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A whole-food, plant-based nutrition program: Evaluation of cardiovascular outcomes and exploration of food choices determinants

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ABSTRACT

Objectives: An ideal diet to prevent cardiovascular diseases contains an unlimited intake of various plant foods and a reduced intake of animal and highly processed foods. Researchers have reported that nutrition education programs that prioritize whole-plant foods effectively contribute to the prevention of unhealthy cardiovascular outcomes. We examined whether a 12-wk nutrition education program in adults from Montreal (Quebec, Canada) with at least one risk factor of cardiovascular disease was effective in modifying their eating patterns toward including more whole-plant foods. We further evaluated the effects of this program on participants' cardiovascular outcomes and explored determinants influencing food choices toward whole-food, plant-based diets.

Methods: A sequential, explanatory, mixed-methods, research design was used. A quantitative step (i.e., single-arm, quasi-experimental trial) preceded participant recruitment for a qualitative phase (i.e., phenomenological study; semistructured interview; thematic analysis). The examined outcomes were changes in cardiovascular risk factors (paired *t* tests) and determinants of food choice (thematic analysis).

Results: Weight (−10.5 lbs; 95% confidence interval [CI]: −9.0 to −12.0), waist circumference (−7.4 cm; 95% CI: −6.5 to −8.4), total cholesterol (−0.87 mmol/L; 95% CI: −0.57 to −1.17), and low-density lipoprotein cholesterol (−29.7% or −0.84 mmol/L; 95% CI: −0.55 to −1.13) all improved significantly ($P < 0.001$). Encouraging ad libitum intake of various whole-food plant-based items appealed more to participants than traditional strategies. Altruistic and societal motives, in addition to health, were identified as key determinants of an increased adoption of whole-food plant-based diets.

Conclusions: The whole-food, plant-based nutrition program improves cardiovascular health in adults and features characteristics that may inform future nutrition programs and public health interventions.

Introduction

In 2012, 46% of the worldwide noncommunicable disease deaths were attributable to cardiovascular diseases (CVDs) [1]. By 2030, CVDs are projected to remain the leading global cause of mortality [2]. In Canada, heart disease and stroke are responsible for one of four deaths [3], and this is unlikely to improve considering the global demographic transition [4]. CVDs are a major public health issue, and effective interventions are needed.

Healthy lifestyles reduce the risk of myocardial infarction up to 94% [5–7], but medicine reduces the risk by 30% [8]. Interventions that target behaviors (e.g., smoking, inadequate diet, and physical inactivity) and intermediate risk factors (e.g., hypertension and obesity) are essential in CVD prevention because unhealthy eating habits may be the most important CVD risk factor [9]. Accordingly, prevention and rehabilitation programs should target healthy food choices.

The nutrition educational program evaluated in this study was led by a private center. Thus, the authors deemed it important to disclose they were the ones who proposed to this center to conduct a study on the nutrition educational program without having any prior relationships of employment, consultancies, honoraria, or personal relationship. The authors maintained full autonomy in the research design, analysis of results, and writing of this article.

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The Canadian Association of Cardiovascular Prevention and Rehabilitation has issued recommendations for CVD prevention and management and suggests that patients should adhere to dietary patterns, including higher amounts of fiber, fruits, nuts, vegetables, grains, and plant-based protein while reducing saturated fats and simple carbohydrates [10]. An ideal diet for CVD prevention contains unlimited intake of various plant foods (e.g., legumes, whole grains, fruits, and vegetables) and a reduced intake of animal (e.g., meat, eggs, and dairy products) and highly processed foods (e.g., high in sugar, salt, or fat). Another Canadian Association of Cardiovascular Prevention and Rehabilitation recommendation states that if patient preferences allow, vegetarian diets should be adopted.

Research shows that nutrition education programs that prioritize whole-plant foods are effective in the prevention of CVDs. Many studies have compared the effect of a whole-food, plant-based (WFPB) diet to other diets among adults with CVD risk factors. In many randomized controlled trials (RCTs), the WFPB diet group achieved better weight outcomes [10–16], greater reductions in waist circumference [14], and larger improvements in blood lipid indicators [14,15,17]. Other RCTs have found that drug dosage for Type 2 diabetes decreased more among adults adhering to a WFPB diet compared with conventional diets [14,16,18]. To date, WFPB nutrition programs have been conducted exclusively in English-speaking settings [11–19], exacerbating a language gap in access to preventive services [20,21].

In nutrition educational programs, improving food choices is the primary goal. To achieve change, intervention must acknowledge the complexity of food choices. The Food Choice Process Model shows that food choices are complex, multidimensional, situational, and interconnected [22]. The model stipulates that food choices result from determinants at three levels: life course events, proximal influences, and personal food systems. Life course events refer to modifications in dietary intake after positive (e.g., childbirth, marriage) or negative transitions (e.g., divorce) [23]. Proximal influences can include ideals, personal or social factors, resources, and contexts. For example, ideals regarding healthy foods have been shown to affect food choices [24]. Personal food system refers to values that guide food choices (e.g., values associated with vegetarian diets [25,26].

Herein, we examined whether a 12-wk WFPB nutrition educational program in adults from a French-speaking area (Quebec, Canada) was effective in modifying eating patterns by including more whole-plant foods. We evaluated the effects of such a program on CVD risk factors and explored determinants that influence food choices toward WFPB diets.

Methods

Study design

A sequential explanatory design [27–29] was used. Recruitment, data collection, and data analysis phases are presented in Figure 1. In the first phase, anthropometric and biologic data were extracted from clinical files of adults with at least one intermediate CVD risk factor. In the second phase, determinants that influence food choices were explored with participants who had already completed the program.

The WFPB educational program included 12 activities: seven workshops aimed to explain the relationships between chronic diseases and diet and introduced participants to ethical dimensions of food choices (i.e., animal welfare, environmental sustainability). Other sessions were practical classes (i.e. one visit to grocery store, four cooking workshops). The intervention did not promote physical activity or smoking cessation, but focused solely on orienting dietary choices toward diets composed of more whole-plant foods. Activities were taught by a multidisciplinary team composed of a registered nutritionist, registered nurse, two chefs, and a specialist in animal ethics. The program cost was Can$810.

Table 1
Criteria for participant recruitment in the quantitative phase

Cardiovascular disease risk factor	Threshold
Body mass index	$\geq$25 kg/m^2
Waist circumference (men/women)	$\geq$102 cm/$\geq$ 88 cm
Systolic blood pressure	$\geq$140 mmHg
Diastolic blood pressure	$\geq$90 mmHg
Serum total cholesterol concentration	$\geq$5.2 mmol/L
LDL cholesterol concentration	$\geq$3.4 mmol/L
HDL cholesterol concentration	<1.16 mmol/L
Triacylglycerols concentrations	$\geq$1.7 mmol/L
Prediabetes or Type 2 diabetes diagnosis	–
Antihypertensive, hypoglycemia, or lipid-lowering medication	–
History of cardiac event (myocardial infarction or stroke)	–

HDL, high-density lipoprotein; LDL, low-density lipoprotein

Recruitment for quantitative phase

Participants were recruited from a list of adults who had already completed the program between September 2011 and July 2015 (n = 328). Among the identified subjects, 183 had at least one CVD risk factor as defined by Alberti et al. (Table 1) [30].

The identified subjects were contacted, but 81 did not respond and eight refused to participate. Overall, 94 adults indicated interest in receiving information. A consent form was sent, but 15 subjects did not return their consent forms (or returned incomplete forms). Seven subjects who returned their consent forms had clinical files with unusable information. In total, data were extracted from 72 participants (Fig. 2). This study was conducted according to the guidelines of the Declaration of Helsinki, and all procedures involving human subjects/patients were approved by the ethics committee of the Research Centre on Aging (Sherbrooke, Québec, Canada; Approval #2015-498). Written informed consent was obtained from all subjects/patients.

Recruitment for qualitative phase

Maximum variation sampling was used. Ten participants who had already completed the program were interviewed: five with low-perceived adherence (LA) and satisfaction toward the program and five with high-perceived adherence (HA) and satisfaction. LA participants were purposely selected by the first author among volunteers, and the program's facilitator recommended HA participants. An objective confirmation of participant characteristics (i.e., weight loss) was obtained using quantitative data. This sampling method is appropriate because HA may have caused the development of strategies to overcome barriers experienced in changing eating habits, but LA participants might have experienced the main barriers encountered in WFPB programs.

Instruments, measures, procedures, and analysis of quantitative phase

Extracted data from clinical files included weight, body mass index (BMI), waist circumference, systolic blood pressure (SBP; mmHg), diastolic blood pressure (DBP; mmHg), lipid profile (serum total cholesterol, low-density lipoprotein [LDL], high-density lipoprotein [HDL], triacylglycerol concentration; mmol/L), fasting blood glucose concentration (mmol/L), and glycated hemoglobin (%). All anthropometric and biologic measures were assessed at baseline and at 12 wk. BMI was calculated from height and weight. Blood pressure was measured using an automated blood pressure monitor. If a nurse considered the blood pressure

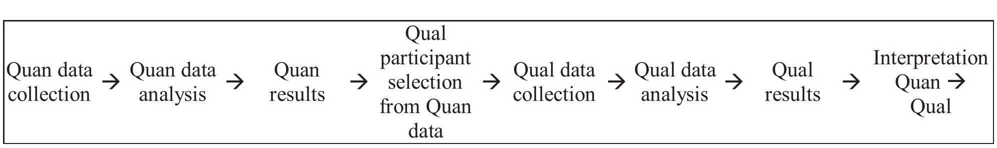

Fig. 1. Sequential explanatory design participant selection model.

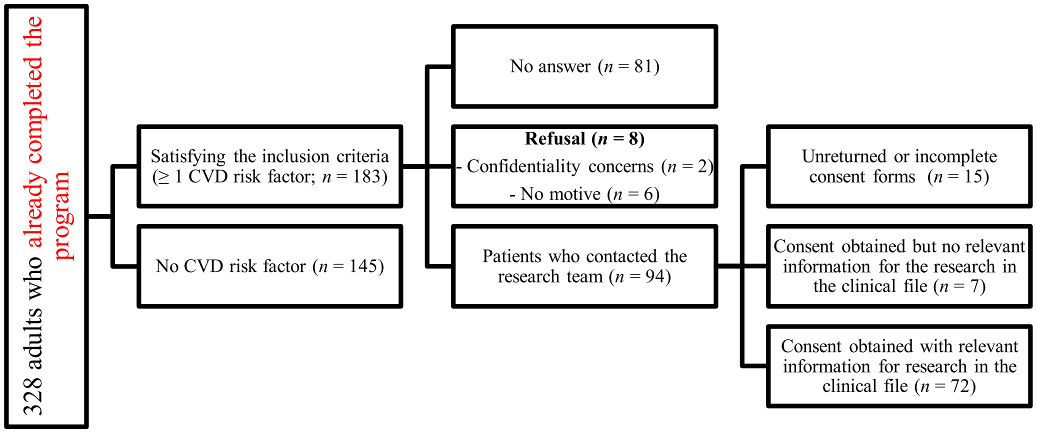

Fig. 2. Sampling process of the quantitative phase.

abnormal, another measure was taken 15 min later. Whether or not patients were in a fasting or postprandial state at the time of the test was noted.

Blood concentrations were measured with the CardioChek Plus Analyzer. Fasting blood glucose concentrations were measured with a Contour Next blood glucose meter, and the percentage of glycated hemoglobin was obtained with the A1 CNow SelfCheck device. For the statistical analyses, paired *t* tests were used to assess the effects of the program on each measure. When the assumptions for paired *t* tests were not respected (i.e., n < 30 or abnormal distribution), the Wilcoxon signed rank test was conducted. IBM SPSS software, version 23, was used for the analyses.

Instruments, measures, procedures, and analysis of qualitative phase

A phenomenological analysis was used to identify WFPB determinants. The interview guide was customized from the framework of the Food Choice Process Model [22,31]. Interviews are relevant to explore food choices because they help to reveal people's thoughts, feelings, fears, and hopes related to personal experiences [32]. In-depth, semi-structured interviews (n = 10) were conducted after program completion. All interviews were transcribed verbatim. Thematic content analysis was used, which allowed for the systematic identification, consolidation, and discursive examination of topics in a text corpus [33]. Coding involved the identification of themes and classifying them under a matrix of categories of the Food Choice Process Model [22]. A preliminary codebook was built after the first interview and revised after each interview. All corpus extracts [34] were translated from French to English. A validation meeting of the final thematic tree was conducted with the participants. QRS NVivo 10 software was used.

Results

Participant Characteristics and Quantitative Results

Participants (n = 72) were mainly women age ≥45 y (Table 2). Nearly one-third of participants were taking at least one prescribed drug for hypercholesterolemia, hypertension, or other chronic conditions, including diabetes. Only 6% of participants were current smokers, and 65% reported prior dieting.

Table 3 shows pre- and postintervention cardiovascular profiles and differences. The variation in sample size is due to missing data. The most available data were weight (n = 64), and the least frequent were fasting blood glucose concentration and percent glycated hemoglobin (n = 6). Seven of 12 indicators improved significantly (i.e., weight, BMI, waist circumference, serum total cholesterol, serum LDL cholesterol concentration, DBP, and percent glycated hemoglobin). Serum HDL cholesterol concentration decreased, but there was no change in the total-to-HDL cholesterol concentration ratio. SBP, serum triacylglycerol concentration, and fasting blood glucose concentration did not change.

Posthoc analyses were conducted for participants who reached the CVD risk factor thresholds (Table 1) [30]. Among participants with elevated blood pressure (i.e., SBP ≥ 140 mmHg; DBP ≥ 90 mmHg; hypertension diagnosis or hypertension pharmaceutical treatment; n = 27) during the preintervention period, the program helped decrease SBP (−11.2 mmHg; 95% confidence interval [CI]: −4.3 to −18.2; *P* = 0.001) and DBP (−7.6 mmHg; 95% CI: −1.8 to −13.5; *P* = 0.006). Among adults with serum total (n = 26) and serum LDL (n = 21) cholesterol concentrations above the threshold or taking cholesterol-reducing medication before the study, serum total cholesterol concentration decreased by 21% (5.64–4.46 mmol/L; *P* < 0.001), and the serum LDL concentrations decreased by 36% (3.43–2.19 mmol/L; *P* < 0.001; Table 3).

Participant characteristics and qualitative results

HA participants almost had a two-fold weight loss and were younger and more likely to be men (Table 4). The determinants that affected food choices toward a WFPB diet are summarized in Table 5.

Efficacy and short-term benefits

As shown by the quantitative data, participants experienced health improvements, which contributed to sustained adherence to and maintenance of new behaviors. Quick and measurable results in HA participants were determinants of WFPB food choices.

Reduction in addictions related to prior eating habits

Most participants highlighted a reduction in addictions to calorie-dense foods However, a distinction between the groups was

Table 2
Participants characteristics (quantitative phase)

Characteristics	Frequencies (%)	*n*
Sex		
Women	47 (65)	72
Age		63
≤44 y	21 (33)	
45–64 y	36 (57)	
≥65 y	6 (10)	
Cardiovascular disease history	27 (38)	
Myocardial infarction	5 (7)	71
Hypertension	17 (24)	71
Diabetes	12 (17)	72
Medication	20 (28)	
Cholesterol	9 (13)	72
Hypertension	11 (16)	71
Others	13 (18)	72
Lifestyle		
Diet history	45 (65)	69
Smoking status	4 (6)	68

Table 3
Paired pre- and postdifferences of anthropometric and biologic indicators of cardiovascular health

	Preintervention (mean)	Postintervention (mean)	% of variation	Mean difference	95 % confidence interval		n	P-value
					Inferior	Superior		
Weight (kg)	88.8	84.1	−5.4	−4.8	−5.4	−4.1	64	< 0.001
Body mass index (kg/m^2)	31.9	30.3	−5.0	−1.6	−1.9	−1.3	49	< 0.001
Waist circumference (cm)	107.3	99.9	−6.9	−7.4	−8.4	−6.5	61	< 0.001
Systolic blood pressure (mmHg)	130.5	125.4	−3.9	−5.0	−10.4	0.3	48	0.064
Diastolic blood pressure (mmHg)	82.9	79.7	−3.9	−3.2	−6.3	−0.1	48	0.041
Serum total cholesterol concentration (mmol/L)	5.03	4.16	−17.3	−0.87	−1.17	−0.57	49	< 0.001
LDL cholesterol concentration (mmol/L)	2.83	1.99	−29.7	−0.84	−1.13	−0.55	44	< 0.001
HDL cholesterol concentration (mmol/L)	1.35	1.16	−14.1	−0.19	−0.25	−0.13	52	< 0.001
Triacylglycerol concentrations (mmol/L)	1.95	2.02	−3.6	0.07	−0.18	0.31	48	0.578
TC/HDL concentration ratio	3.93	3.74	−4.8	−0.19	−0.44	0.06	48	0.135
Fasting blood glucose concentration (mmol/L)[a]	8.37	7.30	−12.8	−1.07	−2.52	0.39	6	0.104[a]
Percent glycated hemoglobin (%)[a]	8.18	6.87	−16.0	−1.32	−2.80	0.17	6	0.028[a]

[a]Wilcoxon signed ranked test
HDL, high-density lipoprotein; LDL, low-density lipoprotein; TC, total cholesterol

observed. HA participants mentioned being less triggered by highly processed foods, but LA participants reported still having cravings for calorie-dense foods. The coexistence of other determinants not addressed by the program (e.g., social isolation) seemed to increase the likelihood of unhealthy food choices.

Selection of adequate food choice strategies

Many participants emphasized that strategies to modify food-related behaviors are important determinants, which differs from previous diets. The elimination and limitation strategies taught in the program were more appealing than conventional strategies. Participants were encouraged to avoid animal products (elimination) and most highly processed foods (limitation) while eating unrestricted amounts of whole-plant foods. According to participants, this strategy helped increase satiety between meals and reduced reliance on cognitive cues to assess food quantities (e.g., portion).

The WFPB program not only provided education on health benefits of such a diet, but also integrated animal and environmental ethics related to food choices. These food values supported a diet closer to whole-plant foods. Hence, the comprehensive coherence of the curriculum seems appealing to participants, bringing additional values that support food choices toward an increase in whole-plant food consumption.

Development of a vegetarian identity

Vegetarian values led participants to limit (or eliminate) animal products. Thus, health, environmental, and ethical concerns together played an important role in the development of the participants' vegetarian identity.

Balancing transformation of and adaptation to physical and social environments

Newly acquired food choice values engaged participants in advocating for WFPB diets. However, these values also led to compatibility issues with existing food norms. On one hand, participants used various techniques to transform their peers' eating habits by acting as role models (e.g., making people taste new recipes, recommending the nutrition program). On the other hand, adapting to and managing a new system of values within their social network in accordance with meat-centered and highly processed food norms was difficult. Adopting a stricter WFPB dietary pattern (i.e., elimination of animal products) may be more challenging and require more creativity when managing social meetings for participants compared with only limiting a food category.

Development of food acquisition and preparation skills

The WFPB program taught participants how to acquire and prepare whole-plant foods. After completion of the program, food acquisition was more straightforward. Instead of wandering around grocery store aisles, participants reported better planning. Fear of increased cost was also an issue, but the fear disappeared after a few visits to the grocery store. For food preparation, participants reported not having integrated all practical knowledge during the program. Yet, participants reported important transformations in their definition of healthy eating, which differed from their previous meat-centered and highly processed food diet and was coherent with the program's goal of increasing whole-plant food consumption.

Table 4
Participant characteristics (qualitative phase; n = 10)

Group	Sex	Age	Preprogram weight (kg)	Postprogram weight (kg)	% weight loss
Low-adherers (n = 5)	F	68	75.9	72.7	−4.3
	F	–	101.8	94.6	−7.1
	F	50	90.1	88.4	−1.9
	F	55	77.8	73.7	−5.3
	F	71	70.9	67.2	−5.1
Mean		**61**	**83.3**	**79.3**	**−4.7**
High-adherers (n = 5)	F	50	91.2	85.2	−6.6
	M	45	113.9	100.5	−11.8
	M	65	107.0	98.0	−8.5
	F	60	76.9	71.7	−6.8
	M	47	95.4	86.7	−9.1
Mean		**53**	**96.9**	**88.4**	**−8.5**

F, female; M, male

Table 5
Synthesis of determinants favoring (or not) WFPB food choices

Themes	Favorable subthemes	Unfavorable subthemes
Efficacy and short-term health benefits	Food and long-term health trajectories are optimistic	–
	Desire to avoid disease and medication	–
	Short-term benefits encourage change	–
Reduction in addictions related to previous eating habits	Reduction of cravings	Dependence on traditional food
	Changes in food preferences	Coexistence of other inadequate behaviors
Selection of adequate food choice strategies	Satiety lasts between meals	Difficulty with texture or taste
	Satiety limits food intake (and not cognitive cues)	–
	Elimination and limitation strategies are more appealing than self-monitoring strategies (portion/calorie counting)	–
	Plant-based junk food tends to be limited	–
	Animal products tend to be eliminated	–
	Use of elimination and limitation strategies differ among individuals	–
Development of a vegetarian identity	Raise in awareness of altruistic motives in food choices (vs. self-centered motives, such as health)	–
	Health is a primary value	–
	A sense of betrayal by the food industry limits highly processed foods	–
Balance between transformation of and adaptation to physical and social environments	Peer education (advocacy for WFPB diets)	Challenges in value negotiation: Vegetarian values and normative food choice values
	Peer acceptance, support, and involvement	Low peer support for change
	Changing the food environment at home	Food accommodations (e.g., cook two different meals)
	Easy access to whole-plant foods in urban settings	Difficulty in eating a WFPB diet outside the home
Development of food acquisition and preparation skills	Development of skills for whole-plant foods acquisition	Fear of the costs associated with a WFPB diet
	Development of skills for WFPB meal preparation	Lack of time to prepare meals
	Personal definition of healthy eating is closer to a WFPB diet	–

WFPB, whole-food plant-based

Discussion

The first objective of the study was to evaluate the effects of a WFPB nutrition program on CVD risk factors among adults in Quebec, Canada. During the program, the mean weight loss was 4.8 kg, which is a healthy weight loss [35] and comparable with similar programs. In a 14-wk RCT (n = 64), Barnard et al. [12] compared a WFPB diet with the recommendations of the National Cholesterol Education Program. The mean weight loss was 5.8 kg in the experimental group versus 3.8 kg in the control group. In another RCT (2 y duration; n = 64) that compared a WFPB diet with the recommendations of the National Cholesterol Education Program among overweight individuals, the experimental group lost more weight at 1 y (−4.9 kg versus −1.8 kg) and 2 y (−3.1 kg versus −0.8 kg) than the control group [13]. However, other intervention studies have not found significant differences for weight, BMI, and waist circumference [36,37]. This inconsistency in the literature highlights the importance of several components of lifestyle educational programs that might influence outcomes, such as quality of the leader and curriculum of the intervention [38].

Regarding blood pressure, improvements in DBP were lower than other programs have reported [39]. These changes in DBP and the absence of change in SBP may be explained by the low prevalence of hypertension in the participants of this study. In participants with blood pressure issues, SBP and DBP decreased by 11.2 mmHg and 7.6 mmHg, respectively. These results are clinically significant because a RCT has shown that a reduction of 10 mmHg in SBP is associated with a 22% reduction in coronary heart disease and 41% reduction in stroke [40]. In epidemiologic studies, a 10-point reduction in SBP is associated with a 46% reduction in cardiometabolic mortality [41]. Furthermore, these improvements are similar to those of a study evaluating the effects of a 1-y vegan diet on patients with hypertension where 20 of 26 participants who completed the program discontinued the use of hypertension drugs [42].

Encouraging the ad libitum consumption of an WFPB diet in an intervention program might be efficient to reduce serum LDL cholesterol concentrations. Reductions in serum LDL cholesterol concentration (30%) were, in fact, similar to those achieved with pharmacologic therapy [43] as well as in a landmark 5-y RCT that showed a reversal of coronary atherosclerosis through lifestyle changes [44]. According to Ferdowsian and Barnard [45], a WFPB diet reduces serum cholesterol concentrations more than other dietary patterns given the decrease (or absence) of animal fat, which is accentuated by the lipid-lowering effect of some plant foods [46]. In a 12-wk, randomized, crossover trial (n = 34), Jenkins et al. [47] found that a portfolio of plant foods high in sterols, soy protein, viscous fibers, and almonds was as effective in lowering serum LDL cholesterol concentrations as a first-generation statin plus a conventional low-fat diet. Regarding the decrease in serum HDL cholesterol concentration and the absence of change in serum triacylglycerols concentration, one review suggests that interventions that focus on whole-plant foods have little impact on these values [48]. Nonetheless, studies that emphasize the consumption of WFPB diets with a low glycemic index and low glycemic load have experienced a 33% decrease in serum triacylglycerols concentration and a 21% increase in serum HDL concentration [49]. Even so, the decrease in serum HDL concentration cholesterol alone is not necessarily detrimental to cardiovascular health [50] if accompanied by a decrease in the total and LDL cholesterol concentrations [51], as was the case in this study.

The second objective of the study was to explore determinants that influence food choices toward a WFPB diet. Determinants of food choices identified in the qualitative phase of this study might explain why WFPB diets were effective in managing CVD risk factors in our study, but also why they were more effective in studies with more robust methodological designs in other cultural contexts [13].

First, short-term benefits are important to steer food choices toward a WFPB diet. Weight loss occurred twice as fast than for people who participated in conventional interventions [52] despite no restriction in caloric intake. An interesting case can be made with regard to the adherence and effects of the Ornish's Program for Reversing Heart Disease, in which 3780 patients participated on 24 sites [53]. Participants showed improvements in BMI, concentrations of triacylglycerol, LDL and total cholesterol, percent glycated hemoglobin, SBP, and DBP after only 12 wk. After 1 y, these improvements were still significant, and 78% of participants were still enrolled in the program despite the high magnitude of changes suggested in several lifestyle spheres, including a vegetarian diet. This compares favorably with the 40% to 50% dropout rates that are usually recorded for cardiac rehabilitation programs [54]. Hence, short-term benefits might be a determinant of adherence to nutrition programs.

Second, some authors proposed that quick changes in diet might reduce addiction to prior eating habits [11,55]. Physiological and psychosocial addiction mechanisms could explain why rapid and intensive changes may lead to better adherence. With lower adherence to a WFPB diet, the consumption of calorie-dense foods might still represent a good share of food intake, which might trigger cravings. Cravings for calorie-dense foods can be partly explained by the physiologic dependency mechanism to sugar [56], which is present in 75% of food products in the United States [57], and by fat addiction [58]. Accordingly, some studies have shown that people who switched from a high-fat diet to a diet emphasizing whole-plant foods, such as whole grains and vegetables [59] or low-fat foods [60] had less desire to eat fat.

Third, the approach used herein may fit better with the current environment in which calorie-dense foods are highly accessible [61]. Recommendations have traditionally focused on portion control and calorie restriction [62]. However, North Americans rely more on external cues to stop eating than other populations that rely more on internal satiety signals [63]. Hence, by limiting calorie-dense foods and eating unlimited amounts of whole-plant foods, external signals become useless because people reach satiety with fewer calories than with previous eating patterns [64]. This is reflected in a recent WFPB intervention study in which participants lost 10.6 kg more than with standard medical care at 6 mo and reported not being hungry [65]. Also, 80% of respondents to a survey ($n = 768$) reported that their experience of hunger had changed after the adoption of a WFPB diet, and 51% of participants reported a significant positive change [66].

Fourth, values associated with vegetarianism contribute to a diet composed of whole-plant foods [26]. Environment and animal ethics are the two most important factors (after health) in the adoption of a vegetarian eating pattern [67]. Notwithstanding, matching vegetarian and vegan values with current social food norms is challenging. For instance, eliminating animal products might lead to the reorganization of one's social network [68]. Limiting animal products may be easier to manage than elimination. In countries such as India, where 42% of households are vegetarians [69], value negotiation might be easier [49]. Besides, in two studies, ethical vegetarians report longer adherence to a vegetarian diet than health vegetarians (9.9 y versus 5.9 y, and 8.0 y versus 5.6 y, respectively) [70,71]. Although the study does not report on diet quality, ethical dimensions of food choice might be an adjuvant didactical tool contributing to longer-term behavior change.

Fifth, physical and social environments have shown to be important factors [72]. Participants indicate that because the program took place in an urban area, whole-plant foods were easy to find, which may be more difficult in rural areas. Similarly, adjusting household environments to WFPB eating patterns may facilitate adherence [73]. Social networks also influence food choices. If peers are not involved, changes will be harder to maintain [24]. For instance, dietary accommodations for other family members (e.g., cook two different meals) can create diet-related tensions [68]. Because 94% of food choices are similar between spouses and up to 87% between adolescents and their parents [74], changes toward a WFPB diet are facilitated when spouses of family members participate.

Finally, skill development in meal preparation and food acquisition are essential [75]. Cost and lack of time are also important barriers [76]. However, our results suggest that fear of high cost associated with healthy eating gradually faded. Evidence shows that changing to a WFPB diet only leads to an increase of US$1.22 per person per week [77] and does not increase the perceived cost during a WFPB program at 3, 6, and 12 mo [65]. Lack of time, which is another commonly reported barrier [75], is inherent to dietary changes because new skills must be acquired in food preparation. According to participants, 12 wk was not sufficient to develop these skills.

All our findings can guide the design of nutrition programs. First, portion- or calorie-restricted diets have been shown to have serious downsides, such as hunger, which is not necessary to achieve better cardiovascular health. This study showed significant CVD risk factor improvements without the use of portion- or calorie control strategies. Second, food acquisition and preparation skills are central to the adoption of WFPB eating patterns. Furthermore, this study shows the necessity for nutrition programs to incorporate hands-on activities, such as grocery store tours and cooking workshops, which are not systematically offered in conventional programs. Last, the inclusion of non-health-related information in nutrition program (e.g., impact of food choices on animal welfare and environmental sustainability) has contributed to the transformation participants' food choice trajectory. The observed transition of focus from self-centered to altruistic motives may guide future research.

Limitations

For the quantitative phase, the single-arm quasi-experimental retrospective design with volunteers may have artificially increased the effects of the WFPB program and limits the generalizability of the results. For the qualitative phase, the sample size was limited. Also, although the results of validation testing reinforce the validity of the results, reaching data saturation would have further increased the validity of the conclusions. Finally, the cost of the program to the participants also raises important questions about equity of access and quality of care.

Conclusions

A WFPB nutrition education program led to significant improvements in various physiological risk factors of CVD. Furthermore, six determinants of food choice toward WFPB diets were identified (i.e., efficacy and short-term health benefits, reduction of addictions related to previous eating habits, selection of adequate food choice strategies, development of vegetarian food identity, balancing transformation of and adaption to physical and social environments, and the development of food acquisition or preparation skills). Together, these findings contribute to the identification of pros and cons of WFPB nutrition educational programs. Future studies should investigate the effectiveness of this program using an RCT design or describe changes in food choice determinants over time with a longitudinal design.

References

[1] World Health Organization. Global status report on noncommunicable diseases. Geneva, Switzerland: World Health Organization; 2014.

[2] Mathers CD, Loncar D. Projections of global mortality and burden of disease from 2002 to 2030. PLoS Med 2006;3:2011–30.
[3] Statistics Canada. Leading causes of death, by sex (Both sexes). Available at: http://www.statcan.gc.ca/tables-tableaux/sum-som/l01/cst01/hlth36a-eng.htm. Accessed April 24, 2017.
[4] World Health Organization. Good health adds life to years - Global brief for World Health Day 2012. Geneva, Switzerland: World Health Organization; 2012.
[5] Akesson A, Weismayer C, Newby PK, Wolk A. Combined effect of low-risk dietary and lifestyle behaviors in primary prevention of myocardial infarction in women. Arch Intern Med 2007;167:2122–7.
[6] Yusuf S, Hawken S, Ounpuu S, Dans T, Avezum A, Lanas F, et al. Effect of potentially modifiable risk factors associated with myocardial infarction in 52 countries (the INTERHEART study): Case-control study. Lancet 2004;364:937–52.
[7] Ford ES, Bergmann MM, Kröger J, Schienkiewitz A, Weikert C, Boeing H. Healthy living is the best revenge. Arch Intern Med 2009;169:1355–62.
[8] Chiuve SE, McCullough ML, Sacks FM, Rimm EB. Healthy lifestyle factors in the primary prevention of coronary heart disease among men: Benefits among users and nonusers of lipid-lowering and antihypertensive medications. Circulation 2006;114:160–7.
[9] U.S. Burden of Disease Collaborators. The state of U.S. health, 1990-2010: Burden of diseases, injuries, and risk factors. J Am Med Assoc 2013;310:591–608.
[10] Carlson JJ, Monti V. Nutrition and dietary interventions for the prevention and management of atherosclerosis. In: Stone JA, ed. Canadian guidelines for cardiac rehabilitation and cardiovascular disease prevention: Translating knowledge into action, 3rd ed., Winnipeg: Canadian Association of Cardiac Rehabilitation; 2009:221–50.
[11] Turner-McGrievy G, Davidson CR, Wingard EE, Wilcox S, Frongillo EA. Comparative effectiveness of plant-based diets for weight loss: A randomized controlled trial of five different diets. Nutrition 2015;31:350–8.
[12] Barnard ND, Scialli AR, Turner-McGrievy G, Lanou AJ, Glass J. The effects of a low-fat, plant-based dietary intervention on body weight, metabolism, and insulin sensitivity. Am J Med 2005;118:991–7.
[13] Turner-McGrievy G, Barnard ND, Scialli AR. A two-year randomized weight loss trial comparing a vegan diet to a more moderate low-fat diet. Obesity 2007;15:2276–81.
[14] Barnard ND, Cohen J, Jenkins DJA, Turner-McGrievy G, Gloede L, Jaster B, et al. A low-fat vegan diet improves glycemic control and cardiovascular risk factors in a randomized clinical trial in individuals with type 2 diabetes. Diabetes Care 2006;29:1777–83.
[15] Elkan AC, Sjöberg B, Kolsrud B, Ringertz B, Hafström I, Frostegård J. Gluten-free vegan diet induces decreased LDL and oxidized LDL levels and raised atheroprotective natural antibodies against phosphorylcholine in patients with rheumatoid arthritis: A randomized study. Arthritis Res Ther 2008;10:2.
[16] Kahleova H, Matoulek M, Malinska H, Oliyarnik O, Kazdova L, Neskudla T, et al. Vegetarian diet improves insulin resistance and oxidative stress markers more than conventional diet in subjects with Type 2 diabetes. Diabet Med 2011;28:549–59.
[17] Jenkins DJA, Wong JMW, Kendall CWC, Esfahani A, Ng VW, Leong TC, et al. Effect of a 6-month vegan low-carbohydrate ('Eco-Atkins') diet on cardiovascular risk factors and body weight in hyperlipidaemic adults: A randomised controlled trial. BMJ Open 2014;4.
[18] Nicholson AS, Sklar M, Barnard ND, Gore S, Sullivan R, Browning S. Toward improved management of NIDDM: A randomized, controlled, pilot intervention using a lowfat, vegetarian diet. Prev Med 1999;29:87–91.
[19] Juneau M, Desgagné P, Poirier P. Prévention secondaire et réadaptation cardiaque. Réseau québécois de cardiologie tertiaire; 2009 [In French].
[20] Woloshin S, Schwartz LM, Katz SJ, Welch HG. Is language a barrier to the use of preventive services? J Gen Intern Med 1997;12:472–7.
[21] Aziz Z, Absetz P, Oldroyd J, Pronk NP, Oldenburg B. A systematic review of real-world diabetes prevention programs: Learnings from the last 15 years. Implement Sci 2015;10:172.
[22] Sobal J, Bisogni CA. Constructing food choice decisions. Ann Behav Med 2009;38:S37–46.
[23] Devine CM, Connors M, Bisogni CA, Sobal J. Life-course influences on fruit and vegetable trajectories: Qualitative analysis of food choices. J Nutr Educ 1998;30:361–70.
[24] Bisogni CA, Jastran M, Seligson M, Thompson A. How people interpret healthy eating: Contributions of qualitative research. J Nutr Educ Behav 2012;44:282–301.
[25] Fox N, Ward K. Health, ethics and environment: A qualitative study of vegetarian motivations. Appetite 2008;50:422–9.
[26] Jabs J, Devine CM, Sobal J. Model of the process of adopting vegetarian diets: Health vegetarians and ethical vegetarians. J Nutr Educ 1998;30:196–202.
[27] Fortin F, Gagnon J, Michaud C. Fondements et étapes du processus de recherche: Méthodes quantitatives et qualitatives 2010. [In French].
[28] Hernández SR, Fernández CC, Baptista LP. Metodología de la investigación. 5th ed. México, DF: McGraw Hill Interamericana Editores; 2010.
[29] Creswell JW, Plano Clark VL. Designing and conducting mixed methods research. Thousand Oaks, Calif.: SAGE Publications; 2007.
[30] Alberti KGMM, Eckel RH, Grundy SM, Zimmet PZ, Cleeman JI, Donato KA, et al. Harmonizing the metabolic syndrome. Circulation 2009;120:1640–5.
[31] Bisogni CA, Sobal J, Jastran M, et al. Creating food choice dialogues. Ithaca: Food Choice Research Group at Cornell; 2003 Cornell University, Departement of Nutritional Sciences.
[32] Gauthier B. Recherche sociale - De la problématique à la collecte de données. 5 ed. Québec: Presses de l'Université du Québec; 2008 [In French].
[33] Paillé P, Mucchielli A. L'analyse qualitative en sciences humaines et sociales. Paris: Armand Colin; 2012.
[34] Morin E. Programme d'interventions nutritionnelles centrées sur une alimentation végétale minimalement transformée: Évaluation des effets et exploration des déterminants influençant les choix alimentaires chez des adultes à risque de maladies cardiovasculaires. Master thesis 2016. [In French].
[35] National Institutes of Health. The practical guide: Identification, evaluation, and treatment of overweight and obesity in adults. United States, North America; 2000.
[36] Kahleova H, Hill M, Pelikánova T. Vegetarian vs. conventional diabetic diet - A 1-year follow-up. Cor Vasa 2014;56:e140–4.
[37] Barnard ND, Cohen J, Jenkins DJA, Turner-McGrievy G, Gloede L, Green A, et al. A low-fat vegan diet and a conventional diabetes diet in the treatment of type 2 diabetes: A randomized, controlled, 74-wk clinical trial. Am J Clin Nutr 2009;89:1588S–96S.
[38] Lillyman S, Farquharson N. Self-care management education models in primary care. Br J Community Nurs 2013;18:556–60.
[39] Berkow SE, Barnard ND. Blood pressure regulation and vegetarian diets. Nutr Rev 2005;63:1–8.
[40] Law MR, Morris JK, Wald NJ. Use of blood pressure lowering drugs in the prevention of cardiovascular disease: Meta-analysis of 147 randomised trials in the context of expectations from prospective epidemiological studies. BMJ 2009;338:b1665.
[41] Cesare MD, Bennett JE, Best N, Ezzati M, Stevens GA, Danaei G, et al. The contributions of risk factor trends to cardiometabolic mortality decline in 26 industrialized countries. Int J Epidemiol 2013;42:838.
[42] Lindahl O, Lindwall L, Spangberg A. A vegan regimen with reduced medication in the treatment of hypertension. Br J Nutr 1984;52:11–20.
[43] Grundy SM, Cleeman JI, Merz CNB, Brewer HB, Clark LT, Hunninghake DB, et al. Implications of recent clinical trials for the National Cholesterol Education Program Adult Treatment Panel III guidelines. Circulation 2004;110:227–39.
[44] Ornish D, Scherwitz LW, Billings JH, Brown SE, Gould KL, Merritt TA, et al. Intensive lifestyle changes for reversal of coronary heart disease. J Am Med Assoc 1998;280:2001–7.
[45] Ferdowsian HR, Barnard ND. Effects of plant-based diets on plasma lipids. Am J Cardiol 2009;104:947–56.
[46] Jenkins DJA, Kendall CWC, Marchie A, Faulkner DA, Wong JM, de Souza R, et al. Effects of a dietary portfolio of cholesterol-lowering foods vs lovastatin on serum lipids and C-reactive protein. J Am Med Assoc 2003;290:502–10.
[47] Jenkins DJA, Kendall CWC, Marchie A, Faulkner DA, Wong JM, de Souza R, et al. Direct comparison of a dietary portfolio of cholesterol-lowering foods with a statin in hypercholesterolemic participants. Am J Clin Nutr 2005;81:380–7.
[48] Turner-McGrievy G, Harris M. Key Elements of plant-based diets associated with reduced risk of metabolic syndrome. Curr Diab Rep 2014;14:1–9.
[49] Pande A, Krishnamoorthy G, Moulick ND. Hypoglycaemic and hypolipidaemic effects of low GI and medium GL Indian diets in type 2 diabetics for a period of 4 weeks: A prospective study. Int J Food Sci Nutr 2012;63:649–58.
[50] Shavlik DJ, Fraser GE. Ten years of life: Is it a matter of choice? Arch Intern Med 2001;161:1645–52.
[51] Bartlett J, Williams SM, Predazzi IM, Bush WS, Kim Y, Havas S, et al. Is isolated low high-density lipoprotein cholesterol a cardiovascular disease risk factor? Circ Cardiovasc Qual Outcomes 2016;9:206–12.
[52] Franz MJ. Weight-loss outcomes: A systematic review and meta-analysis of weight-loss clinical trials with a minimum 1-year follow-up. J Am Diet Assoc 2007;107:1755–67.
[53] Silberman A, Banthia R, Estay IS, Kemp C, Studley J, Hareras D, et al. The effectiveness and efficacy of an intensive cardiac rehabilitation program in 24 Sites. Am J Health Promot 2010;24:260–6.
[54] Scane K, Alter D, Oh P, Brooks D. Adherence to a cardiac rehabilitation home program model of care: A comparison to a well-established traditional on-site supervised program. Appl Physiol Nutr Metabol 2012;37:206–13.
[55] Moss M. Salt sugar fat: How the food giants hooked us. Random House; 2013.
[56] Avena NM, Rada P, Hoebel BG. Evidence for sugar addiction: Behavioral and neurochemical effects of intermittent, excessive sugar intake (English). Neurosci Biobehav Rev 2008;32:20–39.
[57] Ng SW, Slining MM, Popkin BM. Use of caloric and noncaloric sweeteners in US consumer packaged foods, 2005−2009. J Acad Nutr Diet 2012;112:1828–34.
[58] Avena NM, Rada P, Hoebel BG. Sugar and fat bingeing have notable differences in addictive-like behavior. J Nutr 2009;139:623–8.
[59] Mattes RD. Fat preference and adherence to a reduced-fat diet. Am J Clin Nutr 1993;57:373–81.
[60] Ledikwe JH, Ello-Martin J, Pelkman CL, Birch LL, Mannino ML, Rolls BJ. A reliable, valid questionnaire indicates that preference for dietary fat declines when following a reduced-fat diet. Appetite 2007;49:74–83.
[61] Brownell K, Battle HK. Food fight: The inside tory of the food industry, America's obesity crisis, and what we can do about it. The McGraw-Hill Companies, Inc.; 2004.

[62] Burke LE, Wang J, Sevick MA. Self-monitoring in weight loss: A systematic review of the literature. J Am Diet Assoc 2011;111:92–102.
[63] Wansink B, Payne CR, Chandon P. Internal and external cues of meal cessation: The French paradox redux? Obesity 2007;15:2920–4.
[64] Ello-Martin JA, Roe LS, Ledikwe JH, Beach AM, Rolls BJ. Dietary energy density in the treatment of obesity: A year-long trial comparing 2 weight-loss diets. Am J Clin Nutr 2007;85:1465–77.
[65] Wright N, Wilson L, Smith M, Duncan B, McHugh P. The BROAD study: A randomised controlled trial using a whole food plant-based diet in the community for obesity, ischaemic heart disease or diabetes. Nutr Diabetes 2017;7:3.
[66] Fuhrman J, Sarter B, Glaser D, Acocella S. Changing perceptions of hunger on a high nutrient density diet. J Council Nutr 2011;34:5–17.
[67] Wilson MS, Weatherall A, Butler C. A rhetorical approach to discussions about health and vegetarianism. J Health Psychol 2004;9:567–81.
[68] Jabs J, Devine CM, Sobal J. Maintaining vegetarian diets: Personal factors, social networks and environmental resources. Can J Diet Pract Res 1998;59:183–9.
[69] Mehta R, Delgado C, Subrahmanyam S. Annex II: Final Report of IFPRI-FAO Livestock Industrialization Project: Phase II - Policy, Technical, and Environmental Determinants and Implications of the Scaling-Up of Broiler and Egg Production in India, Washington DC: International Food Policy Research Institute; 2003.
[70] Hoffman SR, Stallings SF, Bessinger RC, Brooks GT. Differences between health and ethical vegetarians. Strength of conviction, nutrition knowledge, dietary restriction, and duration of adherence. Appetite 2013;65:139–44.
[71] Radnitz C, Beezhold B, DiMatteo J. Investigation of lifestyle choices of individuals following a vegan diet for health and ethical reasons. Appetite 2015;90:31–6.
[72] Giskes K, van Lenthe F, Avendano-Pabon M, Brug J. A systematic review of environmental factors and obesogenic dietary intakes among adults: Are we getting closer to understanding obesogenic environments? Obes Rev 2011;12:e95–106.
[73] Wansink B. Conditionnés pour trop manger: Comment l'environnement influence votre appétit. Vergèze: Thierry Souccar Editions; 2009 [In French].
[74] Feunekes GI, de Graaf C, Meyboom S, van Staveren WA. Food choice and fat intake of adolescents and adults: Associations of intakes within social networks. Prev Med 1998;5:645–56.
[75] Contento IR. Overview of determinants of food choice and dietary change: Implications for nutrition education. Nutrition education: Linking research, theory, and practice. 2nd ed. Sudbury, Toronto: Jones and Bartlett; 2011.
[76] UK Department of health. Summary of insight research conducted with middle aged adults. Skipton House; 2010.
[77] Hyder JA, Thomson CA, Natarajan L, Madlensky L, Pu M, Emond J, et al. Adopting a plant-based diet minimally increased food costs in WHEL Study. Am J Health Behav 2009;33:530–9.