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Atherosclerosis 170 (2003) 115–124

ATHEROSCLEROSIS

www.elsevier.com/locate/atherosclerosis

Effect of a nutritional intervention promoting the Mediterranean food pattern on plasma lipids, lipoproteins and body weight in healthy French-Canadian women

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Received 25 October 2002; received in revised form 23 April 2003; accepted 14 May 2003

Abstract

The present study examined the effect of a nutritional intervention promoting the Mediterranean food pattern in uncontrolled 'real life' conditions among a group of 77 French-Canadian women. The principal objective was to document changes in the plasma lipid-lipoprotein profile and in body weight that occurred in response to the intervention. The 12-week nutritional intervention included two group sessions, three individual sessions and four 24-h recalls (phone interview) with a registered dietitian. A score based on the 11 components of the Mediterranean pyramid, ranging from 0 to 44 points, was established to evaluate the adhesion to the Mediterranean food pattern. The Mediterranean score increased from 21.1 ± 3.6 at baseline to 28.6 ± 4.4 after 6 weeks of intervention ($P < 0.0001$) with no further increase at week 12. Small but significant decreases in total cholesterol and apolipoprotein B (apoB) as well as in body mass index (BMI) were observed after 6 weeks of intervention. No significant change in plasma concentrations of high density lipoprotein cholesterol (HDL-C), low density lipoprotein cholesterol (LDL-C) and triglycerides (TG) were observed in response to the nutritional intervention. In conclusion, a nutritional intervention program promoting the Mediterranean food pattern was effective in modifying food habits of healthy women from the Québec City metropolitan area and resulted in small but significant effects on specific cardiovascular risk factors.

Keywords: Nutritional intervention; Mediterranean diet; Women; Blood lipids; Body weight

1. Introduction

The increasing interest for the Mediterranean diet arises primarily from results of the Seven Countries Study, which demonstrated that the 15 year mortality rate from coronary heart disease (CHD) in Southern Europe, where a Mediterranean diet was consumed, was two to threefold lower than in Northern Europe or United States [1]. While several variants of the Mediterranean diet have been identified, specific features at the basis of this unique dietary pattern are a high consumption of fruits, vegetables, legumes and grains; food with high monounsaturated to saturated fatty acid (SFA) ratio; moderate consumption of dairy products and ethanol (mainly wine); and low consumption of meat and meat products [2–4]. Recently, results from a dietary intervention performed in men with CHD showed that a Mediterranean diet prevented the recurrence of cardiovascular events more than the usual prudent Western diet [5–7].

Several studies have examined the role of single nutrients or foods in determining the risk of cardiovascular disease [8–13]. Complex diets consumed by free-living individuals do not consist of single nutrients or foods but rather of a combination of foods containing multiple nutrients and non-nutrients. Some studies have shown that the dietary pattern as a whole was more important than specific dietary components with respect to survival among older people [14,15].

The extent to which Canadians may be able to modify their food habits towards the Mediterranean food pattern and whether such changes would be sufficient

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0021-9150/03/$ - see front matter
doi:10.1016/S0021-9150(03)00243-0

to generate significant effects on the metabolic profile is unknown. Most of the studies that have examined the effect of a Mediterranean diet or a diet high in monounsaturated fatty acids (MUFA) on cardiovascular risk have been conducted under relatively well controlled conditions in which food or menus were provided to participants [8,16–18]. Nutritional interventions undertaken in free-living uncontrolled conditions imply that participants receive knowledge, advice and support to modify their food habits in a real-life context, i.e. they continue to buy their foods and cook their meals. Such an intervention favors the modification of food habits but other factors such as cultural, socioeconomic, familial and personal factors will undoubtedly modulate the response to this type of intervention. In this study, our objective was to examine whether a nutritional intervention promoting the Mediterranean food pattern in uncontrolled conditions would result in significant modifications of food habits in French-Canadian women. We also wanted to verify the effects of the intervention on plasma lipid-lipoprotein profile and body weight. For that purpose, we studied a group of 77 healthy women from the Québec City metropolitan area, aged between 30 and 65 years.

2. Subjects and methods

2.1. Subjects

Women from the Québec City metropolitan area were recruited through the Laval University newspaper during the summer of 2001. Women included in the study were aged between 30 and 65 years. To be eligible, women had to be free from metabolic disorders requiring treatment, to have stable body weight for at least 3 months prior to the start of the study and to be in charge of food purchases and meal preparation most of the time. Only women with a diet concordant with usual Canadian food pattern were included in the study. One hundred and twenty eight women were invited to a screening visit for an evaluation of their food habits. Among this initial group of women, 94 were found to be eligible according to the above criteria. Seventy-seven women signed the informed consent form, which had been approved by Ethics Committees of Laval University and 74 women completed the study. Three women left the study for personal reasons. One participant did not complete the food frequency questionnaire (FFQ) at week 12. Therefore, 73 women were included for analyses regarding nutritional data.

2.2. Intervention

The study was conducted in two phases. The first phase started in August 2001 and the second phase began in January 2002. Each phase was conducted using a similar 12-week intervention design. A questionnaire inquiring on general social, anthropometric, physical activity and medical aspects and a FFQ were administered at screening. The nutritional intervention spanned over a 3-month period. The intervention included two group sessions with eight participants per group. The first group session took place during the first week of the intervention. During this 2-h session, the registered dietitian explained the major principles of the Mediterranean diet and health benefits associated to this food pattern. Four weeks after the beginning of the intervention, subjects were invited to a Mediterranean cooking lesson in which they had to produce a complete meal. During both group sessions, efforts were made to promote interaction between participants. Women were also encouraged to ask questions to the dietitian in charge of the session.

The first individual session took place during the first week of the intervention. During that first session, the registered dietitian used the baseline FFQ and the Mediterranean food pyramid (Fig. 1) to identify and promote dietary changes to be undertaken. Suggested modifications were always adapted to the participant's food preferences in order to personalize the objectives. Unannounced qualitative 24-h recalls were performed by telephone at week 2, 4, 8 and 10. The objective of these recalls was to provide support and to reinforce the key principles of the Mediterranean diet. Subjects were invited to two other individual sessions in order to evaluate the changes and to select other objectives for increasing the adherence to the Mediterranean food pattern. Results of the lipid-lipoprotein profile were communicated to each participant only at the end of the 12-week intervention in order to avoid the potential bias that this information could have on nutritional modifications. Three registered dietitians were trained to provide a standardized intervention. The same dietitian provided the two group sessions for all groups included in the study. The participant always met with the same dietitian during the individual sessions.

2.3. Food frequency questionnaire

A quantitative FFQ was administrated at screening ($t = 0$) and then at weeks 6 and 12. The diet of women eligible for this study had to be typical of the Canadian diet. Eligible women were identified by using the FFQ. The FFQ was based on typical foods, which are available in Québec and contains 91 items and 33 subquestions. The FFQ was administered by one of the three dietitians involved in the study. Participants were questioned about frequency of intake for different foods during the last month and were asked to report the frequency of these intakes in terms of day, week or month. A global Mediterranean score based on the

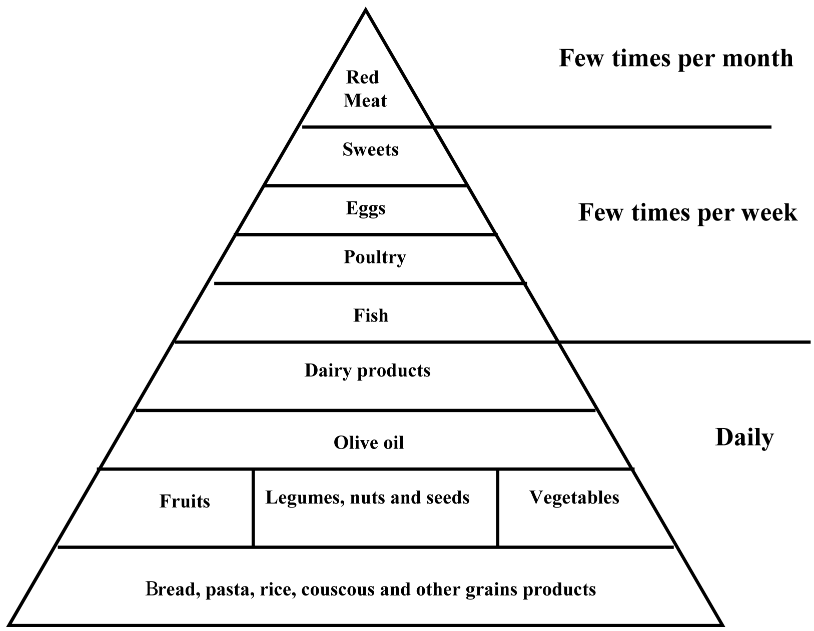

Fig. 1. The Traditional Healthy Mediterranean diet pyramid. Adapted from © Copyright 2000, Oldways Preservation and Exchange Trust.

Mediterranean pyramid components was derived from the FFQ (Fig. 1). A partial score varying from 0 to 4 was attributed to each of the 11 components of the pyramid. Components of the Mediterranean pyramid are: grains, fruits, vegetables, legumes, nuts and seeds, olive oil, dairy products, fish, poultry, eggs, sweets and red meat/processed meat. The total dietary score could therefore vary between 0 and 44 points (Appendix A). A score of 44 implied that an individual's food pattern would be fully compatible with the typical Mediterranean diet. Eligible women were those with a score at screening that was below an arbitrary value of 27. For food groups at the bottom of the pyramid (grains; fruits; vegetables; legumes, nuts and seeds; olive oil; fish) a high score reflected a high consumption. Inversely for food groups at the top of the pyramid (red meat/processed meat; sweets and eggs), a higher score was attributed for a lower frequency of intake. For dairy products, an intake of 2–3 portions a day was considered as a typical Mediterranean intake and 4 points were allowed for such an intake. For poultry, 4 points were allowed when the mean intake was 3 portions per week. More details about the Mediterranean score calculation are provided in Appendix A.

Evaluation of nutrient intake derived from the FFQ was performed using the Nutrition Data System for Research (NDS-R) software version 4.03, developed by the Nutrition Coordination Center, University of Minnesota, Minneapolis, MN, Food and Nutrient Database 31, released in November 2000 [19].

2.4. Anthropometry

At weeks 0, 6 and 12, body weight, height, waist and hip circumferences were measured according to the procedures recommended at the Airlie Conference on the Standardization of anthropometric measurements [20] and the waist-to hip ratio and body mass index (BMI) were calculated.

2.5. Plasma lipid-lipoprotein profile

Blood samples were collected at weeks 0, 6 and 12 from an antecubital vein into vacutainer tubes containing EDTA after a 12 h overnight fast for the measurements of plasma lipid and lipoprotein concentrations. Total plasma cholesterol and triglycerides (TG) levels were determined by enzymatic methods by using the Technicon RA-500 analyzer (Bayer Corp), as previously described [21]. HDL cholesterol (HDL-C) levels were also obtained using autoanalyser after precipitation of very low density lipoprotein (VLDL) and low density lipoprotein (LDL) in the infranatant with heparin and $MnCl_2$ [22]. Apolipoprotein B (apoB) is measured by nephelometry (BN ProSpec, Dade Behring, Newark, USA) with reagents provided by this compagny (N antisera to Human Apolipoprotein B). LDL-C was obtained by the equation of Friedewald et al. [23]. All participants had plasma TG levels below 4.5 mmol/l.

2.6. Statistical analyses

Data collected at the beginning (week 0) and after 6 and 12 weeks of intervention were compared using analysis of variance for repeated measures to identify time effects. In the presence of significant time effects, contrast analyses were used to determine precisely the location of the significant differences. Since the intervention was conducted over two phases and that participants were assigned to subgroups of eight individuals, terms reflecting the potential phase-effect as well as group-effect were systematically entered in each model to account for potential interaction with the treatment effect. Spearman correlations were computed to quantify associations among parametric and non-parametric variables. Partial Spearman correlations were performed between changes in metabolic variables and changes in dietary score to partial out the effect of anthropometric changes. Since changes in food, nutrient and energy intake were comparable at week 6 and 12, only values at week 12 are presented.

Additional analyses were undertaken to determine whether the lipid-lipoprotein response to the intervention may be modulated by baseline characteristics such as abdominal obesity, lipid levels and age. In a first series of analyses, participants were divided on the basis of baseline waist girth using tertiles of the distribution (76.0 and 85.3 cm). In a second series of analyses, women were grouped according to tertiles of LDL-C concentrations (2.6 and 3.3 mmol/l). Finally, in a third analysis the group of women was divided according to age tertiles (43.8 and 50.9 years). The intervention effect within each subgroup as well as the interaction between intervention and baseline characteristics were calculated by analysis of variance. In the presence of significant effects, contrast analyses were performed. Percent changes at weeks 6 and 12 were calculated as the differences between baseline values and value at 6 or 12 weeks respectively. TG concentrations were not normally distributed and analyses were performed on log-transformed values. All analyses were performed with the SAS statistical package version 8.02 (SAS Institute, Cary, NC).

3. Results

At baseline, subjects had a mean BMI of 25.8 ± 3.9 kg/m^2 and a mean waist circumference of 83.4 ± 10.8 cm. Plasma lipid-lipoprotein profile was in the normal range. Mean values at baseline were 3.02 ± 0.75 mmol/l for LDL-C concentrations, 1.63 ± 0.41 mmol/l for HDL-C concentrations and 3.34 ± 0.83 for total cholesterol to HDL-C ratio. The mean age was 46.8 ± 7.9 years.

Table 1
Mediterranean score, anthropometric variables and plasma lipid, lipoprotein and apolipoprotein concentrations at weeks 0, 6 and 12 of the nutritional intervention ($n = 74$)

	Week 0	Week 6	Week 12
Mediterranean score (arbitrary units)[1]	21.1 ± 3.6	28.6 ± 4.4[c]	28.8 ± 4.5[c]
Weight (kg)	67.7 ± 11.9	67.3 ± 11.9[b]	67.3 ± 11.6[b]
BMI (kg/m^2)	25.8 ± 3.9	25.7 ± 3.9[a]	25.6 ± 3.8[b]
Waist circumference (cm)	83.4 ± 10.8	82.8 ± 10.3	82.1 ± 10.2[d]
Total cholesterol (mmol/l)	5.21 ± 0.88	5.08 ± 0.83[a]	5.13 ± 0.84
LDL cholesterol (mmol/l)	3.02 ± 0.75	2.94 ± 0.71	2.96 ± 0.70
HDL cholesterol (mmol/l)	1.63 ± 0.41	1.59 ± 0.38	1.61 ± 0.41
Total chol/HDL-C ratio	3.34 ± 0.83	3.34 ± 0.83	3.32 ± 0.84
Triglycerides (mmol/l)	1.20 ± 0.47	1.18 ± 0.52	1.17 ± 0.49
Apolipoprotein B (g/l)	0.98 ± 0.20	0.93 ± 0.18[c]	0.94 ± 0.22[a]

Values are means ± S.D.
[1] Seventy three subjects.
[a] Significantly different from the value at week 0, $P < 0.05$.
[b] Significantly different from the value at week 0, $P < 0.01$.
[c] Significantly different from the value at week 0, $P < 0.0001$.
[d] Significantly different from the value at week 0 and 6, $P < 0.001$.

As shown in Table 1, the Mediterranean Score increased significantly from 21.1 ± 3.6 at baseline to 28.6 ± 4.4 after 6 weeks of intervention ($P < 0.0001$). No further change was observed between week 6 and week 12 (28.6 ± 4.4 to 28.8 ± 4.5). Partial score increased significantly during the study for olive oil, fruits, vegetables, legumes, nuts and seeds, poultry and fish ($P < 0.01$) for which an increased in the consumption was observed (see Table 2). Partial score also increased for red meat/processed meat and sweets ($P < 0.0001$) for which a decrease in the consumption was observed between week 0 and 12 of the nutritional intervention (Table 2).

As shown in Table 3, the twelve week nutritional intervention resulted in significant decreases in energy intake (173 ± 501 kcal) and in the percentage of energy derived from lipids (2.9% ± 5.9). The percentage of energy derived from saturated fat (SFA) also significantly decreased from 12.2 to 9.4% ($P < 0.004$). No change in the percentage of energy derived from MUFA or polyunsaturated fatty acid (PUFA) were observed in response to the nutritional intervention. However, a significant increase in the MUFA to SFA ratio was induced by the nutritional intervention compared to the baseline value ($P < 0.0001$). The relative intake of carbohydrate and protein increased significantly ($P < 0.0007$) and a significant increase in the absolute fiber intake was observed ($P < 0.0001$) (Table 3).

The effects of the nutritional intervention on metabolic and anthropometric profiles are presented in Table 1. Small but significant decreases in total cholesterol and apoB levels as well as in BMI were observed 6 weeks

Table 2
Number of portions consumed for the different food groups used for the calculation of the Mediterranean score and partial scores for the eleven items of the Mediterranean score at week 0 and week 12

	Items of the Mediterranean food pyramid	Portions		Partial score	
		Week 0	Week 12	Week 0	Week 12
1	Whole grain (portions/day)	2.5±1.3	3.1±1.6[a]	1.9±0.6	2.0±0.9
	Refined grain (portions/day)	1.8±1.2	1.0±1.0[b]		
2	Vegetables (portions/day)	2.5±1.5	3.3±1.3[b]	2.2±1.2	2.9±1.0[b]
	Vegetable juices (portions/day)	0.5±0.6	0.5±0.6		
3	Fruits (portions/day)	1.7±1.1	2.5±1.2[b]	2.0±1.2	2.8±1.1[b]
	Fruit juices (portions/day)	1.0±1.1	1.2±1.1		
4	Legumes, nuts and seeds (portions/week)	2.8±2.8	7.5±4.6[b]	0.4±0.7	1.6±1.1[b]
5	Olive oil (tea spoons/day)	2.5±3.3	3.8±3.2[a]	1.0±0.8	1.6±1.0[b]
	Canola oil (tea spoons/day)	2.3±2.0	1.9±2.1		
6	Dairy products (portions/day)	1.4±1.0	1.5±0.9	2.7±1.5	2.9±1.3
7	Fish and sea foods (g/week)	132±116	282±167[b]	1.9±1.0	3.2±1.0[b]
8	Poultry (g/week)	207±126	279±132[a]	2.5±0.8	2.9±0.9[a]
9	Eggs (number/week)	2.5±1.9	2.2±1.2	3.8±0.8	3.9±0.5
10	Sweets (portions/week)	7.4±5.9	3.9±3.2[b]	1.5±1.3	2.4±1.0[b]
11	Red meat/processed meat (g/week)	616±353	296±194[b]	1.4±1.2	2.5±0.9[b]

Values are means±S.D.
[a] Significantly different from the value at week 0, $P < 0.01$.
[b] Significantly different from the value at week 0, $P < 0.001$.

Table 3
Daily intake of energy and selected nutrients at weeks 0 and 12 of the nutritional intervention ($n = 73$)

	Week 0	Week 12
Energy (kcal)	2130±568	1956±453[a]
Proteins (% of energy)	15.6±2.6	17.0±2.2[b]
Lipids (% of energy)	37.0±6.4	34.1±5.9[b]
SFA (% of energy)	12.2±2.9	9.4±1.9[b]
MUFA (% of energy)	16.1±3.5	15.8±3.8
PUFA (% of energy)	5.9±1.8	6.3±1.5
MUFA/SFA ratio	1.4±0.3	1.7±0.4[b]
Carbohydrates (% of energy)	45.7±6.1	48.2±5.7[a]
Fibers (g)	19.7±5.1	24.6±6.7[b]

Values are means±S.D.
[a] Significantly different from the value at week 0, $P < 0.01$.
[b] Significantly different from the value at week 0, $P < 0.0001$.

after the beginning of the nutritional intervention ($P < 0.05$). Decreases in BMI and apoB remained statistically significant after 12 weeks of intervention whereas plasma total cholesterol concentrations did not, although total cholesterol concentrations did not change significantly between week 6 and 12. Furthermore, waist circumference at week 12 was significantly lower than at baseline ($P < 0.001$). No significant changes in plasma LDL-C, HDL-C and TG concentrations, as well as in total cholesterol to HDL-C ratio were observed in response to the nutritional intervention. It was found that baseline characteristics of participants were an important determinant of the metabolic response to the nutritional intervention. However, significant intervention effects that were found prior to adjustment for baseline values (Table 1) remained after entering the interaction between time and baseline value in the model.

Additional analyses were performed to investigate the contribution of baseline values of waist circumference, LDL-C concentrations and age to anthropometric and metabolic changes that occurred during the nutritional intervention. Table 3 shows baseline characteristics of subjects in each group separated on the basis of waist circumference at baseline. Subjects in the group with the

Table 4
Baseline characteristics of anthropometric and metabolic variables between the three groups separated on the basis of baseline waist circumference

	Tertiles of waist circumference (cm)		
	1st < 76.0 ($n = 24$)	2nd ≥ 76.0 and < 85.3 ($n = 24$)	3rd ≥ 85.3 ($n = 26$)
Age (years)	43.8±8.6	49.2±6.2[a]	47.9±8.1
Weight (kg)	58.3±4.7	65.6±6.0[a]	78.4±12.4[a,b]
BMI (kg/m^2)	22.4±1.4	25.0±2.0[a]	29.8±3.3[a,b]
Waist circumference (cm)	72.6±2.6	80.9±2.7[a]	95.0±8.3[a,b]
Total cholesterol (mmol/l)	4.82±0.71	5.35±0.86[a]	5.44±0.94[a]
LDL-C (mmol/l)	2.68±0.63	3.03±0.67	3.33±0.82[a]
HDL-C (mmol/l)	1.72±0.39	1.74±0.48	1.46±0.29[a,b]
Total chol/HDL-C ratio	2.92±0.72	3.24±0.75	3.80±0.79[a,b]
Apolipoprotein B (g/l)	0.87±0.16	0.99±0.17[a]	1.08 ±0.21[a]
Triglyceride[c] (mmol/l)	0.92±0.24	1.26±0.47[a]	1.42±0.53[a]
Mediterranean score (arbitrary units)	21.6±3.5	21.1±3.4	20.5±4.0

Values are means±S.D.
[a] Significantly different from group 1, $P < 0.05$.
[b] Significantly different from group 2, $P < 0.05$.
[c] Analyses were performed on log transformed values.

lowest waist circumference were characterized by lower BMI, lower concentrations of total cholesterol, LDL-C, apoB and TG, lower total cholesterol to HDL-C ratio as well as higher HDL-C concentrations than the group with the highest waist circumference ($P < 0.05$) (Table 4). Women in the second waist girth tertile were characterized by lower total cholesterol to HDL-C ratio and higher HDL-C levels than women with the highest waist girth but no difference in the concentration of total cholesterol, LDL-C, TG and apoB was observed between these two groups (Table 4).

Fig. 2 shows the response to the intervention in the three groups of women separated on the basis of waist girth at baseline based on tertiles of the distribution. Only women with the highest waist circumference at baseline showed significant decreases in waist circumference, LDL-C and apoB concentrations in response to the intervention. In all three groups, the increase in the Mediterranean score was of the same magnitude.

The effect of age on the response to the intervention was also examined by comparing groups separated on the basis of age tertiles (results not shown). The younger group distinguished itself from the others as it showed significant reduction in weight ($P < 0.005$) and waist circumference whereas the two other groups only showed reduction in waist circumference ($P < 0.05$). A significant decrease in LDL-C occurred only in the older group after 12 weeks of nutritional intervention ($P < 0.05$).

The extent to which baseline LDL-C concentrations modulated the response to the intervention was also investigated. Fig. 3 shows that in the group with the highest baseline value of LDL-C (LDL-C ≥ 3.3 mmol/l), the decrease in LDL-C was significant (7.2%) at week 6 and at week 12 (7.3%) whereas in women with lower baseline LDL-C concentrations no significant change in LDL-C occurred in response to the intervention (Fig. 3). The magnitude of the increases in the Mediterranean score at week 6 and 12 was also similar among the groups separated on the basis of tertiles of LDL-C at baseline (32.5%, 42.3%, 43.5% respectively at week 6).

Changes in the Mediterranean score tended to be associated with changes in LDL-C concentrations ($r = -0.22$, $P = 0.07$), apo B ($r = -0.21$, $P = 0.07$) and BMI ($r = -0.20$, $P = 0.10$). Partial correlation analyses indicated that adjustment for changes in BMI or waist circumference, did not modify correlations between changes in the Mediterranean score and changes in LDL-C and apoB levels.

4. Discussion

Our study was conducted in a group of free-living healthy women. Results showed that in response to a nutritional intervention promoting the Mediterranean dietary pattern, marginal but significant improvements in the metabolic profile were observed. Our results also

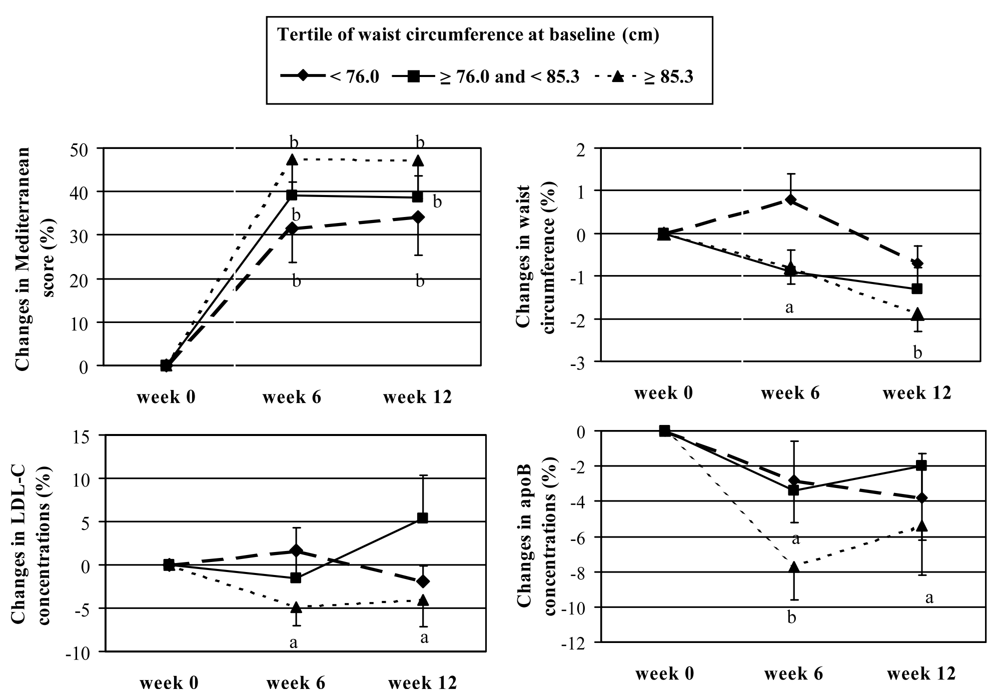

Fig. 2. Impact of waist circumference at baseline (in tertiles) on percentage of changes in (A) the Mediterranean score; (B) waist circumference; (C) LDL-C concentrations and (D) apoB concentrations. 1st tertile: waist circumference < 76.0 cm, 2nd tertile: waist circumference ≥ 76.0 and < 85.3 cm and 3rd tertile: waist circumference ≥ 85.3 cm. [a] Significantly different from week 0, $P < 0.05$. [b] Significantly different from week 0, $P < 0.001$.

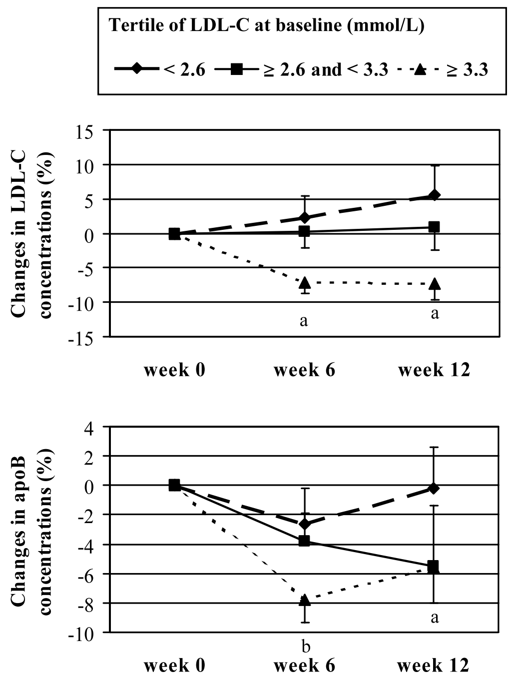

Fig. 3. Impact of LDL-C concentrations at baseline (in tertiles) on percentage of changes in (A) LDL-C concentrations and (B) apoB concentrations. 1st tertile: LDL-C < 2.6 mmol/l, 2nd tertile: LDL-C ≥ 2.6 mmol/l and < 3.3 mmol/l and 3rd tertile: LDL-C ≥ 3.3 mmol/l. [a] Significantly different from week 0, $P < 0.05$. [b] Significantly different from week 0, $P < 0.001$.

indicated that beneficial changes in the metabolic profile were more pronounced among the subgroup of women who had a more deteriorated metabolic profile at baseline. We also showed that the nutritional intervention resulted in significant changes in the global dietary pattern, which were maintained throughout the 12-week study period.

The increasing interest for the Mediterranean diet is attributable primarily to the results of the Seven Countries Study which showed that CHD risk in Southern Europe was two to threefold lower than in Northern Europe or in the United States [1]. Data from the Lyon Diet Heart Study have more recently indicated that intensive nutritional education program promoting a Mediterranean diet resulted in a 50–70% reduction of recurrence rate for myocardial infarction [5–7]. Expert Committees of the American Heart Association have recently produced a statement in which they underline the importance of performing studies that would corroborate results from the Lyon Diet Heart Study in both primary and secondary prevention models [24]. Accordingly, it appears relevant and well justified to investigate how non-Mediterranean individuals would respond to a nutritional intervention promoting the Mediterranean food pattern in real-life conditions. The aim of the present study was therefore to test the effect of a nutritional intervention promoting the Mediterranean food pattern in free-living healthy women from the Québec City Metropolitan area.

Our results showed that after 6 weeks of the nutritional intervention, total cholesterol and apoB levels were reduced by 2.5 and 5.1% respectively in the total sample of women. The nutritional intervention had no significant effect on plasma LDL-C, HDL-C and TG concentrations. Effects of a Mediterranean food pattern on plasma lipids in young (< 30 years) healthy individuals with a normal plasma lipid-lipoprotein profile have also been examined in a randomized-crossover study by Pérez-Jiménez and colleagues and decreases of 12% in total cholesterol, 16% in LDL-C concentrations and 8% in HDL-C were observed [18]. Changes in plasma lipids in that study were of greater magnitude than changes observed in our study. These differences could be explained by the study design. The study by Pérez-Jiménez et al. [18], was conducted as a controlled dietary intervention during which all meals were provided to participants for 28 days while our study was conducted in free-living conditions. In addition, Pérez-Jiménez et al compared the Mediterranean diet to a high SFA diet (20%) whereas in our study comparisons were made against plasma lipid and lipoprotein levels observed on the subjects' usual diet that contained a mean of $12.2 \pm 2.9\%$ of SFA at baseline.

In our study, modest effects on plasma cholesterol and apoB concentrations were observed. However, when women with a more deteriorated metabolic profile were analysed separately, more important changes in plasma lipids and lipoproteins were obtained. We separated our group according to waist circumference at baseline, because it is well established that a high waist girth is associated with many deteriorated metabolic variables [25,26]. Our results showed that women within the group characterized by the highest waist circumference displayed significant decreases in plasma LDL-C (4.1%) and apoB (5.4%) in response to the intervention. Beneficial changes achieved in this subgroup of women were comparable to those obtained in hypercholesterolemic subjects in other studies [17,27] despite the fact that the mean baseline LDL-C values in women with high waist circumference were still in the normal range (3.33 ± 0.82 mmol/l). These results emphasize that the baseline metabolic profile materially modulates the response to the intervention, in this case women with more important metabolic alterations showing a more beneficial response to the intervention. This has been demonstrated by others previously [8,28].

The Mediterranean diet is not considered as being restrictive on the quantity of fat intake. Indeed, percentage of energy derived from fat may vary from less than 25 to more than 35% depending upon the region, but the main visible fat is always in the form of olive oil [29]. Concerns have been raised about the potential weight gain effect associated with such an unrestrained fat intake. Our study conducted in free-living conditions indicates that this may not be the case. Indeed, we observed after 12 weeks of nutritional intervention a significant decrease of 2.9% in the percentage of energy derived from fat and a small but significant reduction in body weight and in waist circumference (0.4 kg and 1.3 cm, respectively). Recently, Castagnetta et al. reported preliminary results of a nutritional intervention which promoted the traditional Mediterranean diet in Italian women. Consistent with our findings, their results showed that a Mediterranean food pattern tended to induce weight loss [30]. In the present study, changes in the dietary pattern expressed as the Mediterranean score tended to be associated with favorable modifications in plasma apoB concentrations even after partialing out the effect of changes in BMI or waist circumference. These results therefore suggest that the decrease in plasma apoB concentrations was not mediated by the slight decrease in BMI and waist circumference that occurred in response to the intervention. In other words, these results suggest that the favorable modification in the metabolic profile were most likely attributable to nutritional changes than to concurrent changes in body weight.

Changes in specific nutrient intakes observed during the 12 week intervention are corroborating results obtained with our Mediterranean Score and demonstrate further that the objectives of our nutritional intervention were reached. In fact, the decrease in SFA observed is concordant with Mediterranean food pyramid principles that promote a low intake of red meat, butter and sweets (which generally contain high amount of SFA and trans fatty acids). The significant increase in fibers that was observed during our intervention is concordant with a higher consumption of vegetables, fruits, whole grains and legumes, nuts and seeds, which is also typical of the traditional Mediterranean diet. Finally, the consumption of MUFA did not change in response to the nutritional intervention but the MUFA to SFA ratio increased significantly. This result can be explained by the fact that in North America, MUFA are mostly provided by animals products such as beef and dairy products and also by partially hydrogenated vegetable oils [31]. Therefore, in our study the increase in the consumption of olive oil was counterbalanced by a reduction in animal sources of MUFA such as red meats, resulting in an absence of changes in absolute MUFA consumption. The higher MUFA to SFA ratio indicates the shift in the quality of dietary lipids from animal to vegetable sources and has been suggested as a typical characteristic of the adhesion to a Mediterranean diet [4].

In conclusion, our data suggest that simple but targeted nutritional intervention promoting the Mediterranean food pattern may be effective in modifying food habits of free living healthy French-Canadian women. These changes in the food pattern were associated with beneficial modifications in metabolic and anthropometric variables in these women, and health benefits were greater in women who showed a more deteriorated metabolic profile at the beginning of the study. In our study, subjects were their own control. Our study design allowed us to demonstrate that the intervention generated significant changes in the food pattern, which were in turn associated with an improvement in the plasma lipid-lipoprotein profile. Further studies will be needed to establish whether our intervention is more efficacious in modifying the cardiovascular risk profile of high risk individuals than other standard nutritional interventions such as the step 1 and 2 AHA diets.

Acknowledgements

J.G. is a recipient of a studentship from the Fonds pour la Formation de Chercheurs et d'Aide à la recherche-Fonds de la recherche en santé du Québec, S.L. is a research scholar from the Fonds de la recherche en santé du Québec and B.L is the recipient of a Canada Research Chair in Nutrition, Functional Foods and Cardiovascular Health from the Canada Research Chair Program. The authors express their gratitude to the subjects and their familly for their motivation and implication throughout the study. We acknowledge the contribution of Nancy Gilbert, M.Sc R.D and Amélie Charest B.Sc to the nutritional intervention and we thank Danielle Aubin for nursing assistance.

Appendix A: The Mediterranean score

Score	0	1	2	3	4
Whole grain products[1]	< 1 portion/day	1–2 portions/day	3–4 portions/day	5–6 portions/day	≥ 7 portions/day
Vegetable consumption[2]	< 1 portion/day	1 portion/day	2 portions/day	3 portions/day	≥ 4 portions/day
Fruit consumption[3]	< 1 portion/day	1 portion/day	2 portions/day	3 portions/day	≥ 4 portions/day
Legumes, nuts and seed consumption[4]	< 0.5 portion/day	0.5 portion/day	1 portion/day	2 portions/day	> 2 portions/day
Olive oil, olives and margarine made of olive oil consumption[5]	< 1 time/day	1 time/day	2 times/day	3 times/day	≥ 4 times/day
Milk and dairy products consumption[6]	< 1 portion/day or > 4 portions/day	4 portions/day		1 portion/day	2–3 portions/day
Fish and seafood (other than breaded)[7]	Never	< 1 portion/week	1 portion/week	2 portions/week	≥ 3 portions/week
Poultry (other than breaded)[7]	Never	< 1 portion/week	1 portion/week or ≥ 4 portions/week	2 portions/week	3 portions/week
Eggs	≥ 7/week		5–6/week		0–4/week
Sweets[8]	≥ 7 times/week	5–6 times/week	3–4 times/week	1–2 times/week	< 1/week
Red meat/processed meat[7]	≥ 7 portions/week	5–6 portions/week	3–4 portions/week	1–2 portions/week	< 1 portion/week

[1] For grain products we have established that a portion was equivalent to 1 slice of bread, half a cup of pasta, rice or couscous, 30 g of cereals. The Mediterranean food pattern promotes whole grains. Therefore, a maximum of 1 point was attributed for the consumption of refined grain products (e.g. white bread or refined cereals).

[2] For vegetables, we have established that a portion was equivalent to half a cup or one medium vegetable. The Mediterranean food pattern promotes fresh vegetables. Therefore, a maximum of 1 point was attributed for the total number of vegetable juice portions (half a cup).

[3] For fruits, we have established that a portion was equivalent to half a cup or one medium fruit. The Mediterranean food pattern promotes fresh fruits. Therefore, a maximum of 1 point was attributed for the total number of fruit juice portions (half a cup).

[4] For legumes, nuts and seeds, we have established that a portion was equivalent to half a cup of legumes, quarter a cup of nuts/seeds or 100 g of tofu.

[5] For olive oil, we have established that 1 point was attributed for each using of this oil. The Mediterranean food pattern promotes the preferential use of olive oil as the main visible fat. Therefore, a maximum of 1 point was attributed for any consumption of canola oil or margarine made with this oil.

[6] For milk and dairy products, we have established that a portion was equivalent to 1 cup of milk or enrich soy beverages, 50 g of cheese or 175 g of yoghurt.

[7] For red meat/processed meat, poultry, or fish we have established that a portion may vary from 50 to 100 g.

[8] For sweets we have established that a portion was equivalent, for example, to 1/12 of cake, 1/6 of pie or 1 regular chocolate bar.

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