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Research Article

Evaluation of Consumption of Poultry Products Enriched with *Omega-3* Fatty Acids in Anthropometric, Biochemical, and Cardiovascular Parameters

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An alternative for prevention and treatment for cardiovascular diseases (CVD) is increasing the intake of bioactive compounds as *omega-3*. However, several countries as México do not consume regularly foods with high content of *omega-3*, mainly fish products due to cultural, social, and economic factors. Therefore, the addition of *omega-3* in other food sources could contribute to completing the requirements established of these fatty acids. To evaluate the effect of the consumption of poultry products supplemented with *omega-3* in healthy population, a phase 1, double blind randomized, controlled parallel-group trial was carried out. After 14 weeks, the supplemented group had an increase in HDL, reducing the atherogenic index. The supplementation with *omega-3* in poultry products could contribute to a cardioprotective effect. It is necessary to complete studies with a higher evaluation period to determine the improvement in anthropometric and cardiovascular parameters.

1. Introduction

The cardiovascular diseases (CVD) are a leading cause of morbidity and mortality worldwide. An estimate of 17.7 million people died from cardiovascular diseases in 2015. World Health Organization (WHO) showed that CVD are the leading cause of mortality in Mexico. Risk factors include tobacco and alcohol use, physical inactivity, unhealthy diets, elevated blood pressure, overweight/obesity, hyperglycemia, and hyperlipidemia [1–5]. Therefore, it is necessary to modify the lifestyles mainly by improving the diet. Several studies show that the consumption of rich food in nutrients improves health. The *omega-3* fatty acids offer a more suitable preventive or therapeutic option for many chronic diseases due to their biological activity [6, 7]. Various institutions had established recommendations for the consumption of *omega-3* as a protective factor against several diseases: the American Dietetic Association (ADA); International Society for the Study of Fatty Acids and Lipids (ISSFAL); French Agency for Food Environment and Occupational Health Safety *Omega-3* Report; European Society of Cardiology; Report FAO: FAT and Fatty acid in Human Nutrition; USDA Dietary Guidelines for Americans. These recommendations of *omega-3* intake differ from 250 mg up to 4 g/day, depending on whether it is for prevention [8, 9] or treatment of several pathologies [9–14]. In order to achieve this level of daily intake of *omega-3*, it is recommended to consume 600–660 g of fish minimally per week [9–11], in particular fatty fish such

as mackerel, lake trout, herring, sardines, albacore tuna, and salmon, or to consume the equivalent in fish oil commercially available as concentrated pharmaceutical preparations [15].

However, Mexico is not a country with a high consumption of fish products due to social, cultural, and economic situations [16]. Compared to the *per capita* consumption of fish products of countries like Spain, Norway, Japan, Myanmar, Korean Republic, Malaysia, Iceland, and Maldives at 43–165 kg/year, Mexico's intake of these products is quite low at 4 kg/year [17]. Therefore, according to other studies, the alternative for increasing intake of *omega-3* could include supplemented daily products such as dairy (yogurt, milk, and margarine), juices, chicken, and eggs [18, 19]. The objective of this research was to evaluate the effects of the consumption of eggs and chicken supplemented with *omega-3* on anthropometric, biochemical, and cardiovascular parameters in healthy population.

2. Material and Methods

2.1. Subjects and Study Design. The study was a phase 1, double blind randomized, controlled parallel-group trial where 29 volunteers of both sexes participated (17 women and 12 men with an average age of 32 ± 5.6 years old, an approximate weight of 74 ± 18 kg, and height of 1.64 ± 0.084 m). They complied with inclusion and exclusion criteria of study. Some participants were excluded from the study due to preexisting conditions, like hypertriglyceridemia and hypercholesterolemia, or because they did not complete the evaluations. At the baseline, participants were randomly assigned to the group that consumed supplemented poultry food (experimental group) or to the control group. Fourteen participants (9 women, 5 men) consumed chicken and eggs supplemented with *omega-3* fatty acids and fifteen participants (8 women and 7 men) consumed chicken and eggs nonsupplemented with *omega-3* fatty acids. Both groups participated for a period of 14 weeks. During this time, participants consumed the poultry products in different preparations; we recommended that they consume the poultry products with fat-free preparations (boiled, grilled, etc.).

The experimental group consumed 250 grams of chicken meat (≈228 mg of *omega-3*) and 3 eggs (≈1590 mg of *omega-3*) each week. The control group consumed the same amount of chicken meat and eggs but without treatment of supplementation. The amount of eggs consumption was calculated according to recommendations established in NOM-043-SSA2-2012 [20] and by the Organization INPROVO [21]. Anthropometric measurements, blood samples for biochemical determination, and cardiovascular function data were collected at the baseline and at the 14th week. Subjects followed their regular habits, as physical exercise and regular diet. They signed the informed consent to participate in the intervention. The study protocol was approved by the Ethic Committee of the Health Sciences Institute of the Autonomous University of the State of Hidalgo, Mexico.

2.2. The Chicken Product. A total of 200 poultry males and females (Cobb and Ross strain) were acquired for production of meat and 60 laying hens (Plymouth rock and Rhode Island strain) for production of eggs. Poultry were housed in stainless steel cages during the period of September to November 2016 and their care was conducted according to the University approved methods. The animals were fed (supplemented and nonsupplemented) with a commercial diet and water provided for ad libitum consumption for 21 days. The commercial diet for supplemented animals was added with 0.5–0.8 g/day of *omega-3* obtained of cod leaver oil. It is the recommended amount to avoid the fish odor and/or flavor in meat and eggs. After 21 days of growth of the animals, the collection of eggs and the obtaining of the meat began. The quality of the meat and eggs supplemented and nonsupplemented with *omega-3* was evaluated according to the established standard in NMX-FF-080-SCFI-2006 [22] and PROY-NOM-159-SSA1-2015 [23].

2.3. Anthropometric Measurements. The anthropometric measurements (weight, height, and waist circumference) were evaluated according to the recommendations established by the Secretary of Health (SSA) in Mexico [24–26]. The body mass index (BMI) was calculated according to the specifications of the World Health Organization (WHO) [27] and the body composition was measured by body densitometry using air-displacement via the Bod Pod®. All testing was done in accordance with the manufacturer's instructions [28] to obtain the values of fat mass (percentage and kilograms), fat-free mass (percentage and kilograms), and weight (kg).

2.4. Biochemical Parameters. Fasting blood samples were collected by venipuncture into vacutainer tubes serum [29], centrifuged at 6500 rpm for 15 minutes (centrifuge brand Hamilton Bell), and stored at −21°C for further analyses. Total cholesterol (TC, optimal value < 200 mg/dL), high density lipoprotein (HDL, optimal value > 40 mg/dL), triglycerides (TG, optimal value < 150 mg/dL), and glucose (optimal value 100 −125 mg/dL) were determined using commercially available kits (Spinreact®), considering the specifications of the clinical practices guide for diabetes and dyslipidemias [30, 31].

LDL (low density lipoprotein) cholesterol was determined according to the following formula [32]:

$$\text{LDL mg/dL} = \text{TC} - \left[\text{HDLc} + \left(\text{Tg}\right) 5\right]. \quad (1)$$

TC is total cholesterol, HDLc is high density lipoprotein cholesterol, and Tg is triglyceride.

The atherogenic index (AI) was calculated with the following formula:

$$\text{Castelli Index} = \frac{\text{Total cholesterol}}{\text{HDL cholesterol}}. \quad (2)$$

According with Castelli [33], a low atherogenic index was considered <4.5, 4.5 to 7 as moderate and >7 high.

2.5. Cardiovascular Function. Cardiovascular function was evaluated with the following parameters.

The heart rate was evaluated at rest using a pulsometer (MedStar®). The ranges were considered optimum with

Table 1: Anthropometric parameters of experimental and control group.

	Week 0	Week 14
Experimental group (n = 14)		
Body weight (Kg)	74.60 ± 19.20[a]	74.5 ± 19.7[a]
Height (m)	1.62 ± 0.09[a]	1.62 ± 0.09[a]
Body mass index (BMI)	28.1 ± 6.1[a]	28.0 ± 6.2[a]
Waist circumference (cm)	90.7 ± 16.2[b]	89.7 ± 16.2[a]
Body fat (%)	33.1 ± 9.6[b]	31.7 ± 9.8[a]
Body fat (Kg)	25.5 ± 11.9[b]	24.5 ± 12.3[a]
Fat-free mass (%)	66.9 ± 9.6[a]	68.2 ± 9.8[b]
Fat-free mass (Kg)	49.0 ± 10.5[a]	49.9 ± 10.6[b]
Control group (n = 15)		
Body weight (Kg)	83.8 ± 17.5[a]	83.2 ± 17.9[a]
Height (m)	1.65 ± .07[a]	1.65 ± 0.07[a]
Body mass index (BMI)	30.4 ± 4.7[a]	30.2 ± 5.1[a]
Waist circumference (cm)	96.6 ± 14.4[a]	95.2 ± 14.2[a]
Body fat (%)	37.2 ± 7.9[b]	35.5 ± 9.2[a]
Body fat (Kg)	31.8 ± 11.0[a]	30.1 ± 12.0[a]
Fat-free mass (%)	62.4 ± 7.6[a]	64.4 ± 9.2[a]
Fat-free mass (Kg)	52.0 ± 10.6[a]	53.0 ± 10.4[b]

[a,b]Different letters between column values (0 and 14th week) indicate significant difference ($p \leq 0.05$ Student's t-test).

values between 65 and 85 beats/minute and considered high with a rate above 85 beats per minute [34].

The arterial pressure was evaluated according to Clinical Practices Guide with an aneroid baumanometer (MedStar®) [34]. According to the American Health Association (2017) 120/80 mmHg is considered as optimum values [35].

2.6. Bruce Exercise Stress Testing. Bruce Exercise Stress test was evaluated according to the Bruce protocol, recording the electrical activity of the heart that occurs in each heart beat during physical exercise. The subjects performed the maximal exercise tests on an endless band (Wellch Allyn®), programed for increasing the angle of inclination and speed. The participants walked in an initial slope of 10% and a speed of 1.7 km/h; every 3 min the slope was increased 2% and speed to 2.5, 3.4, 4.2, 5.0, and 5.5 km/h [36–38]. In addition, every three minutes (0, 3, 6, 9, 12, and 15 minutes) the heart rate, blood pressure, and electrocardiographic segments were registered [PQ (120–200 milliseconds), QRS-interval (60–100 milliseconds), QT (360 milliseconds), and QTc (340–450 milliseconds)], until the individuals reached 80% heart rate, considered as the maximum of cardiac capacity. At the end of the test, the duration and recovery time in minutes were recorded. The test was ended when the subject showed exhaustion, fatigue, or inability to maintain a running cadence [39].

2.7. Statistical Analysis. Statistical analysis was performed using the SPSS statistical software (version 23). The Shapiro-Wilk test was applied to determine the distribution of the data of the variables in the normal curve to identify if the hypothesis would be verified with parametric or nonparametric test. To compare the existence of differences between week 0 and 14th of the intervention in the experimental and control group, a Student's t-test was used. Statistical significance was considered as p value ≤ 0.05 with 95% confidence intervals. In addition, unpaired t-test studies were done together with the analysis of variance between groups for independent samples. The effect size (Δ) was estimated between the means of the before-after observed differences in the treatment groups using Student's t-test.

3. Results and Discussion

No subjects reported any side effects derived from the intake of the poultry products consumed in the study. Participants indicted that supplemented poultry products presented intense flavor and texture softer in comparison with the control products and even with major sensorial characteristics in comparison with common commercial products.

The poultry products complied with high quality parameters according to Mexican specifications. The chicken meat was considered to be at the *"Extra"* category established for products of high quality (NMX-FF-080-SCFI-2006) [22] and the eggs were classified in the *"Extra Mexico"* category, which describes fresh and high quality products (PROY-NOM-159-SSA1-2015) [23].

3.1. Anthropometric Parameters. Table 1 shows the results of anthropometric measurements at the baseline and after the intervention period. In general, both study groups had a BMI higher than 25. The experimental group had an average BMI of ≈28.1 and values considered as overweight or preobesity and the control group had values of ≈30.4 ± 4.7 that indicate obesity, according to the WHO classification [40]. In addition, the participants of both groups had high values of fat percentage (33–37%) and a waist circumference higher than 80 cm (around 90.7 to 96.6 cm). These data coincide with

Table 2: Biochemical parameters of experimental and control group.

	Week 0	Week 14
Experimental group (n = 14)		
Glucose (mg/dL)	91.1 ± 12.7^{a}	98.5 ± 17.2^{a}
Cholesterol (mg/dL)	142.2 ± 47.4^{a}	146.1 ± 39.3^{a}
Triglycerides (mg/dL)	102.0 ± 19.1^{a}	116.0 ± 18.2^{a}
HDL (mg/dL)	$51.9 \pm 12.5^{a*}$	$60.1 \pm 18.9^{b*}$
LDL (mg/dL)	69.9 ± 45.5^{b}	62.7 ± 41.9^{a}
Atherogenic index	2.9 ± 1.1^{b}	$2.6 \pm 1.1^{a*}$
Control group (n = 15)		
Glucose (mg/dL)	97.9 ± 14.4^{a}	97.9 ± 12.2^{a}
Cholesterol (mg/dL)	137.3 ± 35.8^{a}	138.1 ± 45.9^{a}
Triglycerides (mg/dL)	112.9 ± 26.3^{a}	119.5 ± 25.2^{a}
HDL (mg/dL)	$72.2 \pm 21.7^{b*}$	$54.2 \pm 19.9^{a*}$
LDL (mg/dL)	42.5 ± 33.3^{a}	59.2 ± 52.2^{b}
Atherogenic index	2.0 ± 0.66^{a}	$3.3 \pm 3.4^{b*}$

^{a,b}Different letters between column values (0 and 14th week) indicate significant difference ($p \leq 0.05$ Student's t-test). $*$ indicates significant differences between groups in the same column ($p = <0.05$).

current trends (ENSANUT 2006 and 2012) that at least 70% of the Mexican population is overweight and obesity [41].

After the 14th week intervention, both groups improved their anthropometric measurements with a decrease in body fat and an increase in fat-free mass, which could be due to the healthier production conditions of the poultry products (both supplemented and nonsupplemented) in comparison to the conditions of commercial products. The group who consumed supplemented foods with *omega-3* had a decrease in waist circumference after the intervention period, but there was no statistical significance between groups. It is possible that longer periods of study would be necessary to establish a significant difference between the two study groups. Other studies showing the improvement of anthropometric variables with the consumption of *omega-3* supplement foods or *omega-3* supplements (doses of ≈2 g/day) had intervention periods of 4-5 months [42, 43]. These studies had established that the supplementation with *omega-3* could inhibit the differentiation of preadipocytes and an increase of the apoptosis of these cells and/or the regulation of sympathetic nervous system and production of leptin and adiponectin causing the regulation of body fat which leads to changes in the distribution of the ratio of fat-free mass [43, 44].

3.2. Biochemical Parameters. At the beginning of the study, the participants had optimum biochemical parameters (glucose, triglycerides, cholesterol, HDL, and LDL) in accordance with the Procedures Manual of the Secretary of Health (SSA) in Mexico [29, 30] and these were maintained in normal conditions until the end of the intervention (Table 2). The statistical analysis showed differences with HDL (high density lipoprotein) levels between the groups at the beginning of the study, which could be affected by several individual factors of the study population (age, diet, stress, tobacco, alcohol, physical activity, etc.) [33, 45, 46], which must be considered in future supplementation studies. At the end of study, the concentrations of HDL showed a tendency to increase in experimental group (51.9 to 60.1 mg/dL) and LDL (low density lipoprotein) decreased (69.9 to 62.7 mg/dL) causing the reduction of atherogenic index (2.6 to 2), while the control group showed a contrary behavior. The value of the means difference of HDL was 25.47 mg/dL (CI 95% 4.076–46.882, p: 0.021). This represented an increase of 42.5% of the HDL at baseline concentration. These values reinforce the result that there was a positive impact of the supplementation. The effect of the *omega-3* had been found in other studies with supplement foods (yogurt, butter, and pate with fish oil) [47–49] accompanied by a significant reduction of LDL and an increase of HDL in blood.

Some authors have established that LDL reduction and HDL increase correlated with intake of *omega-3* could be due to a variety of mechanisms. The consumption of marine *omega-3* fatty acids could have a relatively neutral effect on LDL and HDL through targeted effects on specific transcription factors and nuclear receptors. Such is the case of PPAR (peroxisome proliferator-activated receptor) that increase HDL by enhancing reverse cholesterol transport [50]. According to some research, the fraction PON1 (paraoxonase), Clusterine, ApoAI, and ApoCIII present in HDL allow regulation in oxidation mechanisms of lipids metabolism [51, 52] and anti-inflammatory process [53] and decrease in proatherogenic lipoproteins (LDL, VLDL) [51, 54]. These functions play an important role in the prevention of atherosclerosis development and other cardiovascular diseases [12, 51, 52, 55]. In addition, other studies show that *omega-3* significantly reduce LDL due to the enzymatic inhibition of *acyl*-CoA: 1,2-diaglycerolacyltransferase impacting hepatic synthesis of triglycerides and LDL [49, 56], protecting the dysfunction of endothelial cells inhibiting lipogenesis and favoring lipolysis, increasing mitochondrial dynamics, and therefore causing a decrease of chronic diseases.

3.3. Cardiovascular Function Parameters. At the beginning of the study, the experimental and the control group reached

Table 3: Cardiovascular function parameters of experimental and control group.

	week 0	week 14
Experimental group (n = 14)		
Test duration (min)	9.8 ± 2.1[a]	10.3 ± 1.9[a]
Recovery time (min)	4.5 ± 1.7[a]	4.0 ± 1.3[a]
Electrocardiogram		
PQ (ms)	157.3 ± 17.2[a]	158.7 ± 15.8[a]
QRS (ms)	91.5 ± 11.8[a]	89.0 ± 9.0[a]
QT (ms)	413.0 ± 31.4[a]	404.1 ± 31.1[a]
QTc (ms)	408.7 ± 31.0[a]	416.5 ± 20.3[a]
Heart rate (beats/minute)		
Before test	82.4 ± 11.1[b]	74.3 ± 10.1[a]
At the test end	135.7 ± 15.9[a]	152.2 ± 15.0[b]
Blood pressure mm/Hg		
Systolic before test	110.5 ± 11.1[a]	106.1 ± 9.2[a]
Systolic at the test end	132.2 ± 11.1[a]	134.6 ± 12.4[a]
Diastolic before test	78.5 ± 7.4[b]	72.8 ± 6.1[a]
Diastolic at the test end	84.2 ± 12.8[b]	74.2 ± 7.3[a]
Control Group (n = 15)		
Test duration (min)	10.6 ± 3.7[a]	10.6 ± 3.5[a]
Recovery time (min)	4.8 ± 1.7[a]	4.5 ± 1.6[a]
Electrocardiogram		
PQ (ms)	158.0 ± 17.4[a]	156.4 ± 16.4[a]
QRS (ms)	98.2 ± 12.4[a]	96.5 ± 12.5[a]
QT (ms)	407.6 ± 36.1[a]	403.2 ± 4.0[a]
QTc (ms)	417.3 ± 22.2[a]	416.8 ± 23.4[a]
Heart rate		
Before test	74.3 ± 11.1[a]	78.2 ± 13.9[b]
At the test end	139.0 ± 19.1[a]	144.1 ± 22.1[a]
Blood pressure mm/Hg		
Systolic before test	109.6 ± 9.3[a]	107.0 ± 12.2[a]
Systolic at the test end	131.0 ± 12.5[a]	134.0 ± 25.6[a]
Diastolic before test	76.0 ± 8.7[a]	74.6 ± 7.4[a]
Diastolic at the test end	81.3 ± 7.4[a]	77.6 ± 10.4[a]

[a,b]Different letters between column values (0 and 14th week) indicate significant difference ($p \leq 0.05$ Student's t-test).

80% of their cardiac capacity at 10 minutes of physical effort without significant changes after the 14th week of study. In addition, the time range of the electrocardiographic segments (PQ, QRS, QT, and QTc) in both groups was normal at each evaluation time, discarding the presence of cardiac arrhythmias or other abnormalities that could affect the performance of the stress test during the evaluation period. The basal heart rate and arterial pressure of the study groups had normal ranges; however, after the 14th week only the experimental group showed a decrease in both parameters changing from normal ranges to optimum (heart rate, diastolic pressure before and after the test) (Table 3). The participants of the experimental group had less fatigue and less heart strain at the 14th week having a normalizing effect on the diastolic pressure according with other studies [57–59]. However, these changes were not statistically significant between the experimental group and the control group. Previously, we have mentioned that these differences could become significant if the time study had been extended.

Several studies [57–59] had shown less cardiac effort after supplementation with *omega-3*, which could be due to several mechanisms, mainly due to the function of these polyunsaturated fats on the permeability and fluidity of the cell membrane improving nervous impulse and muscular contraction. Other authors [60] have established that the aldosterone secretion, increased nitric oxide, and a higher production of prostaglandins are related to a reduction of platelet aggregation contributing with anti-inflammatory

process which allows the regulation of blood pressure and thus the improvement of cardiovascular function.

4. Conclusion

The consumption of supplemented poultry products with *omega-3* increased the HDL concentration and decreased atherogenic index related with cardiovascular diseases improving the overall health status in the test population. Therefore, poultry products supplemented with *omega-3* could be a viable alternative in populations where the consumption of fish products is low. Hence, it is important to replicate these studies with the extension of the time study and the inclusion of other foods.

Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

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