# SUPPLEMENTATION EFFECT OF OMEGA-3 FATTY ACIDS IN OVERWEIGHT AND OBESE MEXICAN SCHOOLCHILDREN

Marcela Rosas-Nexticapa, Diana Alejandra Caballero-Rodríguez, Socorro Herrera-Meza,
Héctor-Gabriel Acosta-Mesa, Isela Santiago-Roque, Lauro Figueroa-Valverde, Elodia García-Cervera,
Eduardo Pool-Gómez, Catalina Cervantes-Ortega and Virginia Mateu-Armand

## *SUMMARY*

*Overweight and obesity are considered global health problems. In Mexico, the prevalence of overweight and obesity among children is growing. Specifically, Veracruz is the Mexican state with the highest rates of childhood overweight and obesity. The present study focuses on evaluating the effect of omega-3 fatty acids (ω-3) supplements in overweight and obese schoolchildren living in Xalapa, Veracruz, Mexico. A total of 121 children, aged 10-12 years, were recruited from five public elementary schools from Xalapa city. The schoolchildren were diagnosed as being overweight or obese and divided into four groups in order to be daily supplemented with 2 or 3 gummies (70 or 105mg of DHA) and 10 or 15g of salmon per day. Supplementation was carried out for three months. Anthropometric measurements (weight, height, BMI, waist-hip ratio) were taken, and serum parameters such as glucose, triglycerides, cholesterol, HDL, VLDL and LDL were determined. The results showed no significant differences in body weight, height, BMI, waist-hip ratio and fat percentage after supplementation. In glucose, percentage change in all supplementations demonstrated no statistical difference. Cardiovascular risk biomarkers decreased: serum CHO, LDL, VLDL, TG and AI, while serum HDL increased. Supplementation of ω-3 fatty acids in children had a beneficial effect on dyslipidemia and, thus, would reduce the expectation of developing cardiovascular diseases.*

## Introduction

Overweight and obesity are considered global health problems (García-Solís *et al*., 2016). According to the National Health and Nutrition Survey (ENSANUT, 2012), in Mexico the prevalence of overweight and obesity in schoolchildren (5-11 years) was 19.8 and 34.4% respectively, of which 36.9% were boys and 32% were girls. Moreover, the report indicates that Veracruz is the state in Mexico with the highest rate of overweight (19.8%) and obesity (14.6%) among children.

Obesity is the main risk factor for developing cardiovascular disease, hypercholesterolemia, hypertriglyceridemia, insulin resistance and type 2 diabetes mellitus, as well as hypertension, arteriosclerosis and premature death from ischemic heart disease (Pajuelo *et al*. 2003; Durá-Travé and Sánchez-Valverde, 2005).

Current sedentary lifestyles, nutritionally-deficient fast-food diets, obesity and genetic factors lead to high cholesterol and other risk factors which are related to heart diseases and affect the coronary arteries (Carretero *et al*. 2005; Valdés and Gómez, 2006). If these health problems are not treated, damage will continue into adult live. As a result of this situation, it is necessary to implement measures in order to improve the health of children in Mexico, not only by changing eating habits and promoting physical activity, but also through feeding supplementation to help decrease the effects caused by overweight and obesity among children.

The consumption of polyunsaturated fatty acids plays an important role in human health (Portillo-Reyes *et al*. 2014). It is well established that omega-3 (ω-3) fatty acid supplementation improves blood lipid concentrations (Pirillo and Catapano, 2013; Escobar *et al*. 2013), decreases serum cholesterol, VLDL (very low density

**KEYWORDS / Children / Obesity / Omega-3 / Overweight / Schoolchildren / Supplemented /**
Received: 04/07/2016. Modified: 09/10/2017. Accepted: 10/11/2017.

**Marcela Rosas-Nexticapa**. Biologic Pharmaceutical Chemist, Universidad Veracruzana (UV), Mexico. M.Sc. and Doctor in Food Science, Veracruz Institute of Technology (ITVer), Mexico. Professor, UV, Mexico. Address: Facultad de Nutrición, UV. Médicos y Odontólogos s/n, Col. Unidad del Bosque, C.P. 91010 Xalapa, Veracruz. México. e-mail: mrosas@uv.mx

**Diana Alejandra Caballero-Rodríguez**. M.Sc. in Nutrition and Food Security, UV, Mexico.

**Socorro Herrera-Meza**. Nutritionist and M.Sc. in Food Science, UV, Mexico. Doctor in Food Science, ITVer, Mexico. Professor, UV, Mexico.

**Héctor-Gabriel Acosta-Mesa**. Computer Systems Engineer, ITVer, Mexico. M.Sc. in Artificial Intelligence, UV, Mexico. Doctor in Artificial Intelligence, University of Sheffield, UK. Research Professor, UV, Mexico.

**Isela Santiago-Roque**. Master in Clinical Pharmacy, Universidad de La Habana, Cuba. Lecturer, UV, Mexico.

**Lauro Figueroa-Valverde**. M.Sc. in Molecular Pharmacology, Instituto Politécnico Nacional, Mexico. Doctor in Biological Sciences, Universidad Autónoma Metropolitana, Mexico. Research Professor, Universidad Autónoma de Campeche (UACam), Mexico.

**Elodia García-Cervera**. M.Sc. in Food Science Technology, Universidad Autónoma de Yucatán (UADY), Mexico. Lecturer, UACam, Mexico.

**Eduardo Pool-Gómez**. M.Sc. in Biochemical Engineering, ITM, Instituto Tecnológico de Mérida, Mexico. Lecturer, UACam, Mexico.

**Catalina Cervantes-Ortega**. Nutritionist and Master in Health Systems Administration, UV, Mexico. Doctor in Government and Public Administration, Escuela Libre de Ciencias Políticas y Administración Pública de Oriente, Mexico. Lecturer, UV, Mexico.

**Virginia Mateu-Armand**. Nutritionist and Master in Clinical Research, UV, Mexico. Lecturer, UV, Mexico.

## EFECTO DE LA SUPLEMENTACIÓN CON ÁCIDOS GRASOS OMEGA-3 EN ESCOLARES CON SOBREPESO Y OBESIDAD

Marcela Rosas-Nexticapa, Diana Alejandra Caballero-Rodríguez, Socorro Herrera-Meza, Héctor-Gabriel Acosta-Mesa,
Isela Santiago-Roque, Lauro Figueroa-Valverde, Elodia García-Cervera, Eduardo Pool-Gómez, Catalina Cervantes-Ortega
y Virginia Mateu-Armand

### *RESUMEN*

*El sobrepeso y la obesidad son considerados como problemas de salud mundial. En México la prevalencia de obesidad infantil va en aumento. Específicamente el Estado de Veracruz ocupa el primer lugar con sobrespeso y obesidad infantil. El objetivo del presente estudio fue evaluar el effecto de la suplementación con ácidos grasos omega-3 (ω-3) en niños escolares con sobrepeso y obesidad, en la ciudad de Xalapa, Veracruz, México. Se evaluaron un total de 121 niños de 10 a 12 años, los cuales fueron reclutados de cinco escuelas primarias públicas de la ciudad de Xalapa. En un inicio, los niños fueron diagnosticados con sobrepeso u obesidad y divididos en cuatro grupos, para ser suplementados diariamente con 2 o 3 gomitas (70 o 105mg de DHA); o con 10 o 15g de salmon. La suplementación se llevó a cabo durante tres meses. Se tomaron medidas antropométricas (peso, talla, IMC, índice cintura-cadera) y parámetros sanguíneos de glucosa, triglicéridos, colesterol, HDL, VLDL y LDL. Los resultados indican que después de la suplementación no existen diferencias significativas en peso, talla, IMC, índice cintura-cadera y porcentaje de grasa. Los biomarcadores de riesgo cardiovascular: CHO, LDL, VLDL, TG e IA disminuyeron; mientras hubo un incremento de HDL en sangre. En conclusión, la suplementación en niños con ácidos grasos ω-3 tuvo en efecto benéfico en la dislipidemia y por ello reduciría la espectativa desarrollar enfermedades cardiovasculares.*

## EFEITO DA SUPPLEMENTAÇÃO COM ÁCIDOS GRAXOS ÔMEGA-3 EM ESCOLARES COM SOBREPESO E OBESIDADE

Marcela Rosas-Nexticapa, Diana Alejandra Caballero-Rodríguez, Socorro Herrera-Meza, Héctor-Gabriel Acosta-Mesa,
Isela Santiago-Roque, Lauro Figueroa-Valverde, Elodia García-Cervera, Eduardo Pool-Gómez, Catalina Cervantes-Ortega
e Virginia Mateu-Armand

### *RESUMO*

*O sobrepeso e a obesidade são considerados como problemas de saúde mundial. No México a prevalência de obesidade infantil vai em aumento. Especificamente o Estado de Veracruz ocupa o primeiro lugar com sobrepeso e obesidade infantil. O objetivo do presente estudo foi avaliar o efeito da suplementação com ácidos graxos ômega-3 (ω-3) em crianças escolares com sobrepeso e obesidade, na cidade de Xalapa, Veracruz, México. Avaliaram-se um total de 121 crianças de 10 a 12 anos, as quais foram recrutadas de cinco escolas primárias públicas da cidade de Xalapa. No começo, as crianças foram diagnosticadas com sobrepeso e/u obesidade e divididos em quatro grupos, a serem suplementados diariamente com 2 ou 3 gominhas (70 o 105mg de DHA); ou com 10 ou 15g de salmão. A suplementação foi realizada durante três meses. Colheram-se medidas antropométricas (peso, tamanho, IMC, índice cintura-quadril) e parâmetros sanguíneos de glicose, triglicerídeos, colesterol, HDL, VLDL e LDL. Os resultados indicam que depois da suplementação não existem diferenças significativas em peso, tamanho, IMC, índice cintura-quadril e porcentagem de gordura. Os biomarcadores de risco cardiovascular: CHO, LDL, VLDL, TG e IA diminuíram; enquanto houve um incremento de HDL no sangue. Em conclusão, a suplementação em crianças com ácidos graxos ω-3 teve um efeito benéfico na dislipidemia e por isso reduziria a expectativa de desenvolver doenças cardiovasculares.*

lipoprotein), triglycerides and the risk of cardiovascular disease (Coronado-Herrera *et al*. 2006; Hartweg *et al*. 2009; Pirillo and Catapano, 2013). In contrast, the effect of ω-3 on serum HDL-cholesterol (high density lipoprotein) remains ambiguous and controversial; while some reports indicate that it increases HDL (Hill *et al*. 2007; Pirillo and Catapano, 2013; Singh *et al*. 2015;), others have indicated that ω-3 supplementation does not increase HDL (Zhang *et al*. 2015; Young *et al*. 2017). Concerning body weight, a number of studies, both in animal and humans, have shown that ω-3 supplementation may not significantly reduce body weight (Buckley and Howe, 2010; Martínez-Victoria and Dolores-Yago, 2012; Du *et al*. 2015; Zhang *et al*. 2015). However, other authors have found a reduction in body weight if supplementation is combined with exercise and diet (Hill *et al*. 2007; Buckley and Howe, 2010; Noreen *et al*. 2010; López-Alarcón *et al*. 2011; Du *et al*. 2015; Simopoulos, 2016).

It has also been found that ω-3 offers certain protection from diabetes (Muley *et al*. 2014; Chen *et al*. 2015), hypertension (Arab-Tehrany *et al*. 2012), psoriasis (Rahman *et al*. 2013) and inflammation due to metabolic syndrome (Jalbert 2013; Lee *et al*. 2013; Legrand-Poels *et al*. 2014), among other medical conditions.

Unfortunately, the consumption of seafood or ω-3 supplementation in Mexico is extremely low compared to other countries (Anuario, 2013). Some authors suggest that epidemic diseases related to obesity and metabolic syndrome in Mexico are due to the lack of these fatty acids in the diet of people (Chiprut *et al*. 2001). Therefore, the purpose of this study was to evaluate the association between ω-3 fatty-acid supplementation in overweight and obese schoolchildren, and their anthropometric and serum lipids measurements, in one of the Mexican states where this problem is most severe.

## Materials and Methods

### *Study design*

A total of 121 schoolchildren aged between 10 and 12 years old were recruited from five public elementary schools in Xalapa, Veracruz, Mexico, with the support of the Educational Council of Veracruz. The children were diagnosed as being overweight or obese. The teachers, parents and schoolchildren were given an explanation of the experiment process, and written and informed consent was received from the parents. The study was authorized by the Ethics Committee of Health Services of Veracruz (SEIC-001-16).

*Inclusion criteria*: Schoolchildren aged between 10 and 12 years old, diagnosed with overweight or obesity (Norma Oficial Mexicana, 1999). Data obtained from body mass index (BMI) was compared with the percentile tables for the Centers for Disease Control and Prevention (CDC, 2016), with the following parameters: normal weight (50-85 percentile), overweight (percentile 85-95) and obesity (>95 percentile). In the present study only schoolchildren diagnosed as obese and overweight participated.

*Exclusion criteria:* Schoolchildren with drug treatments, with a metabolic or any other disease previously diagnosed were excluded. Girls who had passed menarche and all children whose parents had not signed the informed consent were also exluded.

*Supplementation*: Schoolchildren were randomly assigned using the latin square method, to receive daily the supplementation in one of two different ways: as ω-3 gummies manufactured by Biodesa, S.A. de C.V., Mexico, or as salmon from the Bear & Wolf Alaskan brand. Schoolchildren were divided into four groups: i) 2 gummies 60mg of DHA (docosahexaenoic acid) and EPA (eicosapentaenoic acid); ii) 3 gummies (90mg DHA and EPA); iii) 10g of salmon (211mg DHA); and iv) 15g of salmon (316mg DHA) (González-Chávez, 2002). Schoolchildren were supplemented daily over a period of three months, and otherwise no changes in the diet were established during the experiment. The dietary protocol is shown in Figure 1.

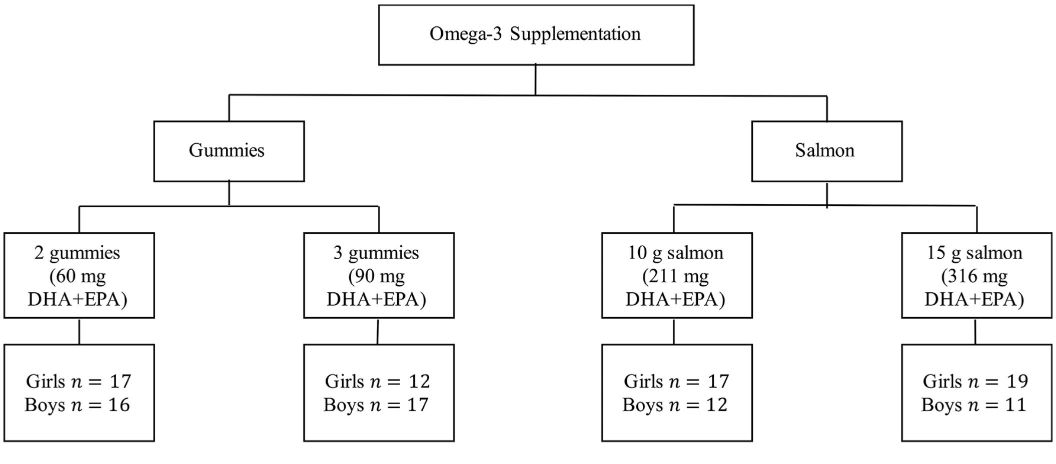

Figure 1. Dietary protocol. Schoolchildren were supplemented daily for a period of 3 months.

Fatty acids composition of gummies and salmon supplementations are shown in Table I. Fatty acids methyl esters of gummies and salmon were analyzed by gas chromatography (GS/MSD; Agilent Model 7890B-5977A-MSD) with capillary column HP-88 (100.0m×0.25mm×0.20µm).

TABLE I
FATTY ACID COMPOSITION
OF DIET SUPPLEMENTED
TO SCHOOLCHILDREN

| Fatty acids | Gummies* | Salmon* |
|---|---|---|
| C12.0 | 18.96 ±0.03 | nd |
| C14:0 | 3.33 ±0.04 | 10.91 ±0.05 |
| C16:0 | 40.18 ±0.02 | 25.39 ±0.06 |
| C16:1 | nd | 1.19 ±0.09 |
| C18:0 | 11.64 ±0.09 | 0.97 ±0.03 |
| C18:1 | 5.67 ±0.08 | 5.38 ±0.02 |
| C18:2 | 16.75 ±0.05 | 1.56 ±0.05 |
| C20:0 | nd | 1.97 ±0.04 |
| C24:0 | nd | 2.67 ±0.06 |
| C20:5 (EPA) | 2.05 ±0.02 | 14.29 ±0.04 |
| C22:6 (DHA) | 1.43 ±0.03 | 35.67 ±0.05 |

Percentage of total fatty acids. Values are expressed as mean ±SE. DHA: docosalhexanoic acid, EPA: eicosapentanoic acid, nd: not detected.

To ensure treatment adherence, children were supplemented daily at school; during the weekend doses were administrated by the parents.

*Anthropometric measurement*: Weight was determined using a using a Tanita, model BF-689. When measurements were taken, children had been fasting and were wearing light clothes and no shoes. Body mass index (BMI) was calculated based on weight and height ($kg·m^{-2}$), and the result was compared to the percentile tables from the Centers for Disease Control and Prevention (CDC, 2016). Waist circumference was measured in the midline between the lower costal margin and the iliac crest, and waist-hip ratio (WHR) was calculated by dividing the waist by the hip measurements (Arjona-Villacaña *et al.* 2008).

*Analytical methods*: Serum glucose levels were measured using the glucose oxidase method (Lott and Turner, 1975). Serum triglyceride concentration was measured using a peroxide-coupled method for colorimetric determination (Bucolo and David, 1973). Serum cholesterol, VLDL and LDL were determined by enzymatic assay (Allain *et al.* 1974), and serum HDL was measured with a Teco Diagnostics kit. Lipid profile results were compared using Kwiterouich (1989).

## *Statistical Analysis*

A Shapiro-Wilk normality test was carried out on each variable in order to verify if the data came from a normally-distributed population. During the statistical data exploration, it was observed that not all variables were normally distributed and, therefore, a non-parametric statistical significance test was applied (Moore and McCabe, 2009; Derrac *et al.* 2011). A paired Wilcoxon signed-rank difference test was developed in order to compare the samples from before and after supplementation. This is a non-parametric statistical hypothesis test used as an alternative to the paired t-test when the population cannot be assumed to be normally distributed as is the case in this study. Differences among the supplementation effects were tested using the Kruskal–Wallis analysis of variance followed by Tukey post-hoc tests for multiple mean comparison. Results are expressed as means ±standard error. Data was analyzed using MATLAB R2009a scientific software (the MathWorks™).

## Results

A total of 121 children (65 girls and 56 boys) participated in the study. Of them, 97

TABLE II
FREQUENCY OF
OVERWEIGHT AND
OBESITY AMONG
GIRLS AND BOYS

| Diagnosis | Gender | |
|---|---|---|
| | Girls | Boys |
| Overweight | 50 | 47 |
| Obesity | 15 | 9 |
| Total | 65 | 56 |

### TABLE III
### METABOLIC PARAMETERS EVALUATED IN CHILDREN BEFORE AND AFTER SUPPLEMENTATION WITH OMEGA-3

| Parameters | Supplementation | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Gummies (2) | | | Gummies (3) | | | Salmon (10g) | | | Salmon (15g) | | |
| | B | A | p | B | A | p | B | A | p | B | A | p |
| Weight (kg) | 55.98 ±2.04 a | 56.56 ±1.90 a | 0.57 | 50.03 ±1.44 a | 50.59 ±1.41 a | 0.85 | 51.68 ±1.71 a | 52.27 ±1.45a | 0.59 | 56.13 ±1.81 a | 57.92 ±1.90 a | 0.46 |
| Height (m) | 1.48 ±0.01 a | 1.51 ±0.01 a | 0.17 | 1.46 ±0.01 a | 1.48 ±0.01 a | 0.38 | 1.45 ±0.01 a | 1.48 ±0.01 a | 0.13 | 1.47 ±0.01 a | 1.51 ±0.01 a | 0.01 |
| BMI (kg·m$^{-2}$) | 25.22 ±0.64 a | 24.76 ±0.63 a | 0.53 | 23.33 ±0.49 a | 23.11 ±0.52 a | 0.83 | 24.28 ±0.50 a | 23.82 ±0.51 a | 0.47 | 25.70 ±0.68 a | 25.41 ±0.70 a | 0.93 |
| WHR (cm) | 83.04 ±1.93 a | 85.93 ±1.72 a | 0.30 | 78.03 ±1.37 a | 80.34 ±1.38 a | 0.32 | 80.43 ±1.38 a | 82.10 ±1.23 a | 0.23 | 82.73 ±1.59 a | 85.62 ±1.72 a | 0.19 |
| Body fat (g) | 33.24 ±1.28 a | 32.62 ±1.17 a | 0.76 | 31.32 ±0.76 a | 30.73 ±0.83 a | 0.56 | 33.24 ±0.90 a | 32.92 ±0.95 a | 0.77 | 35.70 ±1.06 a | 34.81 ±1.06 a | 0.80 |
| GLUC (mmol·l$^{-1}$) | 4.53 ±0.12 a | 5.17 ±0.16 b | 0.01 | 4.55 ±0.09 a | 5.04 ±0-09 b | 0.00 | 4.93 ±0.25 a | 5.20 ±0.11 b | 0.02 | 4.65 ±0.11 a | 5.15 ±0.12 b | 0.00 |
| CHO (mmol·l$^{-1}$) | 4.31 ±0.18 a | 3.55 ±0.13 b | 0.00 | 4.69 ±0.14 a | 3.50 ±0.12 b | 0.00 | 4.37 ±0.19 a | 3.52 ±0.15 b | 0.00 | 4.46 ±0.15 a | 3.35 ±0.09 b | 0.00 |
| HDL (mmol·l$^{-1}$) | 0.94 ±0.05 a | 1.34 ±0.06 b | 0.00 | 0.95 ±0.05 a | 1.40 ±0.06 b | 0.00 | 0.87 ±0.04 a | 1.37 ±0.06 b | 0.00 | 0.89 ±0.05 a | 1.40 ±0.05 b | 0.00 |
| LDL (mmol·l$^{-1}$) | 2.71 ±0.17 a | 1.71 ±0.11 b | 0.00 | 3.00 ±0.16 a | 1.55 ±0.10 b | 0.00 | 2.62 ±0.17 a | 1.62 ±0.12 b | 0.00 | 2.70 ±0.14 a | 1.46 ±0.09 b | 0.00 |
| VLDL(mmol·l$^{-1}$) | 0.70 ±0.06 a | 0.50 ±0.05 b | 0.00 | 0.62 ±0.04 a | 0.50 ±0.04 b | 0.01 | 0.71 ±0.06 a | 0.50 ±0.03 b | 0.01 | 0.75 ±0.06 a | 0.50 ±0.04 b | 0.00 |
| TG (mmol·l$^{-1}$) | 1.50 ±0.12 a | 1.04 ±0.09 b | 0.00 | 1.40 ±0.09 a | 1.08 ±0.08 b | 0.01 | 1.60 ±0.13 a | 1.10 ±0.07 b | 0.00 | 1.70 ±0.14 a | 1.11 ±0.09 b | 0.00 |
| AI | 3.25 ±0.37 a | 1.40 ±0.11 b | 0.00 | 3.47 ±0.37 a | 1.25 ±0.12 b | 0.00 | 3.32 ±0.31 a | 1.32 ±0.14 b | 0.00 | 3.28 ±0.31 a | 1.13 ±0.10 b | 0.00 |

Values are reported as mean ± standard error. The statistical significance (p-value) was obtained using the nonparametric test of Wilcoxon. Different letters mean statistical difference between groups. B: before, A: after, BMI: body mass index, WHR: waist-hip ratio, F: fat, GLUC: serum glucose levels, CHO: serum cholesterol levels, HDL: serum high density lipoprotein levels, LDL: serum low density lipoprotein levels, VLDL: serum very low density lipoprotein levels, TG: serum triglyceride levels, AI: atherogenic index.

children were overweight and 24 were obese (Table II). Statistical descriptors of metabolic parameters in children before and after supplementation with ω-3 fatty acids are shown in Table III. No significant differences in body weight, size, BMI, WHR and fat percentage ($p>0.05$) were observed.

A significant increase ($p<0.05$) was observed in all doses among both girls and boys when serum glucose was compared before and after supplementation. On the other hand, serum cholesterol, LDL, VLDL, TG and AI all showed significant decreases ($p<0.05$) before and after supplementation in all supplemented doses. In addition, a significant increase in serum HDL-cholesterol was found after supplementation with the four doses ($p<0.00001$) (Table III).

We analyzed the percentage of changes observed after supplementation for the different parameters evaluated, in order to verify if there were significant differences after the consumption of the four supplementations and the different doses (60 and 90mg of DHA in gummies and 10 or 15g of salmon). No significant differences were observed among supplementations and doses ($p>0.05$), as shown in Table IV.

In order to explore whether sex could be relevant to determine differences before and after supplementation, we verified if there were any significant differences in the metabolic parameters between girls

### TABLE IV
### PERCENTAGE CHANGE IN THE PARAMETERS EVALUATED BEFORE AND AFTER SUPPLEMENTATION

| Parameters | Supplementation | | | | |
|---|---|---|---|---|---|
| | Gummies (2) | Gummies (3) | Salmon (10g) | Salmon (15) | p-value |
| Weight (kg) | 1.87 ±1.7 | 1.91 ±2.12 | 1.91 ±1.58 | 3.46 ±1.64 | 0.77 |
| Height (m) | 1.64 ±0.46 | 1.15 ±0.46 | 1.75 ±0.35 | 2.38 ±0.31 | 0.53 |
| BMI (kg·m$^{-2}$) | -1.56 ±1.27 | -0.36 ±2.05 | -1.50 ±1.75 | -0.92 ±1.56 | 0.60 |
| WHR (cm) | 3.97 ±1.28 | 3.37 ±1.66 | 2.42 ±1.36 | 3.71 ±1.37 | 0.58 |
| Body fat (g) | -1.06 ±1.65 | -1.24 ±2.23 | -0.87 ±1.36 | -1.84 ±2.91 | 0.95 |
| GLUC (mmol·l$^{-1}$) | 16.54 ±4.59 | 12.09 ±3.18 | 9.72 ±4.06 | 12.80 ±3.99 | 0.86 |
| CHO (mmol·l$^{-1}$) | -15.81 ±2.61 | -24.12 ±2.94 | -17.67 ±2.83 | -22.69 ±2.95 | 0.15 |
| HDL (mmol·l$^{-1}$) | 50.67 ±9.01 | 55.71 ±9.56 | 65.57 ±10.66 | 71.28 ±11.03 | 0.34 |
| LDL (mmol·l$^{-1}$) | -32.67 ±4.02 | -44.34 ±4.43 | -32.74 ±5.92 | -39.67 ±5.88 | 0.12 |
| VLDL(mmol·l$^{-1}$) | -22.08 ±5.03 | -19.70 ±3.30 | -21.34 ±6.32 | -29.96 ±3.71 | 0.32 |
| TG (mmol·l$^{-1}$) | -25.82 ±3.89 | -19.38 ±3.28 | -24.52 ±6.09 | -29.32 ±3.58 | 0.13 |
| AI | -48.35 ±4.18 | -50.17 ±10.22 | -47.67 ±11.00 | -56.43 ±5.15 | 0.29 |

Values are reported as mean ±standard error. The statistical significance (p-value) was obtained using the nonparametric test of Kruskal–Wallis analysis of variance followed by Tukey post-hoc tests for multiple mean comparison. Parameters: see Table III.

### TABLE V
### DIFFERENCES IN METABOLIC PARAMETERS IN CHILDREN AFTER SUPPLEMENTATION

| Parameters | Supplementation | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Gummies (2) | | | Gummies (3) | | | Salmon (10g) | | | Salmon (15g) | | |
| | Girls | Boys | p | Girls | Boys | p | Girls | Boys | p | Girls | Boys | p |
| Weight (kg) | 55.68 ±2.06 a | 57.51 ±3.30 a | 0.86 | 53.28 ±2.50 a | 48.68 ±1.52 a | 0.20 | 54.84 ±1.78 a | 48.64 ±2.11 a | 0.06 | 56.37 ±2.70 a | 60.61 ±2.14 a | 0.20 |
| Height (m) | 1.51 ±0.01 a | 1.51 ±0.02 a | 0.70 | 1.49 ±0.02 a | 1.47 ±0.01 a | 0.49 | 1.49 ±0.01 a | 1.46 ±0.03 a | 0.37 | 1.50 ±0.01 a | 1.52 ±0.01 a | 0.53 |
| BMI (kg·m$^{-2}$) | 24.40 ±0.74 a | 25.14 ±1.04 a | 0.91 | 23.85 ±0.87 a | 22.59 ±0.62 a | 0.29 | 24.54 ±0.66 a | 22.80 ±0.72 a | 0.13 | 24.90 ±0.89 a | 26.29 ±1.13 a | 0.40 |
| WHR (cm) | 84.84 ±1.68 a | 87.09 ±3.10 a | 0.94 | 79.00 ±2.03 a | 81.29 ±1.89 a | 0.38 | 82.89 ±1.71 a | 80.98 ±1.75 a | 0.38 | 83.83 ±2.29 a | 88.71 ±2.35 a | 0.13 |
| Body fat (g) | 31.66 ±1.16 a | 33.64 ±2.09 a | 0.93 | 31.72 ±0.60 a | 30.04 ±1.35 a | 0.11 | 33.28 ±1.18 a | 32.41 ±1.64 a | 0.52 | 35.08 ±1.13 a | 34.33 ±2.20 a | 0.73 |
| GLUC (mmol·l$^{-1}$) | 5.20 ±0.30 a | 5.15 ±0.16 a | 0.33 | 4.90 ±0.17 a | 5.13 ±0.10 a | 0.25 | 5.20 ±0.15 a | 5.22 ±0.19 a | 0.88 | 5.30 ±0.15 a | 4.90 ±0.22 a | 0.07 |
| CHO (mmol·l$^{-1}$) | 35.40 ±2.12 a | 36.10 ±1.80 a | 0.41 | 33.62 ±1.84 a | 36.40 ±1.70 a | 0.28 | 34.45 ±1.93 a | 36.84 ±2.50 a | 0.52 | 33.94 ±1.21 a | 33.40 ±1.60 a | 1.00 |
| HDL (mmol·l$^{-1}$) | 1.26 ±0.08 a | 1.43 ±0.10 a | 0.18 | 1.55 ±0.07 a | 1.29 ±0.09 b | 0.04 | 1.27 ±0.8 a | 1.50 ±0.09 b | 0.04 | 1.46 ±0.06 a | 1.31 ±0.10 a | 0.18 |
| LDL (mmol·l$^{-1}$) | 1.74 ±0.17 a | 1.68 ±0.15 a | 1.00 | 1.38 ±0.15 a | 1.68 ±0.15 a | 0.23 | 1.49 ±0.12 a | 1.82 ±0.24 a | 0.19 | 1.42 ±0.11 a | 1.54 ±0.17 a | 0.67 |
| VLDL(mmol·l$^{-1}$) | 0.54 ±0.08 a | 0.45 ±0.03 a | 0.84 | 0.36 ±0.02 a | 0.58 ±0.05 b | 0.00 | 0.53 ±0.05 a | 0.46 ±0.04 a | 0.39 | 0.49 ±0.05 a | 0.52 ±0.07 a | 1.00 |
| TG (mmol·l$^{-1}$) | 1.08 ±1.17 a | 1.00 ±0.07 a | 0.55 | 0.80 ±0.05 a | 1.30 ±0.11 b | 0.00 | 1.14 ±0.11 a | 1.00 ±0.09 a | 0.24 | 1.10 ±0.11 a | 1.20 ±0.15 a | 0.65 |
| AI | 1.51±0.16 a | 1.29 ±0.15 a | 0.21 | 0.92 ±0.12 a | 1.49 ±0.16 b | 0.03 | 1.30 ±0.16 a | 1.34 ±0.25 a | 0.91 | 1.04 ±0.12 a | 1.29 ±0.18 a | 0.21 |

Values are reported as mean ±standard error. The statistical significance (p-value) was obtained using the nonparametric test of Wilcoxon. Different letters mean statistical difference between groups. Parameters: see Table III.

and boys after supplementation (Table V). Significant differences ($p<0.05$) were found when the children were supplemented with 90mg of DHA (3 gummies), specifically in serum HDL-cholesterol (girls 1.55 ±2.70 *vs* boys 1.23 ±3.45mmol·l$^{-1}$), serum HDL-cholesterol (girls 1.55 ±0.07 *vs* boys 1.29 ±0.09mmol·l$^{-1}$, $p<0.05$), serum VLDL (girls 0.36±0.02 *vs* boys 0.58 ±0.05mmol·l$^{-1}$, $p<0.05$), serum TG (girls 0.80 ±0.05 *vs* boys 1.30 ±0.11mmol·l$^{-1}$, $p<0.05$) and AI (girls 0.92 ±0.12 *vs* boys 1.49 ±0.16, $p<0.05$).

## Discussion

It has been well established that ω-3 supplementation has potential health benefits, both in humans and in rats, in a number of diseases, including cardiovascular disorders, diabetes mellitus, some mental illnesses and inflammatory disorders, among others (Golub *et al.* 2011). The objective of the present study was to evaluate the effect of ω-3 fatty-acid supplementation through different doses of gummies and salmon, in overweight and obese schoolchildren.

Effects regarding ω-3 supplementation and reduction in body weight are controversial and the issue remains unclear. Some studies have suggested that ω-3 fatty acids consumption has no effect on reducing body weight in rats (Buckley and Howe, 2010) nor in humans (Martínez-Victoria and Dolores-Yago, 2012; Du *et al.* 2015; Zhang *et al.* 2015). On the other hand, other authors have found a relationship between supplementation with fish oil and reduction in fat mass and body weight in humans (Noreen *et al.* 2010), especially when combined with diet and exercise (Hill *et al.* 2007; Buckley and Howe, 2010; Noreen *et al.* 2010; Du *et al.* 2015; Simopoulos, 2016). In the present study no significant differences in body weight, height or BMI were found after supplementation among children at any of the doses applied (Table III). Some of these results are consistent with a study of Mexican obese children, 9-18 years old, supplemented with ω-3, where out of a total of 76 children, 16 lost weight and 27 children gained weight, while insulin resistance was decreased and changes in proinflammatory cytokines were observed (López-Alarcón *et al.* 2011).

Some studies show that fish oil can reduce waist-hip ratio (WHR) in humans (DeFina *et al.* 2010; Munro and Garg, 2013; Du *et al.* 2015). Nevertheless, in our study, no significant differences were observed in WHR in both girls and boys supplemented with any of the four different doses used (Table V).

In terms of serum glucose, no significant differences were observed among any of the groups. The percentage change in all supplementations demonstrated no statistical difference (Table IV). However, the effect of ω-3 fatty-acid supplementation on serum glucose is inconsistent. Some authors have found a protective and homeostatic association between ω-3 fatty-acid consumption and type 2 diabetes mellitus (Muley *et al.* 2014; Chen *et al.* 2015), while others observed no association whatsoever (Hartweg *et al.* 2009; Chen *et al.* 2015). Variations in results may relate to dosage and duration, ethnic population or trial design (Chen *et al.* 2015). It should be mentioned that the sugar supply provided by the gummies supplementation does not alter any metabolic parameter, since it does not exceed the recommended daily dose established in schoolchildren (10% of total caloric intake; WHO, 2015).

The effect of the consumption of ω-3 fatty acids on lowering serum cholesterol has been previously studied (Pirillo and Catapano, 2013). In our study, supplementation with ω-3 led to a significant decrease in total serum cholesterol. This reduction was observed with all doses used; however, children who consume 90mg of DHA and 15g of salmon showed a greater decrease (-24.12 and -22.69%, respectively). Serum cholesterol was also found to decrease with 60mg of DHA (-15.81%) and 10g of salmon (-17.67%) (Table IV). Some authors have found that ω-3 fatty-acid supplementation produces an increase in LDL-cholesterol, and it has been suggested that the consumption of fatty acids has no therapeutic effect (Hartweg *et al.* 2009; Sperling and Nelson, 2015). In contrast, our results confirm a significant decrease in LDL cholesterol as a result of different supplementation doses (Figure 2). In addition, VLDL cholesterol was also decreased (60 and 90mg of DHA, -22.08 and -19.70%; 10g and 15g salmon, -21.34 and -29.96%, respectively). Similarly, some reports have suggested that ω-3 consumption lowers VLDL cholesterol in humans (Harris *et al.* 2008; Pirillo and Catapano, 2013).

In children, increased serum cholesterol, LDL and VLDL are related to the development of atherosclerotic and cardiovascular disease in adolescent and young adults (Lui *et al.* 2010; Delgadillo-Guerra and Romero-Hernández, 2013). Due to this, it is necessary to generate strategies to decrease cardiovascular risk factors and hyperlipidemia in children, so as to reduce the impact of this illness in adulthood (Delgadillo-Guerra and Romero-Hernández, 2013).

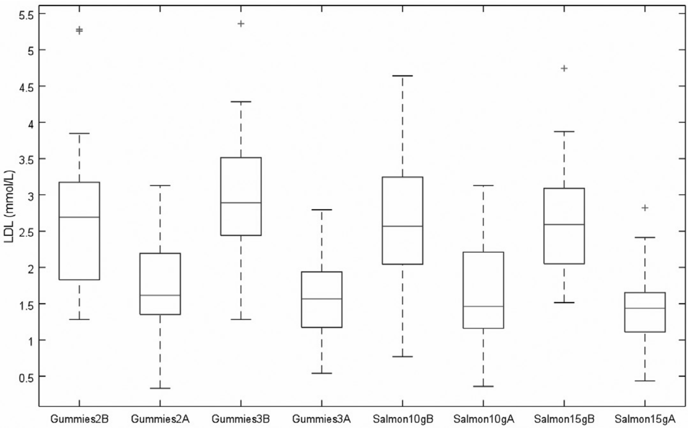

Figure 2. LDL distribution of each group before (B) and after (A) supplementation. Within each box, the central mark is the median, the edges of the box are the 25th and 75th percentiles, the whiskers extend to the most extreme data points not considered outliers, and outliers are plotted individually.

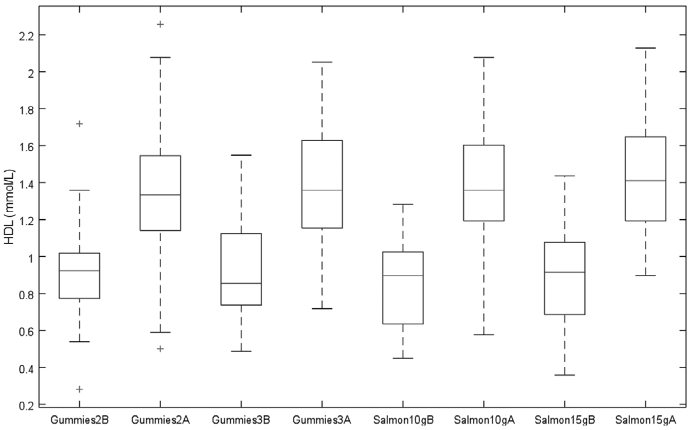

Figure 3. HDL distribution of each group before (B) and after (A) supplementation. Within each box, the central mark is the median, the edges of the box are the 25th and 75th percentiles, the whiskers extend to the most extreme data points not considered outliers, and outliers are plotted individually.

As expected, the children's HDL-cholesterol serum levels showed no significant differences prior to the experiment; however, after the supplementation period, this parameter showed higher concentrations with 60 and 90mg of DHA (50.67 and 55.71%, respectively) and with 10 and 15g of salmon (65.57 and 71.28%, respectively) (Figure 3). Although this effect remains unclear, our results are consistent with other research that confirms that omega-3 fatty-acid supplementation can increase serum HDL-cholesterol (Ballesteros-Vázquez *et al.* 2012; Pirillo and Catapano, 2013; Singh *et al.* 2015).

Various studies in humans have reported positive effects on triglyceride profiles as part of the ω-3 diet (Sauder *et al.* 2013; Chen *et al.* 2015; Leslie *et al.* 2015). According to our data, triglyceride levels were significantly diminished through supplementation with gummies (-25.82 and -19.38%, respectively) as well as with salmon (-24.52 and -29.32%, respectively) (Table V).

Atherosclerosis is a leading cause of death and disability. One of the indices that can help to predict cardiovascular risk is the atherogenic index (AI), which is related to plasma atherogenicity: people with high coronary risk exhibit an increase in AI (Singh *et al.* 2015). In our study, AI was significantly decreased at all dosage levels (Table IV), mostly in 15g of salmon (-56.43%). These results confirm that cardiovascular risk in schoolchildren decreased with omega-3 supplementation.

## Conclusions

The supplementation of omega-3 fatty acids in overweight and obese children had beneficial effects on cardiovascular risk biomarkers and dyslipidemia. As such, supplemented doses may offer benefits for human health, such as the prevention of hyperlipidemia and a reduced risk of developing cardiovascular diseases. However, its impact on body weight, BMI and fat reduction in children requires further research.

## ACKNOWLEDGMENTS

The first author acknowledges the financial support provided by the Mexican National Council for Education as part of PRODEP, for supporting the second year of the Thematic Networks Academic Collaboration UNACAM-CA-12 project. The second author acknowledges the financial support provided by CONACyT (scholarship number 6817).

## REFERENCES

Allain CC, Poon LS, Chan CS, Richmond W, Fu PC (1974) enzymatic determination of total serum cholesterol. *Clin. Chem. 20*: 470-475.

Anuario (2013) *Anuario Estadístico de Acuacultura y Pesca* Comisión Nacional de Acuacultura y Pesca. Sagarpa y Conapesca. Mazatlán, Mexico

Arab-Tehrany E, Jacquot M, Gaiani C, Imran M, Desobry S, Linder M (2012) Beneficial effects and oxidative stability of omega-3 long-chain polyunsaturated fatty acids. *Trends Food Sci. Technol. 25*: 24-33.

Arjona-Villicaña RD, Gómez-Díaz RA, Aguilar-Salinas CA (2008) Controversias en el diagnóstico del síndrome metabólico en poblaciones pediátricas. *Bol. Med. Hosp. Infant. Med. 65*: 488-501.

Ballesteros-Vásquez MN, Valenzuela-Calvillo LS, Artalejo-Ochoa E, Robles-Sardin AE (2012) Ácidos grasos *trans*: un análisis del efecto de su consumo en la salud humana, regulación del contenido en alimentos y alternativas para disminuirlos. *Nutr. Hosp. 27*: 54-64.

Buckley JD, Howe PRC (2010) Review: long-chain omega-3 polyunsaturated fatty acids may be beneficial for reducing obesity. *Nutrients 2*:1 212-1230.

Bucolo G, David H (1973) Quantitative determination of serum triglycerides. *Clin. Chem. 19*: 476-482.

Carretero JJ, Martín-Bautista E, Baró L, Fonollá J, Jiménez J, Boza JJ, López-Huertas E (2005) Efectos cardiovasculares de los ácidos grasos omega-3 y alternativas para incrementar su ingesta. *Nutr. Hosp. 20*: 63-69.

CDC (2017) Centers for Disease Control and Prevention www.cdc.gov. (Cons. 28/09/ 2017).

Chen C, Yu X, Shao S (2015) Effects of omega-3 fatty acid supplementation on glucose control and lipid levels in type 2 diabetes: A meta-analysis. *PloS One. 10*.

Chiprut R, Castellanos-Urdaibay A, Sánchez-Hernández C, Martínez-García D, Elena-Cortez M, Chiprut R, Ovadía PDC (2001) La obesidad en el siglo XXI avances en la etiopatogenia y tratamiento. *Gac. Med. Mex. 137*: 323-334.

Coronado-Herrera M, Vega-y-León S, Gutiérrez-Tolentino R, García-Fernández B, Díaz-González G (2006) Los ácidos grasos omega -3 y omega-6: nutrición, bioquímica y salud. *Rev. Educ. Bioquím. 25*: 72-79.

DeFina LF, Marcoux LG, Devers SM, Cleaver JP, Willis BL (2010) Effects of omega-3 supplementation in combination with diet and exercise on weight loss and body composition. *Am. J. Clin. Nutr. 93*: 455-462.

Delgadillo-Guerra H, Romero-Hernández M (2013) Valores del perfil lipídico, presión arterial e índices CT/C-HDL y C-LDL/C-HDL como factores de riesgo cardiovascular en niños de una escuela básica del Estado Bolivar, Venezuela. *Saber 25*: 265-272.

Derrac J, García S, Molina D, Herrera F (2011) Practical tutorial on the use of nonparametric statistical tests as a methodology for comparing evolutionary and swarm intelligence algorithms. *Swar Evol. Comput. 1*: 3-18.

Du S, Jin J, Fang W, Su Q (2015) Does fish oil have an anti-obesity effect in overweight/obese adults? A meta-analysis of randomized controlled trials. *PLoS One. 10*: 1-20.

Durá-Travé T, Sánchez-Valverde F (2005) Obesidad infantil: ¿Un problema de educación individual, familiar o social? *Acta Pediatr. Esp. 63*: 204-207.

ENSANUT (2012) *Encuesta Nacional de Salud y Nutrición. ResultadosNacionales2012.* Mexico. http://ensanut.insp.mx/informes/ENSANUT2012ResultadosNacionales2Ed.pdf (Cons. 28/09/2017).

Escobar J, Estrada L, Gómez L, Gil AM, Cadavid A (2013) ¿Pueden los ácidos grasos omega 3 y 6 contrarrestar los efectos negativos de la obesidad en la gestación? *Rev. Chil. Obstet. Ginecol. 78*: 244-250.

García-Solís P, Reyes-Bastidas M, Flores K, García OP, Rosado JL, Méndez-Villa L, Garcia-G C, García-Gutiérrez D, Kuri-García A, Hernández-Montiel HL, Soriano-Leon O, Villagrán-Herrera ME, Solis-Sainz JC (2016) Fat mass obesity-associated (FTO) (rs9939609) and melanocortin 4 receptor (MC4R) (rs17782313) SNP are positively associated with obesity and blood pressure in Mexican school-aged children. *Brit J Nutr. 116*: 1834-1840.

Golub N, Geba D, Mousa SA, Williams G, Block RC (2011) Greasing the wheels of managing overweight and obesity with ω-3fatty acids. *Med. Hypoth. 77*: 1114-1120.

González-Chávez A (2002) Consenso mexicano sobre el tratamiento integral del síndrome metabólico. *Rev. Mex. Cardiol. 13*: 4-30.

Harris WS, Miller M, Tighe AP, Davidson MH, Schaefer EJ (2008) Omega-3 fatty acids and coronary heart disease risk: Clinical and mechanistic perspectives. *Atherosclerosis 197*: 12-24.

Hartweg J, Farmer AJ, Holman RR, Neil A (2009) Potential impact of omega-3 treatment on cardiovascular disease in type 2 diabetes. *Curr. Opin. Lipidol. 20*: 30-38.

Hill AM, Buckley JD, Murphy KJ, Howe PRC (2007) Combining fish-oil supplements with regular aerobic exercise improves body composition and cardiovascular disease risk factors. *Am J Clin Nutr. 85*: 1267-74.

Jalbert I (2013) Diet nutraceuticals and the tear film. *Exp. Eye Res. 117*: 138-146.

Lee H, Lee IS, Choue R (2013) Obesity, inflammation and diet. *Pediatr. Gastroenterol. Hepatol. Nutr. 16*: 143-152.

Legrand-Poels S, Esser N, L'homme L, Scheen A, Paquot N, Piette J (2014) Free fatty acids as modulators of the NLRP3 inflammasome in obesity/type 2 diabetes. *Biochem. Pharmacol. 92*: 131-141.

Leslie MA, Cohen DJ, Liddle DM, Robinson LE, Ma DW (2015) A review of the effect of omega-3 polyunsaturated fatty acids on blood triacylglycerol levels in normolipidemic and borderline hyperlipidemic individuals. *Lip. Health Dis. 14*: 53.

Liu Y, Liang H, Liu H, Li S, Zhou Y, Cheng H, Zhou L (2010) Association of serum adiponectin levels with artherosclerosis and the metabolic syndrome in obese children. *J. Pediatr. Endocrinol. Metab. 23*: 743-751.

López-Alarcón M, Martínez-Coronado A, Velarde-Castro O, Redón-Macías E, Fernández J (2011) Supplementation of n3 long-chain polyunsaturated fatty acid synergistically decreases insulin resistance with weight loss of obese prepubertal and pubertal children. *Arch. Med. Res.42*: 502-508.

Lott JA, Turner K (1975) Evaluation of Trinder's glucose oxidase method for measuring glucose in serum and urine. *Clin. Chem. 21*: 1754-1760.

Martínez-Victoria E, Dolores-Yago M (2012) Omega 3 polyunsaturated fatty acids and body weight. *Br. J. Nutr. 107*: S107-S116.

Moore SD, McCabe PG (2009) *Introduction to the Practice of Statistics*. 6*th* ed. Freeman. New York, USA. 814 pp.

Muley A, Muley P, Shah M (2014) ALA, fatty fish or marine n-3 fatty acids for preventing dm? A systematic review and meta-analysis. *Curr. Diabet. Rev. 10*: 158-165.

Munro A, Garg ML (2013) Dietary Supplementation with long-chain ω-3 polyunsaturated fatty acids and weight loss in obese adults. *Obes. Res. Clin. Pract. 7*: 173-181.

Noreen EE, Sass MJ, Crowe ML, Pabon VA, Brandauer J, Averill JL (2010) Effects of supplemental fish oil on resting metabolic rate, body composition, and salivary cortisol in healthy adults. *J. Int. Soc. Sports Nutr. 7*: 1-7.

Norma Oficial Mexicana (1999) *NOM-031-SSA2-1999. Para la Atención a la Salud del Niño*. www.salud.gob.mx/unidades/cdi/nom/031ssa29.html (Cons. 22/09/2017).

Pajuelo J, Rocca J, Gamarra M (2003) Obesidad infantil: sus características antropométricas y bioquímicas. *An. Fac. Med. 64*: 21-26.

Pirillo A, Catapano AL (2013) Omega-3 Polyunsaturated fatty acids in the treatment of hypertriglyceridaemia. *Int. J. Cardiol. 170*: S16-S20.

Portillo-Reyes V, Pérez-García M, Loya-Méndez Y, Puente AE (2014) clinical significance of neuropsychological improvement after supplementation with omega-3 in 8–12 year-old malnourished Mexican children: A randomized, double-blind, placebo and treatment clinical trial. *Res. Devel. Disabil. 35*: 861-870.

Rahman M, Beg S, Ahmad MZ, Kazmi I, Ahmed A, Rahman Z, Ahmad FJ, Akhter S (2013) Omega-3 fatty acids as pharmacotherapeutics in psoriasis: current status and scope of nanomedicine in its effective delivery. *Curr. Drug Targets 14*: 708-722.

Sauder KA, Skulas-Ray AC, Campbell TS, Johnson JA, Kris-Etherton PM, West SG (2013) Effects of omega-3 fatty acid supplementation on heart rate variability at rest and during acute stress in adults with moderate hypertriglyceridemia. *Psychosom. Med. 75*: 382-389.

Simopoulos AP (2016) Review: An increase in the omega-6/omega-3 fatty acid ratio increases the risk for obesity. *Nutrients 8*: 128.

Singh S, Arora RR, Singh M, Khosla S (2015) Eicosapentaenoic acid vs docosahexaenoic acid as options for vascular risk prevention: A fish story. *Am. J. Ther. 0*: 1-6.

Sperling LS, Nelson JR (2015) History and future of omega-3 fatty acids in cardiovascular disease. *Curr. Med. Res. Opin. 3*: 1-11.

Kwiterouich P (1989) *The John Hopkin's Complete Guide for Avoiding Heart Disease*. Johns Hopkins University Press. Baltimore, MD, USA. 416 pp.

UNICEF (2017) *Health and Nutrition*. United Nations International Children's Emergency Fund. www.unicef.org/mexico/spanish/17047.htm (Cons. 28/09/2017).

Valdés MS, Gómez VA (2006) *Temas de Pediatría*. Ciencias Médicas. La Habana, Cuba.

WHO (2015) *Ingesta de Azúcares para Adultos y Niños*. World Health Organization www.who.int/nutrition/publications/guidelines/sugars_intake/es/ (Cons. 28/09/2017).

Young AJ, Marriott BP, Champagne CM, Hawes MR, Montain SJ, Johannsen NM, Berry K, Hibbeln JR (2017) Blood fatty acid changes in healthy young Americans in response to a 10-week diet that increased n-3 and reduced n-6 fatty acid consumption: A randomised controlled trial. *Br J Nutr 117*: 1257-1269.

Zhang YY, Liu W, Zhao TY, Tian HM (2017) Efficacy of omega-3 polyunsaturated fatty acids supplementation in managing overweight and obesity: a meta-analysis of randomized clinical trials. *J. Nutr. Health Aging 21*: 187-19.