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Comparison of a dietary intervention promoting high intakes of fruits and vegetables with a low-fat approach: long-term effects on dietary intakes, eating behaviours and body weight in postmenopausal women

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The aim of the present study was to compare the long-term effects of two dietary approaches on changes in dietary intakes, eating behaviours and body weight: (1) approach using restrictive messages to limit high-fat foods (low-fat intake; LOFAT); (2) approach emphasising non-restrictive messages directed towards the inclusion of fruits and vegetables (high intake of fruits and vegetables; HIFV). A total of sixty-eight overweight or obese postmenopausal women were randomly assigned to one of the two dietary approaches. The 6-month dietary intervention included three group sessions and ten individual sessions with a dietitian. Dietary intakes, eating behaviours and anthropometrics were measured at baseline, at the end of the dietary intervention (T=6) and 6 months and 12 months after the end of the intervention (T=12 and T=18). In the LOFAT group, energy and fat intakes were lower at T=6 when compared with baseline and remained lower at T=12 and T=18. In the HIFV group, fruit and vegetable intakes increased significantly at T=6 but were no longer significantly different from baseline at T=12 and T=18. Dietary restraint increased at T=6 and remained higher than baseline at T=18 in the LOFAT group while no significant change was observed in the HIFV group. At T=6, body weight was significantly lower than baseline in both groups (LOFAT: −3·7 (SD 2·8) kg; HIFV: −1·8 (SD 3·0) kg) and no significant difference in body-weight change from baseline was found between groups at T=18. We concluded that weight loss was similar at 1-year follow-up in both dietary approaches. Despite relatively good improvements in the short term, the adherence to a 6-month dietary intervention promoting high intakes of fruits and vegetables was difficult to maintain.

Fruits and vegetables: Low-fat diets: Weight loss: Postmenopausal women

Worldwide prevalence of overweight and obesity has reached epidemic proportions and will continue to increase in the coming years[1]. Moreover, some life periods are associated with body modifications. One example is the menopause transition for which weight gain and body-fat redistribution lead to a more preferential abdominal adipose tissue accumulation[2,3]. These changes in body-weight composition and body-fat redistribution have been associated with an increased risk of developing metabolic diseases such as type 2 diabetes[4]. Consequently, it has been recommended to limit weight gain in overweight or obese postmenopausal women in order to help them to enhance their overall health[5]. Many energy-restricted dietary programmes have been successful in helping individuals losing 5–10 % of their initial body weight, which has been found sufficient to significantly improve their metabolic profile[6,7]. Maintenance of weight loss is, however, not easy to achieve for a majority of individuals[8] since adherence to energy-restricted diets is difficult to maintain in the long term. Moreover, restrictive diets may have negative effects such as an increase in binge eating episodes[9] as well as a greater risk of depressive symptoms[10].

Rolls *et al.*[11] suggested that increasing fruit and vegetable intakes may be an effective approach for long-term weight management as it emphasises positive messages rather than negative restrictive messages conveyed by low-fat diets. Fruits and vegetables have generally a low energy density (defined as kJ/g) because of their high water and low fat content. Moreover, high intakes of fruits and vegetables have been associated with a low prevalence of obesity[11]. As individuals seem to consume a constant weight of food each day rather than a constant amount of energy[12], eating foods with a low energy density, such as fruits and vegetables, could reduce energy intake and consequently weight loss

Abbreviations: HIFV, high intake of fruits and vegetables dietary intervention; LOFAT, low-fat dietary intervention; T=0, baseline; T=6, end of the dietary intervention; T=12, 6 months after the end of the intervention; T=18, 12 months after the end of the intervention.

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could occur. Accordingly, weight-loss interventions proposing dietary advice to increase fruits and vegetables, combined with advice to reduce energy intake, have been shown to induce a significant weight loss[13,14]. To the best of our knowledge, no study has yet investigated the effects of a dietary intervention based on positive messages promoting an increased consumption of fruits and vegetables without focusing on energy or fat reduction.

Therefore, the purpose of the present study was to compare among postmenopausal women one approach using restrictive messages to limit high-fat foods (low fat intake; LOFAT) with another approach emphasising non-restrictive positive messages directed towards the inclusion of fruits and vegetables (high intake of fruits and vegetables; HIFV) without any advice on energy or fat reduction. Our intervention was built according to the theory of approach–avoidance orientation as proposed by Elliot & Church[15]. According to this theory, approach goals focus on desirable objectives and involve moving toward the desirable objectives whereas avoidance goals focus on undesired targets and imply moving away from these undesired targets. Therefore, in the present study, we wanted to compare an intervention based on an approach goal (i.e. increasing fruit and vegetable intakes) with an intervention based on an avoidance goal (decreasing high fatty food intake). The primary outcome of the present paper was weight maintenance and the secondary outcomes were changes in dietary intakes, eating behaviours and metabolic profile between the end of the 6-month dietary intervention (T=6) and 1-year follow-up (T=18 months). We hypothesised that women from the HIFV approach would have a better long-term maintenance of dietary changes and thereby a better maintenance of body-weight loss than women from the LOFAT approach. Results of the short-term dietary intervention have been published elsewhere[16].

Materials and methods

Subjects

A total of sixty-eight overweight or obese postmenopausal women aged between 45 and 68 years were recruited through local newspapers in the Quebec City metropolitan area (Canada) to participate in a weight-loss programme. Women had to have a BMI $\geq 28\,kg/m^2$. They also had to have a waist circumference $\geq 88\,cm$. This waist circumference cut-off value has been identified as a marker of the metabolic syndrome and has been associated with an increased risk of CVD[17]. Only women with stable body weight ($\pm 2{\cdot}5\,kg$ for the last 3 months before the study) were included. Postmenopausal status was determined by the absence of menses for at least 1 year and by a measure of the follicle-stimulating hormone between 28 and 127 IU/l. None of the women included in the present study had type 2 diabetes or any other metabolic disorders. Women were excluded if they were using any type of hormone therapy. Type 2 diabetes was detected according to the criteria presented by the Report of the Expert Committee on the Diagnosis and Classification of Diabetes Mellitus using a 2 h oral glucose tolerance test[17]. Also, women showing a high level of depressive symptoms or having eating disorders (as determined respectively by the Beck Depression Inventory[18] and the Eating Disorder Examination Questionnaire[19]) were excluded. During the 6-month dietary intervention, five women dropped out for personal reasons (two women in the LOFAT group and three women in the HIFV group). During the 1-year follow-up, seven women dropped out for personal reasons (three women in the LOFAT group and four women in the HIFV group). Personal reasons mentioned were time limitations, moving to another city and familial issues. The present study was conducted according to the guidelines laid down in the Declaration of Helsinki and all procedures involving human subjects were approved by the Laval University Research Ethics Committee. Written informed consent was obtained from all subjects.

Intervention

Two dietary approaches similar in terms of treatment intensity but differing in terms of targeted nutritional changes were compared. Postmenopausal women were randomly assigned to one of the two following approaches through the use of permuted block randomisation: (1) an approach using restrictive messages to limit high-fat foods (LOFAT; *n* 33) and (2) another approach emphasising non-restrictive messages directed towards the increase in fruit and vegetable intakes (HIFV; *n* 35). The LOFAT approach focused specifically on restrictive messages to decrease high-fat food consumption in the diet with key messages and intervention tools that facilitate the identification and restriction of high-fat foods. The HIFV approach focused on positive messages promoting the consumption of fruits and vegetables with key messages and intervention tools specifically designed to emphasise the inclusion of fruits and vegetables in the diet without any advice given on fat reduction. Both dietary approaches were based on changes in food habits and no specific goal for energy restriction was identified. Each phase was conducted using a similar 6-month (24 weeks) intervention design with three group sessions (weeks 1, 2 and 7) and ten individual sessions with a registered dietitian (weeks 3, 5, 9, 11, 13, 16, 18, 20, 22 and 24). Of these individual sessions, three (weeks 11, 18 and 22) were carried out on the phone. The study was conducted in two phases. The first started in January 2006 (thirty-one women; fifteen in the LOFAT group and sixteen in the HIFV group) and the second began in November 2006 (thirty-seven women; eighteen in the LOFAT group and nineteen in the HIFV group). Two registered dietitians were in charge of the dietary interventions and were trained to provide a standardised intervention. They were unaware of the research hypotheses. Each dietitian was in charge of an equal number of women from both dietary intervention groups in order to avoid an intervener effect.

Group sessions

Before randomisation, subjects received general information about nutrition, physical activity and weight-related issues. This information was conveyed through two group sessions (2 h each) at weeks 1 and 2. During these two group sessions, subjects from both approaches were mixed together in order to avoid bias that could result from the characteristics of the group. These two sessions included basic notions on health-related risk associated with obesity, general recommendations

for healthy eating (Canadian Food Guide), explanations on food labels, information related to energy density, portion sizes at home and in restaurants, food purchasing and preparation, risks associated with unhealthy dieting, satiety and hunger signals, importance of physical activity, and environment cues that favour overconsumption of foods. The third group session was a cooking lesson. For this session, while the same recipes were used in both groups (carrot and parsnip soup, breadcrumbed chicken, ratatouille, couscous, fruit smoothie and apple sauce cookies), subjects were grouped according to their intervention arm (LOFAT or HIFV). Subjects in the LOFAT approach received specific advice to decrease fat in cooking while subjects in the HIFV approach received advice on how to incorporate fruits and vegetables in recipes.

Individual sessions

The individual intervention developed was inspired by a cognitive behavioural approach[20]. Women's personal factors such as cognition, emotions, patterns of behaviours and external events were addressed throughout the behavioural change process. In both groups, the first individual session was initiated by questioning women about their motivations and expectations in terms of dietary changes and weight loss. The dietitian stressed the importance of setting realistic and achievable goals and re-emphasised the fact that a body weight loss of 5–10 % is sufficient to improve health. It is important to mention that regarding food habit changes, individual targets in accordance with the characteristics of the dietary intervention were established rather than common targets for all women in each group. Therefore, the dietitian had a client-centred approach, since the individual targets were established in collaboration with the participant. In that context, individual targets and the ways to achieve them could vary between subjects. In both groups, the dietitian used qualitative food records completed by the participant as an intervention tool to review and identify changes that could be carried out. Subjects were asked to record their food intake throughout the 6-month dietary intervention (at least 3 d per week). Perceptions of hunger and satiety were also noted in the food record. Subjects in both intervention groups received the same amount of instruction about hunger and satiety signals and physical activity changes. In both approaches, individual follow-up sessions were the occasion to discuss about the reach of objectives and to set new objectives or to readjust them. In order to avoid bias, subjects were unaware that the research study included two different weight-loss interventions.

During the first individual session in the LOFAT group, the dietitian helped the participant to identify objectives that contribute to decrease the consumption of high-fat foods and portion size of fatty foods. The high energy density of foods with high fat content, their low satiety effect and their effect on facilitating a positive energy balance were explained to participants. Additional information on food labelling was provided to the participants in order to give them tools to choose food with a lower fat content. Recipes and a list of substitutions that could be performed were provided and cooking methods that do not use fat were proposed. No specific goal for energy intake was established. On the other hand, during the first individual session in the HIFV group, the dietitian helped the participant to identify objectives that contribute to increase fruit and vegetable consumption. Information about the low energy density of fruits and vegetables, their effect on satiety and their potential facilitating effect on reducing energy intake was explained. Recipes and documentation about conservation of fruits and vegetables were provided to facilitate planning of meals. Information about less-known varieties of fruits and vegetables was given and participants were encouraged to try some of these 'new' fruits and vegetables. It is important to mention that the focus was on fresh fruits and vegetables rather than juices and fried vegetables because of their lower fibre content and higher energy density, respectively. The Healthy Plate Model (Idaho Healthy Plate)[21] was used to promote consumption of vegetables. The plate model allows half of the plate to vegetables, one-quarter to grains products and one-quarter to meats and alternatives. No specific goal for energy intake was established. In the HIFV approach, the dietitian never directly suggested that women reduce their consumption of high-fat foods in order to reach the objective of increasing fruit and vegetable consumption. In the case that a woman would suggest by herself to reduce high-fat food intake as a way to incorporating fruits and vegetables in her diet, the dietitian would approve this suggestion but would also try to propose other unrestrictive ways to reach the objective.

FFQ

A validated FFQ was administered five times: at screening, at baseline, at the end of the dietary intervention (T=6 months) and during follow-up (T=12 months and T=18 months)[22]. At screening, to be eligible, women had to consume fewer than seven portions per d of fresh fruits and vegetables (excluding juices and potatoes) and more than 25 % of energy provided by dietary fat. Briefly, the FFQ was administered by a registered dietitian and is based on typical foods that are available in Québec. It contains ninety-one items and thirty-three subquestions. 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. Evaluation of nutrient intakes derived from the FFQ was performed using Nutrition Data System for Research software (version 4.03; developed by the Nutrition Coordination Center, University of Minnesota, Minneapolis, MN, USA; Food and Nutrient Database 31, released in November 2000). The daily number of fruit and vegetable servings was established as 125 ml or a medium fruit or vegetable, excluding fried vegetables, potatoes and juices. Dietary energy density was defined as energy content (kJ/g) of all food excluding beverages, as previously suggested[23].

Anthropometric measurements

Anthropometric variables were measured at baseline, at T=6 months, at T=12 months and at T=18 months. Height, body weight and waist circumference were measured using standardised procedures as reported previously[24].

Eating behaviours

The Three-Factor Eating Questionnaire (TFEQ) assesses three factors that refer to cognitions and behaviours associated with eating. The TFEQ was completed at baseline, at T=6 months, at T=12 months and at T=18 months. These factors are dietary restraint, disinhibition and hunger. More precisely, dietary restraint is a conscious control of food intake with concerns about shape and weight. Disinhibition is an overconsumption of food in response to a variety of stimuli, such as emotional stress, associated with a loss of control on food intake. Finally, hunger refers to food intake in response to feelings and perceptions of hunger[25]. This questionnaire has been validated and all scales have good test–retest reliability[25,26]. More specific subscales can also be derived from these three general TFEQ factors[9,27]. Specific subscales for dietary restraint are rigid and flexible restraint[9]. Rigid restraint is defined as a dichotomous, all-or-nothing approach to eating, dieting and weight, whereas flexible restraint is a more gradual approach to eating, dieting and weight in which, for example, foods perceived as being 'fattening' are eaten in limited quantities without feelings of guilt[9]. Two specific subscales of hunger (internal and external locus to hunger) have also been suggested[27]. Internal hunger refers to the type of hunger which is interpreted and regulated internally, whereas external hunger is rather triggered by external cues[27].

Dietary history

Each participant completed a questionnaire on dietary history. More specifically, subjects had to indicate whether they had experienced dieting in the past: 'Have you ever been dieting (weight loss greater than 10 lbs (4·5 kg))?' and 'How many times have you ever been dieting?'.

Metabolic measurements

Metabolic variables were measured at baseline, at the end of the 6-month dietary intervention (T=6 months) and during follow-up (T=12 months and T=18 months). Blood samples were collected after a 12 h overnight fast from an antecubital vein into vacutainer tubes containing EDTA. Lipid and lipoprotein profiles were determined as previously described[28]. Systolic and diastolic blood pressure was measured in the right arm of seated resting participants, as previously described[29].

A 75 g oral glucose tolerance test was performed in the morning after an overnight fast at baseline, at the end of the 6-month dietary intervention (T=6 months) and 1 year after the end of the intervention (T=18 months) as previously described[28]. Insulin sensitivity was determined with the Cederholm index[30].

Statistical analyses

Statistical analyses were performed using SAS software (version 8.2; SAS Institute, Inc., Cary, NC, USA). Anthropometric variables, dietary intakes, eating behaviours and metabolic variables were analysed according to the intention-to-treat procedure in which baseline values were carried forward for subjects with missing data at T=6 months, T=12 months and T=18 months. Subjects who withdrew from the study during the intervention (i.e. during the first 6 months) were excluded. Therefore, sixty-three subjects were included in the analyses. All statistical analyses were also performed with completers only (*n* 56). Women in the HIFV group were stratified into three groups according to the tertile of change in fruit and vegetable intakes between T=0 (baseline) and T=6 months. Similarly, women in the LOFAT group were stratified into three groups according to the tertile of change in fat intake between T=0 and T=6 months. Differences within and between groups were tested by the PROC MIXED procedure for repeated measurements (SAS software). Adjustment for baseline values of each dependent variable tested was systematically performed[31]. When significant group × time interactions were observed, simple effects between times and groups were tested to further depict the main interaction effect. Pairwise differences between and within group means were further tested with the Tukey–Kramer adjustment. Spearman correlations were performed to determine associations between changes in body weight and changes in eating behaviours within each dietary group. To compare the proportion of women in each dietary approach who reached their lowest body weight at T=6 months, T=12 months and T=18 months, χ^2 analysis was performed. For all statistical analyses performed, the critical *P* value for significance was set at 0·05.

Power calculations were based on previous weight-loss studies[32], considering an attrition rate of 20 %. It was estimated that a sample of twenty-six subjects per intervention group would allow the detection of a 7 % difference in body weight at T=18 months, with a standard deviation of 10 %, a probability of rejecting a null hypothesis (α) of 0·05 and a probability of correctly accepting a true null hypothesis (power) of 0·80.

Results

Retention rates

There were no significant differences in age (LOFAT: 58·1 (SD 4·6) years; HIFV: 56·2 (SD 4·4) years) and in baseline body weight (LOFAT: 85·8 (SD 8·9) kg; HIFV: 85·0 (SD 8·9) kg) between the groups. Of the sixty-eight subjects randomised at baseline, sixty-three participants completed the 6-month dietary intervention (93 %) (LOFAT: *n* 31 (94 %); HIFV: *n* 32 (91 %)). At 1-year follow-up (T=18 months), fifty-six participants (82 %) (LOFAT: *n* 28 (85 %); HIFV: *n* 28 (80 %)) were tested. Women who withdrew from the study were characterised by more previous dieting attempts compared with those who completed the study (6·5 (SD 3·5) *v.* 4·3 (SD 2·8) times) but had a similar baseline body weight (86·2 (SD 10·8) *v.* 85·2 (SD 8·5) kg).

Changes in dietary intakes

Fruit and vegetable intakes increased significantly at the end of the 6-month dietary intervention compared with baseline in the HIFV group and were significantly higher than in the LOFAT group (Fig. 1). However, during follow-up,

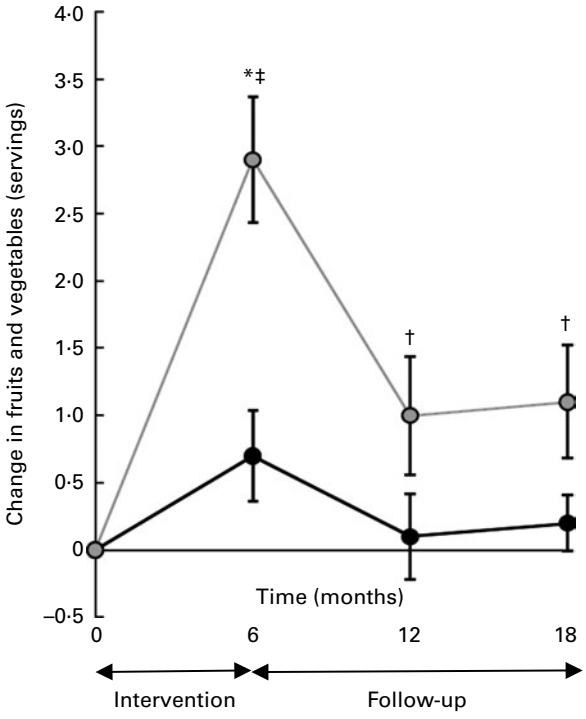

Fig. 1. Change in fruit and vegetable intakes during the dietary intervention (0–6 months) and follow-up (between 6 and 18 months). (●), Low-fat dietary intervention (LOFAT) group (*n* 31); (◍), high intake of fruits and vegetables dietary intervention group (*n* 32). Values are means, with standard errors represented by vertical bars. *Mean value was significantly different from that at baseline ($P<0·05$). †Mean value was significantly different from that at 6 months ($P<0·05$). ‡Mean value was significantly different from that of the LOFAT group ($P<0·05$).

fruit and vegetable intakes returned towards baseline values in the HIFV group and intakes measured at T=12 months and T=18 months were no longer significantly different from baseline intakes. Moreover, women who increased the most their fruit and vegetable intakes at T=6 months decreased the most their fruit and vegetable intakes during follow-up (r −0·85; $P<0·0001$) but did not return to baseline values (T=0 months = 4·2 portions, T=18 months = 6·4 portions; $P<0·0001$). As shown in Table 1, while energy intake remained constant during the 6-month dietary intervention in the HIFV group, it decreased at T=12 months and T=18 months compared with baseline, as was also observed for protein and carbohydrate intakes. Total fibre intake and weight of food returned towards baseline values at T=12 months and T=18 months while energy density remained significantly lower compared with baseline in the HIFV group. In the LOFAT group, energy, protein, carbohydrate and fat intakes as well as energy density were significantly lower at T=6 months than baseline and remained lower during the follow-up period compared with baseline values. As noted for fruit and vegetable intakes in the HIFV group, women who decreased the most their fat intake at T=6 months increased the most their fat intake during follow-up (r −0·48; $P=0·01$) but did not return to baseline value (T=0 months = 128·7 g, T=18 months = 91·4 g; $P=0·0050$). Similar results were found when analyses were performed with completers only.

Changes in body weight

At the end of the 6-month intervention, body weight decreased significantly in both groups compared with baseline (Fig. 2(a)). Despite a tendency for weight regain between T=12 months and T=18 months in the LOFAT group (1·2 (SD 1·1) kg; $P=0·06$), body weight remained lower than baseline at 1-year follow-up (T=18 months) whereas weight loss was no longer significant at T=18 months in the HIFV group. Waist circumference decreased significantly in both groups during the 6-month intervention but the decrease remained significant at 1-year follow-up (T=18 months) only in the LOFAT group (Fig. 2(b)). No significant difference in the percentage of weight loss was found between groups at T=18 months (LOFAT: −3·0 (SD 4·4) %; HIFV: −1·6 (SD 5·3) %). In completers of the LOFAT group, 32 % of subjects had a body weight that was at least 5 % lower than initial body weight and 21 % of subjects gained weight compared with baseline body weight at 1-year follow-up (T=18 months). In the HIFV group, 29 % of subjects had a body weight at T=18 months that was at least 5 % lower than initial body weight and 39 % of subjects gained weight compared with baseline body weight ($\chi^2 = 1·9$; $P=0·3790$). Moreover, in the LOFAT group, 43 % of subjects reached their lowest body weight at T=6 months, 32 % at T=12 months and 11 % at T=18 months while in the HIFV group, 21 % of subjects reached their lowest body weight at T=6 months, 32 % at T=12 months and 29 % at T=18 months ($\chi^2 = 4·4$; $P=0·3527$).

Changes in metabolic variables

At the end of the 6-month intervention, fasting plasma glucose and insulin as well as systolic and diastolic blood pressure were significantly lower than at baseline in the LOFAT group. Fasting plasma insulin and systolic blood pressure significantly decreased in the HIFV group (Table 2). At 1-year follow-up (T=18 months), only fasting insulin remained lower than at baseline in both groups whereas systolic blood pressure remained lower than its value at baseline only in the HIFV group. These results remained significant after adjustment for body-weight changes. Similar results were found when analyses were performed with completers only.

Changes in eating behaviours

Table 3 presents eating behaviours at baseline, at the end of the 6-month intervention and during follow-up (T=12 months and T=18 months). At T=6 months, T=12 months and T=18 months, dietary restraint and flexible restraint were higher than baseline in the LOFAT group whereas no change was observed in the HIFV group. Rigid restraint did not change during the intervention or at follow-up in either group. However, in the LOFAT group, women who increased the most their rigid restraint at T=6 months increased the most the energy density of their diet during follow-up (r 0·31; $P=0·04$). Disinhibition remained lower at T=18 months compared with baseline in both groups. Hunger was not significantly different at T=18 months compared with baseline in both groups but external locus to hunger was significantly lower at T=18 months than baseline in the

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Table 1. Daily energy, macronutrients and energy density at baseline, at the end of the dietary intervention (T=6) and 6 months (T=12) and 12 months (T=18) after the end of the intervention§

(Mean values and standard deviations)

	LOFAT group (*n* 31)		HIFV group (*n* 32)		Difference between groups	
Variables	Mean	SD	Mean	SD	Effect	*P*
Energy (kJ)						
Baseline	10 288	2703	9205	2389	Time	<0·001
T=6 months	8121*	2117	8644	2113	Group	0·196
T=12 months	8360*	2125	8368*	2092	Time × group	0·010
T=18 months	8586*	2473	8259*	2443		
Protein (g)						
Baseline	99·5	27·6	95·2	30·1	Time	<0·001
T=6 months	83·9*	22·6	89·9	24·8	Group	0·781
T=12 months	87·2*	25·6	86·7*	21·8	Time × group	0·081
T=18 months	88·4*	25·3	84·2*	24·2		
Carbohydrate (g)						
Baseline	284·3	59·9	262·3	63·0	Time	<0·001
T=6 months	241·3*	55·8	256·8	55·7	Group	0·131
T=12 months	236·2*	49·4	243·1	64·8	Time × group	0·042
T=18 months	241·4*	58·8	239·0*	74·7		
Fat (g)						
Baseline	101·5	40·1	83·8	29·2	Time	<0·001
T=6 months	72·0*	27·9	74·4	25·4	Group	0·234
T=12 months	78·1*	28·5	75·0	23·3	Time × group	0·014
T=18 months	80·9*	31·4	75·5	28·7		
Total fibre (g)						
Baseline	23·8	5·6	23·6	6·2	Time	0·006
T=6 months	23·5	6·2	26·7*‡	5·1	Group	0·049
T=12 months	21·8	5·2	23·9†	5·8	Time × group	0·033
T=18 months	23·0	6·8	23·5†	7·1		
Energy density (kJ/g)						
Baseline	7·0	1·1	6·5	1·1	Time	<0·001
T=6 months	5·9*	0·9	5·5*	1·1	Group	0·468
T=12 months	6·2*	1·0	6·0*	1·2	Time × group	0·594
T=18 months	6·3*†	0·8	6·0*	1·2		
Weight of food (g)						
Baseline	1278	294	1262	318	Time	<0·012
T=6 months	1190	291	1398*‡	285	Group	0·0141
T=12 months	1178	278	1252†	283	Time × group	<0·001
T=18 months	1187	288	1227†	351		

LOFAT, low-fat dietary intervention; HIFV, high intake of fruits and vegetables dietary intervention.
* Mean value was significantly different from that at baseline ($P<0·05$).
† Mean value was significantly different from that at T=6 months ($P<0·05$).
‡ Mean value was significantly different from that of the LOFAT group ($P<0·05$).
§ Baseline values were included as covariate in all models.

HIFV group. Further correlations were performed between change in body weight and change in eating behaviours during follow-up (between T=6 months and T=18 months). No significant associations were found in the LOFAT group. In the HIFV group, changes in dietary restraint and flexible restraint were both negatively associated with change in body weight (r −0·52 and r −0·42 respectively; $P<0·05$) while change in hunger was positively associated with change in body weight (r 0·38; $P=0·049$).

Discussion

The main objective of the present study was to compare the effects of two dietary interventions on long-term weight-loss maintenance. The approach using restrictive messages to limit high-fat foods (LOFAT) as well as the approach emphasising non-restrictive messages directed towards the increased consumption of fruits and vegetables (HIFV) led to significant weight loss at the end of the 6-month intervention. At 1 year after the end of the intervention (T=18 months), weight loss remained significant in the LOFAT group while it was no longer significant in the HIFV group compared with baseline. However, no difference in weight loss was observed at T=18 months between groups.

From our findings, it is difficult to determine which of the two approaches was more successful in terms of weight maintenance. At 1 year after the end of the intervention, body weight in the HIFV group was no longer significantly lower than at baseline. As opposed to what was observed in the HIFV group, body weight at T=18 months in the LOFAT group was significantly lower than at baseline. This is an indication of the LOFAT approach being more successful. However, in the present study, when we compared the percentage of subjects with a body weight at T=18 months who had reached a weight loss that was at least 5 % lower than at baseline (29 % in the HIFV group *v.* 32 % in the LOFAT group) no difference was found between the two approaches. Furthermore, the fact that only the LOFAT

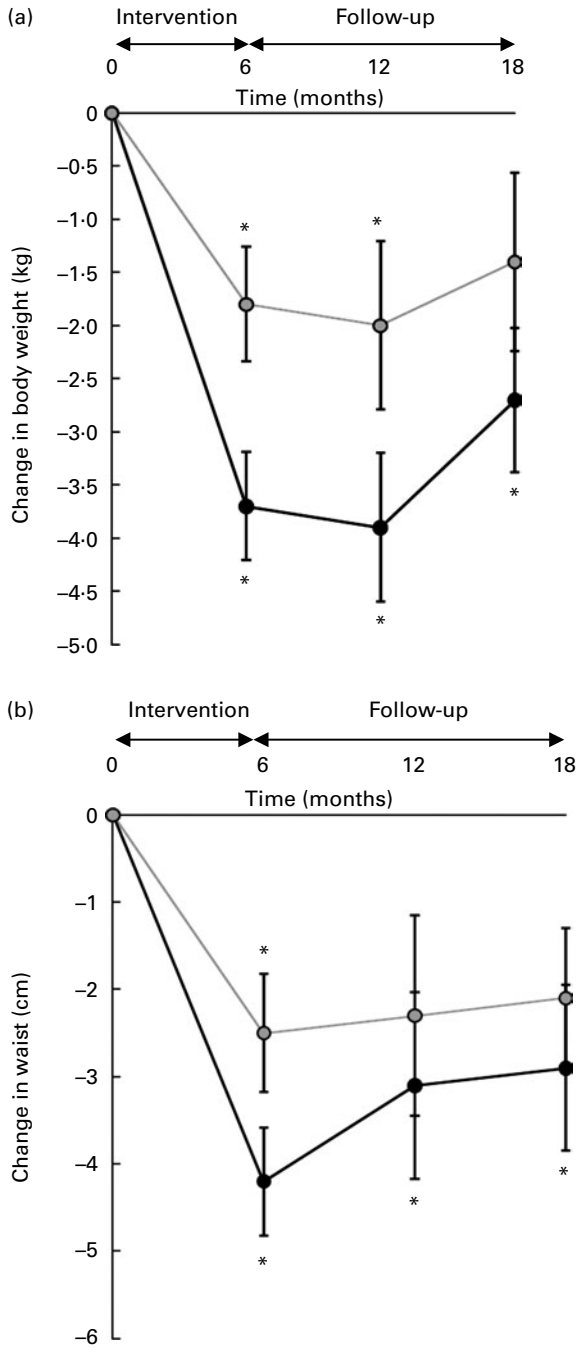

Fig. 2. Change in body weight (a) and in waist circumference (b) during the dietary intervention (0–6 months) and follow-up (between 6 and 18 months). (●), Low-fat dietary intervention group (*n* 31); (◉), high intake of fruits and vegetables dietary intervention group (*n* 32). Values are means, with standard errors represented by vertical bars. * Mean value was significantly different from that at baseline ($P<0·05$).

group experienced a tendency to weight regain between T=12 months and T=18 months lessened the overall success of the LOFAT group. Globally for both approaches, we observed a relatively small mean weight loss. Considering that individuals usually gain between 0·4 and 0·9 kg/year[33], our two dietary approaches can be considered as being successful for prevention of weight gain since 79 % of women from the LOFAT group and 61 % of women from the HIFV group had a lower body weight at T=18 months compared with baseline. Furthermore, when comparing more specifically weight changes observed in our HIFV approach with those obtained in other studies promoting a high intake of fruits and vegetables in a context of weight loss[13,34], we can conclude that we obtained smaller weight losses. These differences may be explained by the fact that previous studies had also recommended a decrease in energy and/or fat intakes in addition to the promotion of high intakes of fruits and vegetables. For example, Ello-Martin *et al.*[34] showed a mean decrease of 7·9 kg at the end of a 12-month intervention promoting both fat reduction and increases in fruit and vegetable intakes in women.

Women from the HIFV approach were not able to maintain their high intakes in fruits and vegetables at follow-up, while in women from the LOFAT approach, fat intake remained significantly lower at T=18 months than at baseline. This is in contrast with our initial hypotheses. In fact, we hypothesised that women from the HIFV approach would have a better long-term maintenance of dietary changes and thereby a better maintenance of body-weight loss than women from the LOFAT approach. This hypothesis was based, in part, on the theory of approach–avoidance orientation proposed by Elliot & Church[15]. In a recent study performed by Sullivan & Rothman[35], it was demonstrated that when subjects could choose between an approach goal (eating more healthy snacks) or an avoidance goal (eating fewer unhealthy snacks), those who chose the avoidance goal had fewer healthy eating habits after the 2-week period during which they had to implement their goal. In the present study, women did not choose to be in the LOFAT group (i.e. avoidance goal) or in the HIFV group (i.e. approach goal) as they were randomly assigned to either one of these approaches. Therefore, it is possible that our HIFV approach would work better for women who would be naturally inclined to choose an approach goal rather than an avoidance goal.

It is also possible that an approach goal intervention might be especially difficult to implement when the ultimate target is weight loss. In fact, many overweight women have experimented with dieting many times in their life. More specifically, women from our sample had attempted weight loss a mean of 4·6 times. According to the 1998 National Health Interview Survey[33], the most common strategies used by women who try to lose weight are eating less energy and fat, those strategies being related more to avoidance goals. Therefore, a non-restrictive intervention promoting an increased intake in fruits and vegetables is likely to be very different from previous experiences of these women in terms of dieting attempts. It could be proposed that such a new way of approaching weight loss might need more support and counselling to be implemented efficiently. Accordingly, Pierce *et al.*[36] demonstrated that the adherence to a high fruit and vegetable intake dietary pattern was possible in the long term, since subjects from the Women's Healthy Eating and Living Study (WHEL) maintained their dietary changes for 4 years. The objective of that intervention was to prevent breast cancer recurrence by a high-vegetable low-fat dietary pattern without emphasis on weight loss. During the 4-year follow-up, subjects stayed in contact with the research staff and they received personal calls as well as monthly

Table 2. Metabolic variables at baseline, at the end of the dietary intervention (T=6) and 6 months (T=12) and 12 months (T=18) after the end of the intervention§

(Mean values and standard deviations)

	LOFAT group (*n* 31)		HIFV group (*n* 32)		Difference between groups	
Variables	Mean	SD	Mean	SD	Effect	*P*
Total cholesterol (mmol/l)						
Baseline	5·15	0·75	5·28	0·86	Time	<0·001
T=6 months	5·04	0·84	5·13	0·81	Group	0·724
T=12 months	5·53*†	0·76	5·57*†	1·01	Time × group	0·613
T=18 months	5·34	0·80	5·29‡	0·85		
LDL-cholesterol (mmol/l)						
Baseline	3·18	0·68	3·32	0·79	Time	<0·001
T=6 months	3·13	0·76	3·21	0·74	Group	0·503
T=12 months	3·47†	0·69	3·52†	0·96	Time × group	0·391
T=18 months	3·30	0·74	3·25‡	0·83		
HDL-cholesterol (mmol/l)						
Baseline	1·35	0·27	1·34	0·28	Time	<0·001
T=6 months	1·32	0·22	1·36	0·28	Group	0·421
T=12 months	1·48*†	0·26	1·45*†	0·27	Time × group	0·759
T=18 months	1·43†	0·29	1·43	0·30		
TAG (mmol/l)						
Baseline	1·34	0·39	1·35	0·45	Time	<0·001
T=6 months	1·28	0·44	1·23	0·45	Group	0·611
T=12 months	1·26	0·37	1·29	0·52	Time × group	0·898
T=18 months	1·31	0·47	1·33	0·48		
Fasting plasma glucose (mmol/l)						
Baseline	6·03	0·43	6·02	0·50	Time	<0·001
T=6 months	5·77*	0·34	5·91	0·53	Group	0·193
T=12 months	5·79*	0·42	5·89	0·49	Time × group	0·569
T=18 months	5·83	0·48	5·88	0·57		
Fasting plasma insulin (pmol/l)						
Baseline	147	55	132	57	Time	<0·001
T=6 months	93*	37	101*	41	Group	0·269
T=12 months	108*	40	112*	41	Time × group	0·198
T=18 months	100*	49	94*	37		
Cederholm index						
Baseline	12·2	2·6	12·5	3·4	Time	<0·001
T=6 months	13·7	3·2	13·3	3·6	Group	0·477
T=12 months	–	–	–	–	Time × group	0·892
T=18 months	13·2	3·1	14·0	4·1		
Systolic blood pressure (mmHg)						
Baseline	119	14	122	12	Time	<0·001
T=6 months	113*	11	117*	13	Group	0·953
T=12 months	114	11	116*	15	Time × group	0·723
T=18 months	115	9	117*	13		
Diastolic blood pressure (mmHg)						
Baseline	80	8	80	8	Time	<0·001
T=6 months	76*	9	78	9	Group	0·831
T=12 months	77	8	78	7	Time × group	0·535
T=18 months	78	8	77	7		

LOFAT, low-fat dietary intervention; HIFV, high intake of fruits and vegetables dietary intervention.
* Mean value was significantly different from that at baseline ($P<0·05$).
† Mean value was significantly different from that at T=6 months ($P<0·05$).
‡ Mean value was significantly different from that at T=12 months ($P<0·05$).
§ Baseline values were included as covariate in all models.

newsletters reinforcing food choices. It can also be proposed that additional intervention components should be added to our HIFV approach to increase its long-term efficacy. For example, it might be useful to intervene on beliefs relating to the increase in fruit and vegetable intakes and/or adding a social support component such as group sessions in order to share experiences related to the intervention.

Dietary restraint did not increase either during the intervention or during the follow-up in the HIFV group. This result is not surprising and is in line with our intervention goals since we wanted to promote dietary changes that would lead to weight loss without using restrictive messages, namely because restrictive weight-loss approaches have been associated with some adverse effects such as an increase in obsessive thought about food[37] and an increase in binge eating[9]. Although dietary restraint levels did not change during or after the intervention in women from the HIFV group, and despite no significant relationship being observed between change in dietary restraint and change in body weight during the 6-month intervention (r 0·06; $P=0·71$), a significant negative association was, however, found between changes in dietary restraint and changes in body

Table 3. Eating behaviours at baseline, at the end of the dietary intervention (T=6) and 6 months (T=12) and 12 months (T=18) after the end of the intervention‡

(Mean values and standard deviations)

	LOFAT group (*n* 31)		HIFV group (*n* 32)		Difference between groups	
Variables	Mean	SD	Mean	SD	Effect	*P*
Dietary restraint						
Baseline	8·2	4·6	9·6	4·0	Time	<0·001
T=6 months	12·5*	4·3	11·0†	4·5	Group	0·015
T=12 months	10·8*	4·3	10·2	4·6	Time × group	0·002
T=18 months	11·0*	4·4	10·7	4·7		
Flexible restraint						
Baseline	2·5	1·7	3·1	1·7	Time	<0·001
T=6 months	4·2*	2·0	3·3†	1·8	Group	0·004
T=12 months	3·7*	1·8	3·3	1·7	Time × group	0·002
T=18 months	3·7*	1·7	3·5	1·7		
Rigid restraint						
Baseline	2·8	1·9	3·3	1·6	Time	0·004
T=6 months	3·4	1·8	3·5	1·8	Group	0·219
T=12 months	3·0	1·9	3·2	1·9	Time × group	0·483
T=18 months	3·4	1·8	3·3	2·1		
Disinhibition						
Baseline	8·7	3·3	9·8	3·1	Time	<0·001
T=6 months	6·9	3·1	7·8*	3·1	Group	0·472
T=12 months	6·9*	2·9	7·2*	3·0	Time × group	0·218
T=18 months	7·1*	2·9	7·0*	2·9		
Hunger						
Baseline	5·6	3·5	6·9	3·8	Time	<0·001
T=6 months	3·9*	3·4	4·9*	3·8	Group	0·929
T=12 months	3·8*	3·4	4·9*	3·7	Time × group	0·865
T=18 months	4·6	3·6	5·5	4·0		
Internal locus to hunger						
Baseline	1·8	1·9	2·9	2·4	Time	<0·001
T=6 months	1·4	1·7	1·8*	2·2	Group	0·451
T=12 months	1·2	1·8	1·7*	2·2	Time × group	0·207
T=18 months	1·7	2·0	2·1	2·1		
External locus to hunger						
Baseline	2·5	1·3	3·3	1·4	Time	<0·001
T=6 months	1·8*	1·6	2·4*	1·7	Group	0·933
T=12 months	1·7*	1·4	2·4*	1·7	Time × group	0·542
T=18 months	2·1	1·5	2·3*	1·8		

LOFAT, low-fat dietary intervention; HIFV, high intake of fruits and vegetables dietary intervention.
* Mean value was significantly different from that at baseline ($P<0·05$).
† Mean value was significantly different from that of the LOFAT group ($P<0·05$).
‡ Baseline values were included as covariate in all models.

weight during the follow-up (between T=6 months and T=18 months). We also found that women who increased the most their dietary restraint during the follow-up also decreased the most their fat intake (r −0·40; P=0·04). This suggests that women from the HIFV group who kept on trying to lose weight during the follow-up did so by getting back to more familiar dieting strategies such as increasing dietary restraint and decreasing fat intake.

At 1-year follow-up (T=18 months), dietary restraint, particularly flexible restraint, was significantly higher in the LOFAT group compared with baseline. Contrary to rigid restraint, flexible restraint reflects a positive attitude toward dieting and weight control and has been positively associated with weight loss[38] whereas undesirable effects associated with dietary restraint are more likely to be explained by the rigid aspect of dietary restraint[9,39]. Despite the fact that the LOFAT approach focused on restrictive messages to decrease the consumption of high-fat foods, it is interesting to note that rigid restraint did not increase in response to the LOFAT intervention. This might be explained by the fact that although the main objective was to reduce the consumption of high-fat foods, specific strategies to reach this objective were always individualised and no specific target was set for energy intake. Therefore, our LOFAT approach was more flexible than rigid and was adapted to individual needs and specific situations and this might explain why we did not observe any increase in rigid restraint. However, even if dietary restraint remained high during the follow-up in the LOFAT group, energy density increased and a tendency to weight regain was observed. In the LOFAT group, we observed a tendency to weight regain between T=12 months and T=18 months. Accordingly, the majority of women participating in a dietary weight-loss intervention experience weight regain once the intervention stops[40]. In fact, weight loss has been found difficult to maintain when the dietary counselling becomes less frequent[34,41]. This result seems conflicting with other studies, since an increased dietary restraint has been

associated with weight maintenance[42]. However, we cannot disregard the fact that the non-significant 11 % decrease in dietary restraint that was observed between T=6 months and T=18 months could have been clinically sufficient to influence weight regain.

At the end of the 6-month intervention, similar metabolic changes were observed in both groups despite a weight loss of almost twice in the LOFAT group. In fact, at the end of our dietary intervention, fasting plasma insulin and systolic blood pressure were significantly improved in the HIFV group despite a small weight loss (2·0 % of initial body weight) and remained lower than baseline at T=18 months. Furthermore, improvements in fasting insulin and blood pressure were independent of body-weight loss.

The present study has some limitations, such as the small sample size, which restrained us in the statistical analyses that could be used. Moreover, no control group was compared with our intervention groups, which prevented us from determining the absolute efficacy of our intervention. Despite the small weight loss observed in the HIFV group in the long term, we believe it was relevant to develop and test this new weight-loss intervention considering the low success rate of weight-loss maintenance following traditional dietary interventions.

In conclusion, a 6-month dietary intervention restricting high-fat foods was successful in maintaining food habits while the adherence to a 6-month dietary intervention promoting high intakes of fruits and vegetables was difficult to maintain. However, it is difficult to determine which of the two approaches was more successful in terms of weight maintenance, since no significant difference in weight loss at T=18 months was found between the two intervention groups. Other studies will be needed to determine additional intervention components that could be added to the HIFV approach in order to improve long-term adherence.

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The contributions of the authors were as follows: A. L. carried out the study, data analyses and drafted the manuscript; S. J. W., V. P. and C. B. participated in the design of the study and coordination; A.-A. D.-B. and C. T. participated in the dietary intervention study implementation; S. L. was the principal investigator and participated in the design of the study, coordination and helped to draft the manuscript. All authors read and approved the final manuscript.

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