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Effect of N3-Poliunsaturated Fatty Acids as Coadjuvant in the Antihypertensive Treatment in Spanish Postmenopausal Women

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Abstract

Objective: The purpose of this study is to evaluate the effects of taking low doses of omega-3 (1,5 g/day) in hypertensive women.

Method: Longitudinal clinical trial Health Center of San Fernando de Badajoz. Primary care. 55 postmenopausal hypertensive women. For the study, participants were divided into two groups, group supplementation (GS) (n=28) and one control group (CG) (n=27). Supplementation with n-3 PUFA to the experimental group for 6 months (1.5 g/day). The control group was given nothing. The variables of the study have been blood pressure, n-3 fatty acid supplementation and it was tried to control nutritional intake.

Results: In SG, systolic blood pressure decreased significantly at the third ($p<0.001$) and sixth ($p<0.001$) month after starting the study, and three months ($p<0.01$) since the end of supplementation. With regards to diastolic blood pressure levels in the same group, also produced a decrease that became significant ($p<0.01$) after six months of supplementation and maintained at three months of concluding the supplementation, even without acquire statistically signification. We have shown increases in the plasma percentages of fatty acids C20:5n3 and C22:6n3, after three months of initiating supplementation ($p<0.05$), after 6 months of it ($p<0.001$) and in three months of leaving supplementation ($p<0.001$). Arachidonic acid decreases throughout the supplementation period and this reached a statistically significant difference after 6 months within supplementation.

Conclusions: The intake of 1.5 g/day of fish oil as coadjuvant in the treatment of all kinds of arterial hypertension improves blood presure and other cardiovascular diseases.

Keywords: Postmenopausic women; Hypertension; Lipids; n-3-fatty acid

Introduction

Cardiovascular disseases (CD) are the main cause of death in Spain [1]. A wide number of surveys have shown an inverse relationship among CD and the n-3 poliunsaturated fatty acids (n-3 PUFAs) intake [2-5]. In this sense, it has been research in surveys of nutritional intervention, among humans and animals, the kinetics of n-3 PUFAs, their incorporation to cellular structures and their link to eicosanoids metabolism, in comparison with n-6PUFAs [6-8]. Furthermore, the efficacy of several fatty acids derived from fish oil, like the eicosapentaenoic acid (20:5n-3 or EPA) and the docosahexaenoic acid (22:6n-3 or DHA) as well as other minor important PUFAs, in the treatment of cardiovascular disseases with minimum daily intakes of 0.5 g/day in healthy individuals and 1 g/day in patients diagnosed with CD [9]. Several surveys have demonstrated anticarcinogenic, antitrombotic and antiarrithmic effects of n-3 PUFAs [10]. However, it has been stated that the effects of n-3 PUFAs on CD depends on the balance with other nutritional compouds, like n-6 PUFAs [11]. Arterial hypertension (AHT) is a serious, infradiagnosed dissease, with growing prevalence and, frequently, poorly controlled [12]. AHT is determined as an arterial pressure ≥ 140 mmHg and/or ≥ 90 mmHg. It is generally treated with antihypertensive farmacological treatment. AHT affects more of the 15% of occidental countries inhabitants, with an unknown etiology, but frequently affected by nutritional factors, like the fat intake [13,14]. Among Spanish inhabitants, some surveys have pointed out that AHT ranges between the 30 and the 50% of total population [15]. AHT surveys trends to attribute hypotensive properties to n-3 PUFAs [16,17] althought the results are contradictory [5]. Some meta-analysis and reviews have attributed this discrepancy to the variability of several critical factors, like dosage, sample size, timing and duration of the treatment and the patient's selection criteria [18-20]. Althought some data have demonstrated the diminution of arterial tension (AT) with n-3 PUFAs in the essential hipertension [18,21,22], it was suggested that the supplementation with diet could be more appropriate in the prevention strategies than in the AHT treatment [18]. Nutritional supplements rich in n-3 PUFAs can decrease the AT. However, their use has been reduced due to the high dosage needed as well as to the side concominant effects. Several meta-analysis and intervention surveys [20,23] have suggested that high dosage supplementation with n-3 PUFAs (tipically 3 g/day) can reduce significantly the AT in arterial hypertesive patients [22,24], but with side effects. So, the aim of the present survey was to evaluate the effect of low-medium dosage n-3

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PUFAs (1,5 g/day) as coadjuvant treatment, in combination with other antihypertensives, in the AT of Spanish postmenopausal women.

Material and Methods

Participants

55 hypertensive postmenopausal women participated in this survey. All of them were recruited from the San Fernando Clinic of Badajoz (Spain). The participants were ramdomly divided in two groups: the supplementation group (SG; n=28) who were supplemented with n-3 PUFAs, and the control group (CG; n=27) who were not supplemented. As inclusion criteria, it was stablished by the physician that all participants should present at least 12 moths of amenorrhea, and to should be diagnosed as hypertensive at least 3 months before the beginning of the survey. General characteristics of both groups are presented in Table 1. All hypertensive participants were diagnosed in accordance with the criteria of the fifth Joint National Committee on Detection, Evaluation, and Treatment of High Blood Pressure of 1993 (JNC-V) (SBP> 140; DBP> 90 mmHg). Antihypertensive farmacological treatment were followed homogeneously between groups, and consisted in: diet (n=8), diuretics (n=16), calcium antagonists (n=10), Inhibitors of the angiotensin-converting enzyme (n=6), calcium antagonists plus diuretics (n=10). Inhibitors of the angiotensin-converting enzyme plus calcium antagonists plus diuretics (n=5). The change of pharmacological treatment during the experimental period was fixed as exclusion criteria.

The supplementation of the SG consisted in fish oil capsules composed of fish from salmon, trout, mackerel, herring and sardine, with a nutritional composition equivalente to 21% of EPA and 11% of DHA. Both groups were controlled in the third and sixth months of the survey and three months after the supplementation period (6 months). All participants were previously informed about the survey, participated voluntary and all of them gave their signed informed consent. This research was carried out under the Helsinki Declaration ethic guidelines, updated at the World Medical Assembly in Seoul in 2008, for research with human subjects.

Dietetic control

All participants followed a similar 1500 Kcal, low in sodium, diet. Before the start of the survey a nutritional questionarie was applied to each participant in order to ensure no differences between groups in the intake of macronutrients and n-3 and n-6 PUFAs. The nutritional control was carried out by the same physician during the whole experimental period. The questionarie consisted of 3 consecutive days (2 weekdays and 1 weekend day) registry. The same registry was applied to all partincipans at the beginning, at the third and sixth monts of the supplementation period and three monts after this period. In order to determine macro and micronutrients of their diets, different tables of nutricional composition were used [25]. It was previously objectified and protocolized the different quantities of food ingested by participants, stablishing a standardization in order to diminished the error in the nutritional records introduced in the databases.

	Supplementation group	Control group
Age (years)	61.8 ± 6.96	62.2 ± 8.42
Postmenopausal years (years)	13.62 ± 8.34	13.82 ± 9.42
Heigh (m)	1.51 ± 0.05	1.52 ± 0.05
Wheigh (kg)	75.16 ±11.69	76.18 ± 11.44
BMI (kg/m^2)	32.70 ± 4.67	32.78 ± 4.52

Table 1: Characteristics of both groups.

Anthropometric meassurements

Antrhopometric characteristics of all participants were evaluated always at the same time. To determine the body wheight, a *Seca* weighing machine (Hamburg, Germany©) with a precision of ± 100 g was used; to determine the height, a *Seca* tallimeter (Hamburg, Germany©) with a precision of ± 1 mm was used; body fat percentajes were measured with a *Holtain* plicometer (Crymych, United Kingdom©) with a precision of ± 0.2 mm. The equations used to calculate the body fat mass were determined by Porta et al., (1993) [26] of the Spanish Group of Cineanthropometry. Body mass index (BMI) was calculated dividing body wheigh (kg) by squared heigh (m^2).

Blood arterial pressure meassurement

Bloord arterial pressure was meassured in sitting position in the left forearm, leaning it in a soft surface, at the heart high. Each measurement was repeated three times in similar conditions, waiting three minutes between meassurements. All measurements were performed by the same skilled physician with an esfigmonamoter of mercury (Riester, 660-2-306). The measurements were made at the beginning of the survey and each 15 days of the experimental period. All evaluations were performed in the same clinic, in similar conditions.

Blood samples determination

One blood extraction was taken of the antecubital vein to each participant. The extrations were performed in the morning after, at least, 8 hours of fasting. Blood samples were ploted in glass tubes with lithium herparine. Once obtained, the samples were centrifuged at 2500 rpm during 10 minutes. After this process, erythrocytes were isolated, extracted from plasma and washed three times with a sodium chloride at 0.9%. Finally, they were frosted at -80ºC until biochemical analysis. Total plasma cholesterol and tryglycerides were determined by spectrophotometry, using a Hitachi 717 autoanalyzer and commercial kits for biochemical determination. To determine total fatty acids in plasma and erythrocyte, 0.5 mL were extrcted of each sample, then, 2 mL of methanol/benzene (4:1) with an internal pattern (17:0) were added. Once mixed, the samples were softly shaked in a magnetic stirrer while 200 µL of Acetil chloridre were progressively added. After that, the samples were stoppled and sealed with Teflon in order to avoid evaporation losses. Once sealed, the samples were heated at 100ºC for one hour and cooled in coold water. Then, 5 mL of CO_3K_2 at 6% were slowly added to each sample to stop the reaction and neutralize the mixtures. After that the samples were centrifugued at 6000 rpm during 5 minutes. Then, the benzene extracts containing mutilated fatty acids were taken for the tubes to be injected in the chromatographer.

For each sample, 3 µL of benzene extrac were injected. A gas chromatographer HP-5890 Series II was used to determine the biochemical analysis. This chromatographer was equipped with a HP-5972 mass spectrometer detector. The column used to determinate the samples was a capilar column SGE-BPX70 of 50 m. 0.33 × 0.25. The fatty acids determined with this technique were: saturated fatty acids (SFAs): 14:0, 16:0, 18:0; Monounsaturated fatty acids (MUFAs) 16:1, 18:1 y 20:1; n-6 poliunsaturated fatty acids (n6-PUFAs): 18:2, 18:3.6, 20:3 y 20:4; and n-3 poliunsaturated fatty acids (n3-PUFAs): 18:3.3, 20:5, 22:5 y 22:6.

Statistical analysis

All data were analyzed with the software *IBM SPSS Statistics* in the version 22.o for *windows*. The results are expressed as average ± standard deviation. The minimum percetaje required for statistical

significance was fixed in 5% ($p<0.05$). Wilcoxon test was used to compare differences between each group alog the different moments of evaluation.

Results

Participants characteristics

All the 55 women completed the survey. Table 1 recopilates the characteristics of both groups at the beginning of the survey. This data manifest an accurate adaptation of the participants to the inclusion criteria.

Dietary intake of cholesteroland fatty acids during the survey

Table 2 refects the weekly nutritional intake of SFAs, MUFAs, n3-PUFAs and n6-PUFAs of all participants of both groups.

Anthropometric evaluation

Table 3 shows the anthropometric characteristics of both groups during the survey.

As it can be observed in Table 3, no anthropometric changes are produced in the CG. However, the SG experienced a highly significant (p<0.001) diminution in the tripecs and subscapular folds after 6 months of supplementation. Additionally, 3 months after the supplementation period, the diminution in body wheigh (p<0.01) and in triceps (p<0.001), subscapular (p<0.001) and abdominal (p<0.001) folds maintain significantly lower in comparison to the initial values.

Blood pressure and lipidic profile

Table 4 shows data about blood pressure and total plasma cholesterol and tryglicerids concentrations during the research period.

Table 4 shows that no changes have been occurred in any parameter of the CG. In the SP, the SBP decreased significantly (p<0.01) during the supplementation period, and it was maintained decreased (p<0.05) three monts after this period, in comparison to the initial values. However, the DBP only decreased significantly (p<0.05) afther 6 months of supplementation. Total cholesterol decreased (p<0.05) after 3 months after supplementation and it was maintained (p<0.05) 3 months after the supplementation period. Tryglycerides only reaches statistical significance afther 6 months of supplementations, being higher (p<0.05) in comparison to the initial values.

Total plasma fatty acids concentrations

Table 5 presents the effects of MUFAs supplementations in the total plasma fatty acids profile.

As previously occurred, no changes were produced in the CG in any parameter. The n3-PUFAs supplementation affected the levels of DHA and EPA, wich increased (p<0.05) after 3 months of supplementation, after 6 months of supplementation (p<0.001), and continued augmented (p<0.001) after three months after the supplementation period. N3-PUFAs also showed a similar trend during the survey. N6/n3-PUFAs index decreased (p<0.05) afther 6 months of supplementation, and maintained these values three months after the end of the supplementation (p<0.05). It is remarkable that after the survey the FA C24:1, C18:2-6, C20:3-6, C20:4-6, C20:5-3, C22:6-3 (p<0.001); C18:3-6 (p<0.01); C14:0 and C18:1E (p<0.05) increased in comparison to the initial values.

Erythrocite fatty acids profile

The results of the different percentajes of fatty acids in the erythrocyte membrane are presented in Table 6.

Biochemistry	Quantity
Cholesterol	1285.40 ± 272.10
Saturated Fatty Acids (SFA)	106.45 ± 44.71
Monounsaturated Fatty Acids (MUFAs)	174.35 ± 82.08
Total Polyunsaturated Fatty Acids (PUFAs)	52.71 ± 28.55
C14:0	9.44 ± 5.85
C16:0	63.06 ± 25.74
C18:0	21.21 ± 9.52
C16:1	7.44 ± 3.19
C18:1	154 ± 74.93
C18:2-6	48.6 ± 29.25
C18:3-3	0.36 ± 0.27
C20:4-6	3.35 ± 1.41
C20:5-3 (EPA)	0.89 ± 0.90
C22:6-3 (DHA)	2.38 ± 2.13

Table 2: Weekly intake of Cholesterol (mg/week) and fatty acids (g/week).

	Start		3 Months		6 Months		3 Months post	
	SG	CG	SG	CG	SG	CG	SG	CG
Wheigh (kg)	75.16 ± 11.69	76.18 ± 11.44	75.96 ± 11.57**	75.33 ± 11.34	76.43 ± 11.75*	76.13 ± 11.43	76.39 ± 11.71**	75.99 ± 10.22
Triceps fold (mm)	38.52 ± 6.71	37.42 ± 5.2	36.21 ± 8.57	38.02 ± 6.92	33.48 ± 7.28***	37.62 ± 6.40	30.01 ± 6.87***	35.01 ± 4.61
Subescapular fold (mm)	31.17 ± 6.83	30.17 ± 5.31	29.28 ± 7.93	31.57 ± 5.43	28.37 ± 7.55***	30.97 ± 6.23	24.96 ± 5.64***	31.98 ± 2.25
Suprailiac fold (mm)	22.64 ± 5.24	23.04 ± 4.22	23.05 ± 5.39	22.98 ± 6.02	23.69 ± 6.16	23.95 ± 6.00	20.27 ± 4.80	23.52 ± 6.02
Abdominal fold (mm)	38.70 ± 6.61	39.42 ± 6.02	38.31 ± 6.03	38.90 ± 5.99	35.37 ± 5.53	37.99 ± 8.24	29.61 ± 5.64***	39.62 ± 7.80

*p< 0.05; **p< 0.01;***p< 0.001, Wilcoxon test.

Table 3: Effects of n3-PUFAs supplementation on anthropometric parameters.

	Start		3 Months		6 Months		3 Months post	
	SG	CG	SG	CG	SG	CG	SG	CG
SBP (mmHg)	159.53 ± 19.58	147.56 ±14.48	146.37 ± 13.90**	148.62 ±12.23	144.44 ± 18.20**	144.18 ± 13.22	153.88 ± 18.04 *	143.44 ± 14.12
DBP (mmHg)	96.44 ± 11.61	84.01 ± 5.24	93.80 ± 6.04	85.22 ± 6.42	90.06±7.96*	86.01 ± 5.32	93.77 ± 9.06	83.12 ± 5.18
Total Cholesterol (mg/dL) (50-200)	226.66 ± 31.92	215.24 ±10.10	214.29 ± 33.35*	214.12 ± 13.12	228.51 ± 31.86	210.34 ± 11.40	217.37 ± 33.40*	211.18 ± 12.11
Total tryglycerides (mg/dL) (35-150)	115.44 ± 43.98	118.1 ± 44.12	117.14 ± 52.01	121.05 ± 43.12	135.88 ± 57.26*	125.33 ± 50.34	117.25 ± 53.07	120.45 ± 43.12

*p< 0.01; ** p< 0.001, Wilcoxon test.

Table 4: Effects of n3-PUFAs supplementation on parameters of blood pressure, total cholesterol and tryglycerides.

	Start		3 months		6 months		3 months post	
	SG	CG	SG	CG	SG	CG	SG	CG
C14:0	0.67 ± 0.29	0.70 ± 0.23	0.67 ± 0.21	0.69 ± 0.31	0.80 ± 0.38	0.72 ± 0.19	0.70 ± 0.20*	0.81 ± 0.23
C16:0	23.61 ± 5.10	24.24 ± 6.20	24.47 ± 2.32	24.40 ± 4.30	25.22 ± 1.99*	24.11 ± 6.00	20.47 ± 1.46	24.31 ± 4.80
C18:0	9.75 ± 2.10	9.86 ± 1.89	10.45 ± 1.39*	10.14 ± 2.53	9.93 ± 2.04	9.63 ± 3.1	8.51 ± 3.20	9.67 ± 3.01
C16:1	1.27 ± 0.75	1.34 ± 1.01	1.04 ± 0.56	1.46 ± 0.82	1.33 ± 0.58	1.34 ± 0.42	1.20 ± 0.56	1.84 ± 0.51
C18:1Z	19.52 ± 3.69	20.01 ± 4.10	18.25 ± 4.47	19.43 ± 3.18	19.01 ± 3.30	18.63 ± 2.99	19.11 ± 3.64	19.65 ± 2.87
C18:1E	1.28 ± 0.21	1.18 ± 0.31	1.16 ± 0.19	1.24 ± 0.35	1.12 ± 0.28	1.63 ± 0.48	1.82 ± 0.82*	1.13 ± 0.16
C24:1	1.11 ± 0.34	1.56 ± 0.88	0.91 ± 0.28*	1.35 ± 0.12	1.04 ± 0.29	1.43 ± 0.51	1.29 ± 0.37***	1.21 ± 0.29
C18:2-6	30.98 ± 5.30	31.22 ± 5.89	32.19 ± 5.66*	31.64 ± 5.89	32.20 ± 4.87*	31.42 ± 6.01	32.02 ± 5.96***	30.99 ± 5.14
C18:3-6	0.06 ± 0.14	0.06 ± 0.23	0.04 ± 0.12	0.07 ± 0.20	0.05 ± 0.15	0.06 ± 0.20	0.29 ± 0.26***	0.04 ± 0.18
C18:3-3	0.02 ± 0.09	0.02 ± 0.06	0.01 ± 0.07	0.02 ± 0.10	0.01 ± 0.06	0.02 ± 0.11	0.29 ± 0.67**	0.02 ± 0.08
C20:3-6	0.98 ± 0.48	0.92 ± 0.52	0.96 ± 0.54	0.91 ± 0.61	0.98 ± 0.52	0.95 ± 0.3	1.79 ± 0.63***	0.90 ± 0.33
C20:4-6	6.12 ± 2.04	6.42 ± 2.13	5.51 ± 1.84	6.74 ± 2.21	5.27 ± 1.61*	6.34 ± 1.99	7.09 ± 1.99***	6.42 ± 2.22
C20:5-3 (EPA)	0.32 ± 0.44	0.34 ± 0.47	0.66 ± 0.52*	0.45 ± 0.27	1.05 ± 0.82***	0.39 ± 0.54	1.58 ± 0.49***	0.49 ± 0.54
C22:6-3 (DHA)	2.09 ± 0.65	2.12 ± 0.55	2.53 ± 0.87*	2.22 ± 0.45	2.85 ± 0.66***	2.10 ± 0.32	2.56 ± 0.79***	1.99 ± 0.98
SFAs	34.03 ± 6.67	34.78 ± 6.82	36.43 ± 5.20	35.23 ± 6.20	37.03 ± 3.09	34.46 ± 5.20	30.92 ± 3.84	34.79 ± 25
MUFAs	23.18 ± 4.23	23.64 ± 5.02	21.73 ± 5.40	23.40 ± 4.33	21.45 ± 3.61	23.04 ± 4.15	23.43 ± 4.25	23.83 ± 5.12
Total PUFAs	40.57 ± 6.28	41.70 ± 6.72	41.83 ± 6.02	42.11 ± 5.70	40.44 ± 5.19	41.31 ± 6.07	45.64 ± 6.11	40.17 ± 6.54
n-6 PUFAs	38.14 ± 5.90	39.22 ± 6.02	38.60 ± 6.10	39.41 ± 5.80	37.50 ± 4.90*	38.80 ± 6.00	41.19 ± 5.89	38.37 ± 5.76
n-3 PUFAs	2.43 ± 0.42	2.48 ± 0.48	3.20 ± 0.41*	2.69 ± 0.49	3.91 ± 0.40**	2.51 ± 0.51	4.43 ± 0.42**	2.50 ± 0.96
n-6/n-3 index	15.69 ± 2.42	15.81 ± 2.40	12.06 ± 2.10	14.65 ± 2.50	9.59 ± 1.92*	15.45 ± 2.87	9.29 ± 1.97*	15.34 ± 2.78

*p< 0.05; **p< 0.01; ***p< 0.001, Wilcoxon test.

Table 5: Effects of n3-PUFAs supplementation on fatty acids percentajes and the relationship of n6/n3-PUFAs in plasma.

	Start		3 months		6 months		3 months post	
	SG	CG	SG	CG	SG	CG	SG	CG
C14:0	0.53 ± 0.25	0.41 ± 0.22	0.40 ± 0.25	0.48 ± 0.31	0.48 ± 0.60	0.49 ± 0.29	0.45 ± 0.25	0.47 ± 0.45
C16:0	22.49 ± 7.65	22.68 ± 7.42	25.00 ± 2.37	23.69 ± 6.42	27.91 ± 2.35	23.52 ± 6.90	23.19 ± 4.86	22.68 ± 6.65
C18:0	19.76 ± 5.74	18.12 ± 5.14	19.21 ± 2.37	19.24 ± 4.99	20.43 ± 2.54	20.54 ± 6.44	18.00 ± 2.00	19.32 ± 4.84
C16:1	0.16 ± 0.39	0.17 ± 0.42	0.33 ± 0.44	0.18 ± 0.53	0.30 ± 0.54	0.24 ± 0.39	0.22 ± 0.43	0.22 ± 0.62
C18:1Z	1.76 ± 0.96	1.22 ± 0.16	0.00 ± 0.00	1.01 ± 0.63	0.48 ± 0.80	1.02 ± 0.87	0.00 ± 0.00	0.00 ± 0.00
C18:1E	17.54 ± 4.24	16.45 ± 5.22	15.48 ± 1.98	16.22 ± 3.61	17.65 ± 2.18	17.14 ± 5.00	15.46 ± 2.10	16.32 ± 5.22
C24:1	6.92 ±1.60	5.97 ± 1.86	5.47 ± 1.36	6.53 ± 1.32	5.60 ± 1.52	6.04 ± 3.50	6.61 ± 5.06	7.00 ± 1.80
C18:2-6	12.25 ± 2.42	13.25 ± 3.13	14.13 ± 3.26	13.52 ± 3.00	12.68 ± 2.53	12.95 ± 3.54	12.15 ± 1.32	14.00 ± 3.13
C18:3-6	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.07 ± 0.36	0.00 ± 0.00
C18:3-3	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
C20:3-6	1.03 ± 0.72	1.15 ± 0.85	1.08 ± 0.48	1.25 ± 0.64	1.15 ± 0.62	1.09 ± 0.95	1.06 ± 0.55	1.10 ± 0.81
C20:4-6	8.30 ± 2.75	8.98 ± 3.75	7.91 ± 2.31	8.44 ± 2.87	7.92 ± 2.01	7.61 ± 2.44	8.51 ± 2.27	7.99 ± 2.89
C20:5-3 (EPA)	2.96 ± 0.66	3.21 ± 0.54	2.88 ± 1.12	2.99 ± 0.87	2.83 ± 0.89*	2.12 ± 0.58	3.62 ± 3.41	3.08 ± 0.72
C22:6-3 (DHA)	3.72 ± 2.13	3.68 ± 3.22	2.85 ± 1.23	3.56 ± 1.97	2.70 ± 1.26*	3.42 ± 2.54	3.20 ± 1.47	3.83 ± 2.42
SFAs	40.95 ± 10.81	41.43 ± 11.20	50.25 ± 4.26	43.41 ± 19.01	54.97 ± 4.56	44.55 ± 4.56	48.74 ± 6.10	42.47 ± 6.90
MUFAs	26.40 ± 7.40	24.62 ± 6.04	22.31 ± 4.25	23.94 ± 4.33	24.11 ± 2.84	24.44 ± 3.42	22.30 ± 4.61	23.54 ± 3.98
Total PUFAs	29.63 ± 7.40	28.26 ± 2.22	27.43 ± 4.67	29.76 ± 4.12	28.83 ± 4.96	27.19 ± 5.40	28.95 ± 5.74	30.01 ± 4.89
n-6 PUFAs	21.58 ± 6.71	23.38 ± 6.54	23.12 ± 6.43	23.21 ± 6.70	21.71 ± 6.56	21.65 ± 5.98	21.72 ± 6.01	23.09 ± 7.02
n-3 PUFAs	6.68 ± 1.65	6.69 ± 1.62	5.73 ± 1.51	6.55 ± 1.60	5.53 ± 1.52*	6.54 ± 1.59	6.82 ± 1.60	6.91 ± 1.64
n-6/n-3 index	3.23 ± 0.51	3.33 ± 0.54	4.03 ± 0.52	3.54 ± 0.49	3.92 ± 0.50	3.31 ± 0.54	3.18 ± 0.49	3.34 ± 0.50

*p< 0.05, Wilcoxon test.

Table 6: Effects of n3-PUFAs supplementation on fatty acids percentages of the erythrocyte membrane.

It can be observed in the Table 4 that no changes occurred in the erythrocyte membranes of the CG. In the case of SG, the values of EPA, DHA and n3-PUFAs decreased ($p<0.05$) after 6 months of supplementation.

Discussion

In the present survey, all participants were diagnosed as hypertensive and postmenopausal, and sensibly older than the participants of other similar surveys [27]. They also presented clear risk factors for cardiovascular issues and obesity, eating low quantities of n3-PUFAs in their initial diets (Table 2). In this survey, the participants formed two diferente, homogeneous groups that made it possible to research the effects of fish oil supplementation (n3-PUFAs) as coadjuvant therapy in the treatment of arterial hypertension. The administration of 1.5 g/day of fish oil in the SG decreased significantly the systolic blood pressure (SBP) ($p<0.001$) and the diastolic blood pressure (DBP) ($p<0.01$) (Table 4).

Some previous surveys have demonstrated a diminution in the blood pressure as consequence of n3-PUFAs [22,28], but with dosages higher than 3 g/day. In this sense, surveys with animas and humans have demonstrated that EPA and DHA are incorporated in a different way in plasma [29], platelets, cellular membranes [6] and fatty tissue [30]. According to these reports, the diminution in the SBP experienced by the SG could be due to a progressive doby accumulation of n3-PUFAs during the supplementation period. It is highly remarkable here that these participants had previously had a low nutritional intake of these nutrients. So, the administration of this fish oils in this survey could effectively reduce their BP. In fact, this diminution is higher when the supplementation period is lengthened. Theoretically, this n3-PUFAs accumulation could maintain the BP diminution three months afther the supplementation. However, the DBP diminutions were produced more slowly, reaching the statistical significance ($p<0.05$) 6 months afther the beginning of the supplementation period. After the treatment, the BP trends to return to the previous values, without statistical significance (Table 4). Additionally to these cardiovascular effects, anthropometric changes were produced in this survey. The SG experienced a diminution of subcutaneous body fat. This is a remarkable fact, because the subcutaneous fat induces a great tension on the cardiovascular system, increasing the cardiac output and finally reaching the BP. This periferical subcutaneous fat reduction could reduce the BP by itself. It should be considered that in the previous surveys the skinfolds were not considered among hypertensive patients and this could taint the obtained results. Cholesterol concentrations were high (≥ 200 mg/dL) during all the survey and only decreased singnificantly at the third month os the supplementation. This fact reinforces the results previously obtained in similar populations with fish oils and vitamin E [31], as well as with an increment in the intake of PUFAs from extra virgin olive oil [32]. In relationship to total plasma FA (Table 5), the increment of FA 16:0 and C18:0 experienced in the SG at 3 and 6 months of supplementation can be due to a greater mobilization of periferical fat mass as consequence of a higher n3-PUFAs intake. In the case of PUFAs, a total increment occurred, buth no in the cases of, EPA and DHA, as occurred in previous surveys [28]. Oppositely, the n-6 family showed an increase in the 18:2 and a diminution in the C20:4-6. In this sense, a diminution in the activity of the enzyme Δ5 desaturase induced by the intake of EPA and DHA could block the formation processes of the n6-PUFAs and, consequently, reach the disponibility of the n3 substrates for the cellular lipooxygenase and cyclooxygenase, inducing an increase in the levels of A3 thromboxane (A3TX) in the plateles (inactive as proagregant) and I3 prostaglandin (I3PG), a power vasodilator, in endothelial cells. In no supplementation conditions among this population the n6-PUFAs production is not blocked so that the n-6 substrates are used to produced I2PG (vasodilator) and A2TX (power proagregant) [33]. This fact could induce a higher arterial vasodilation status, a lower vasoconstriction and platelet aggregation (A3TX) and, consequently, a diminution in the BP [34]. It has been recommended a relationship between n6/n3-PUFAs in the diet of 2-3/1. In this sense, it is believed that the diminution of the intake of n3-PUFAs, specially EPA and DHA in the last 50 years is the main case of several disseases [33]. In the present survey, the proportion of n6/n3-PUFAs was, approximately 15-16/1 in the diets of the SG, accompanied by similar plasma proportions. This is a great proportion in comparison to the recommended one. However, with the fish oil supplementation this proportion was reduced to 9-10/1 which could improve the BP and the health of the postmenopausal participants. The fatty acids percentajes of the erythrocyte membranes of the pacients (Table 6) decreased significantly in the cases of EPA and DHA after 6 months of supplementation, which may be an indicative of a greater metabolism of n3 substrates by the cellular cyclooxygenase and the lipoxygenase, increasing the production of n3-eicosaoinds (thromboxanes and XA and PG prostaglandins) and reachin the antihypertensive effects. In the erythrocytes of this survey, it can be observed a diminution of the 14:0, 16:0 and 18:0, but without statistical significance and an augment of n6-20:3 and a diminution of the 20:4-6 without statistical signification.

Conclusion

It can be concluded that the intake of 1.5 g/day of fish oil in postmenopausal, hypertensive women produces a diminution in the systolic and diastolic blood pressures. These results are produced, in the case of the systolic blood pressure, after three months of supplementation and are maintained three monts after the end of the supplementation. However, it seems that it requires more time of supplementation to achieve similar results in the diastolic pressure. These diminutions could be due to high levels of n3-PUFAs in plasma and erythrocyte, which may promote arterial vasodilation.

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