the importance of dietary ω-3 PUFAs in contributing to human vision development remains poorly understood, which is partly related to the complexity of fatty acid metabolism and the incomplete knowledge of the pathways of transfer and fatty acid uptake in the retina.

Many authors have reported that approximately 10% to 20% of school-age children in developing countries have various vision problems [8–12]. Vision problems adversely affect children's learning through both direct and indirect mechanisms, including compromising sensory perception, hampering cognition, and negatively affecting socioemotional development and connectedness to school [13]. As children progress in school, their vision may deteriorate due to increasing class work and homework. They may become nearsighted, farsighted, or they may develop astigmatism, which may significantly affect visual acuity. The study and development of a feasible and efficient vision intervention is of great importance to promote children's visual acuity.

During the past decades, a growing body of research has revealed that ω-3 PUFAs are closely related to the visual function development in infants [4,14–18]. However, reports on the studies of ω-3 PUFAs and the visual acuity of school-age children are scarce. In the past several years, our research group studied the effects of ω-3 PUFAs on lipid metabolism and function improvement in children with lower IQs or attention-deficit hyperactivity disorder (ADHD). Because ω-3 PUFAs were highly concentrated in both the retina and brain, when we studied the effects of ω-3 PUFAs on children with ADHD or lower IQs, we also wanted to know whether ω-3 PUFAs plays any role in improving the visual acuity of school-age children in these clinical groups. Moreover, it is of interest to explore the roles of ω-3 PUFAs in the visual acuity of children, which is closely related to the integrity of the retina. Therefore, before and after supplementation with ω-3 PUFAs, we tested the visual acuity of the school-age children with lower IQs or ADHD, and found that ω-3 PUFAs seemed to play a valuable role in improving the visual function of such children. We then conducted a detailed analysis of visual acuity to examine the effects of ω-3 PUFAs on visual acuity in children with lower IQs or ADHD. We also analyzed the fatty acid composition of red blood cell (RBC) membranes to evaluate any improvement in the fatty acid profiles of these children. The findings should provide valuable information about the use of natural dietary ω-3 PUFAs to improve the visual acuity and fatty acid profiles of this age group. To avoid the side effects of drugs or chemically synthesized PUFAs tablets [19], a healthy and natural ω-3 PUFA dietary supplement was used in this study.

Participants and methods

Study participants

The study population included 179 children ages 7 to 12 y, of whom 88 had lower IQs (<90) and 91 had ADHD. The children were screened from 1556 students in two township primary schools of Zhejiang Province, China. All the students were tested to obtain their IQ scores and to diagnose ADHD (Fig. 1).

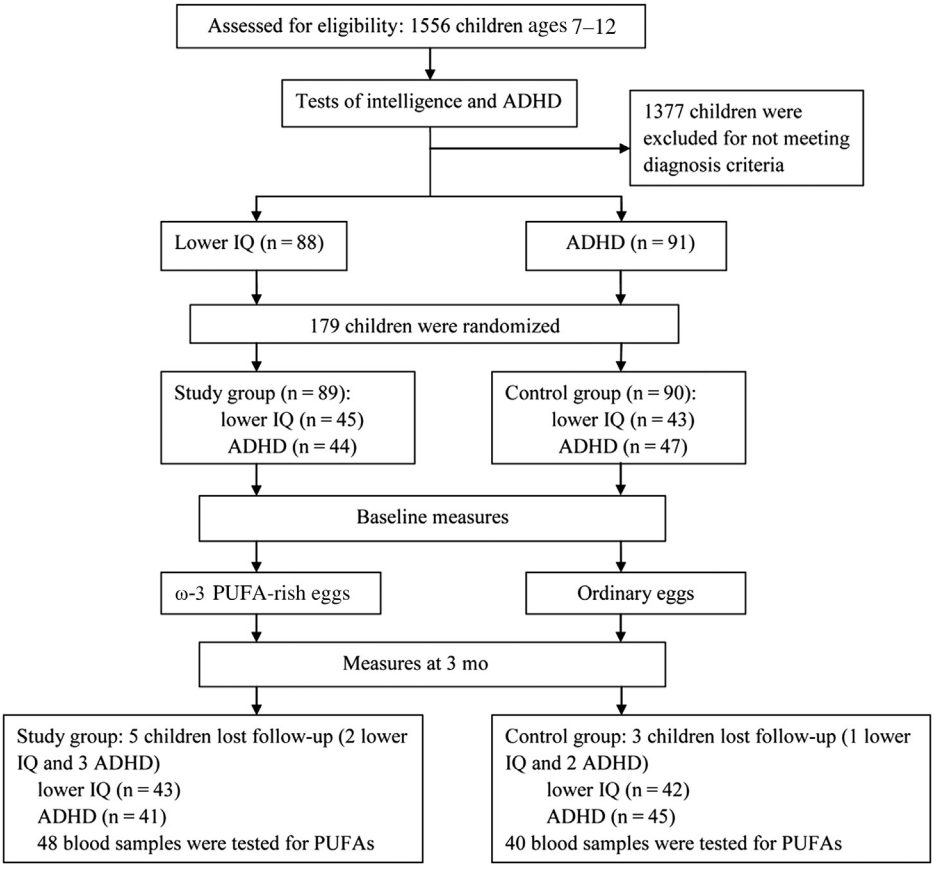

Fig. 1. Participant and group characteristics. We screened 1556 school-age children; 88 lower IQ children and 91 ADHD children were enrolled; however, due to loss to follow-up, only 171 children finished the trial. ADHD, attention-deficit hyperactivity disorder; PIFA, polyunsaturated fatty acid.