One-year Dietary Changes in a Lifestyle Study for Metabolic Syndrome in the Canadian Primary Care Context

by

Airu Li

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ABSTRACT

ONE-YEAR DIETARY CHANGES IN A LIFESTYLE STUDY FOR METABOLIC SYNDROME IN THE CANADIAN PRIMARY CARE CONTEXT

Airu Li
University of Guelph, 2017

Advisor:
Dr. P. Brauer

The Canadian Health Advanced by Nutrition and Graded Exercise (CHANGE) project was a one-year feasibility study of lifestyle treatment (i.e. diet and exercise) of metabolic syndrome. This secondary analysis examined dietitian counselling and participants' food behaviour changes over 12 months. The results indicated that, similar to the 3-month results, dietitians mainly focused on a group of food behaviour goals (e.g. *Balanced meals*, *Increase fruit and vegetables*, etc.) and behaviour change techniques (e.g. *Review of goals*, *Goal setting*, *Feedback on performance*, etc.) while others were seldom used. Participants changed and maintained some food behaviours over one year, with the greatest changes in participants with poorer baseline diet. Some food behaviours were more easily changed than others. Qualitatively, some, but not all food behaviour changes seemed to be associated with food behaviour goals dietitians used in counselling. More research is needed to understand patient dietary behaviour change and dietitian counselling.

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List of Abbreviations

BCT	Behaviour Change Technique
BMI	Body Mass Index
CALO-RE	Coventry, Aberdeen & London – Refined
CFG	Canada's Food Guide
CHANGE	Canadian Health Advanced by Nutrition and Graded Exercise
CVD	Cardiovascular Disease
DASH	Dietary Approaches to Stopping Hypertension
FBG	Food Behaviour Goal
FFQ	Food Frequency Questionnaire
HDL-C	High-Density Lipoprotein Cholesterol
HEI	Healthy Eating Index
HEI-C	Canadian Healthy Eating Index
LDL-C	Low-Density Lipoprotein Cholesterol
MEDAS	Mediterranean Diet Adherence Screener
MD	Mediterranean Diet
MDS	Mediterranean Diet Score
MetS	Metabolic Syndrome
PREDIMED	PREvención con DIeta MEDiterránea
PROCAM	Prospective Cardiovascular Munster
RD	Registered Dietitian
RCT	Randomized Controlled Trial
T2DM	Type II Diabetes Mellitus

Introduction

Cardiovascular disease and diabetes have been growing concerns across the world. Metabolic syndrome (MetS), which is characterized by a cluster of metabolic abnormalities including elevated fasting glucose, elevated triglycerides, lower high-density lipoprotein cholesterol (HDL-C), elevated blood pressure, and central obesity (elevated waist circumference), is also a growing concern since it is associated with increasing risk of developing diabetes and cardiovascular disease (Leiter et al., 2011; Grundy et al., 2005). Approximately 20% of adult Canadians have MetS (Riediger & Clara, 2011). The number of people who have increased risk of having MetS (i.e. having at least one risk factor of MetS) has been increasing over the past few years (Statistics Canada, 2012; 2014).

Lifestyle modification is recommended as primary intervention for MetS management (Grundy et al., 2005; Leiter et al., 2011) and diet is major part of the lifestyle changes needed for MetS patients. Efficacy studies have provided evidence that healthy lifestyle habits, including diet and exercise, is more successful than usual care to resolve MetS status (Yamaoka & Tango, 2012) and is most achievable by team-based health care approach (Bassi, 2014).

It is important to understand the process of change in dietary and lifestyle interventions since the ultimate goal of these interventions is to prevent progression to clinical disease within the constraints of typical clinical practice in the health care system.

Therefore, the feasibility and acceptability of interventions to care providers and patients are critical considerations for development of effective treatments. Several key elements, including the context, what aspects of diet to be changed and what outcomes to be measured, need to be addressed in future studies.

To date, there are some knowledge gaps in research on the effectiveness of lifestyle interventions for MetS patients:

1. The diet component of the intervention is more complex than generally appreciated as multiple eating behaviours typically need to change and be sustainable over the long-term. Diets are often viewed as a whole and only as one aspect of lifestyle treatment. While some studies have shown that an increase in diet quality scores are linked to clinical improvement such as weight loss, reduction in BMI, waist circumference, fasting blood glucose, etc. (Jacobs et al., 2009; Martinez-González, 2012; Fung et al., 2005), diets need to be examined in more detail to figure out where changes occur.
2. In those studies that have examined dietary change in detail, the majority measured the change only at the level of nutrients. Although foods are excellent sources of certain nutrients (e.g. fruits/vegetables are great sources of fibre; meat is a great source of proteins), they are not identical. Dietary assessment and counselling mostly focuses on food intake, not nutrient intake. Hence, there is a need to focus on food intake behaviours in addition to nutrients in clinical research, to make results more easily translatable into clinical practice.

3. Lifestyle modification aims for permanent changes in lifestyle behaviours (Fappa et al., 2008), which means successful lifestyle change can be sustained over a longer period of time. Short-term dietary changes are valuable in examining direct effects of interventions; however, measures of dietary intake during follow-up periods are equally important as they provide information on how well people can adhere to new behaviours over time; one year is a typical longer-term follow-up period. More studies are needed that assess longer-term effectiveness of diet counselling.

To address the knowledge gaps above, this research study examined change in food behaviours over a longer period of time. This study was a secondary analysis of dietary data from a one-year lifestyle modification program, the Canadian Health Advanced by Nutrition and Graded Exercise (CHANGE) project (Jeejeebhoy et al., 2017). Previous studies have already reported dietary changes in the short-term (3 months), and in this study the process of change from shorter term to longer term was examined to determine what changes occurred and lasted longer.

The goal of this study was to examine how dietitians counselled and how patient dietary behaviours changed over 12 months in a diet intervention for metabolic syndrome delivered in three primary care settings.

The primary objective was to determine to what extent each dietary behaviour change was maintained over 12 months by comparing dietary behaviour change at months 12 and months 3;

The secondary objectives were:

1. To explore if dietitian counselling foci (i.e. food behaviour goals) were associated with change in diet at months 12;
2. To explore the characteristics and food behaviours of a priori subgroups at baseline and overtime by comparing the experience of:
    a) Those who completed and who did not complete follow-up assessment at months 12;
    b) those with lower and higher HEI-C scores at baseline;
    c) those with lower and higher PROCAM risk scores at baseline.

Literature Review

Metabolic Syndrome

Definition

Metabolic syndrome (MetS) is defined as having any three of the five following risk factors: elevated fasting blood glucose, high blood pressure, elevated triglyceride levels, low high-density lipoprotein cholesterol levels, and central obesity (Alberti et al., 2009). The harmonized criteria for clinical diagnosis of MetS are described in Table 1.

Table 1 Criteria for clinical diagnosis of MetS.

Risk factor component	**Categorical cut point**	
	Males	**Females**
Elevated waist circumference		
Europids/Caucasian/Mediterranean/Middle East/Sub-Saharan Africans	≥ 94 cm	≥ 80 cm
Asian and South Central Americans	≥ 90 cm	≥ 80 cm
US and Canadian	≥ 102 cm	≥ 88 cm
Reduced high-density lipoprotein cholesterol (HDL-C)	< 1.0 mmol/L (40 mg/dL)	< 1.3 mmol/L (50 mg/dL)
Elevated triglycerides*	≥ 1.7 mmol/L (150 mg/dL)	
Elevated blood pressure*	≥ 130/85 mmHg	
Elevated fasting glucose*	≥ 5.6 mmol/L (100 mg/dL)	

* Drug treatment is an alternative measure.

Prevalence

According to Statistics Canada 2012-13 report on MetS, the prevalence of MetS was estimated to be 21% in Canadian adults between 18 and 79 years of age (Statistics Canada, 2014). A similar percentage was also reported in Riediger and Clara's study (2011). Age was reported to have strong association with the prevalence of MetS (Statistics Canada, 2014): approximately 39% of the Canadian population who aged 60-79, compared with 13% of those aged 18-39, were determined to have MetS. In the same report, the prevalence was also slightly higher in males than that in females (22% vs. 20%). Despite the proportion of population with determined MetS, which means having three or more component risk factors, 44% of Canadian adults had two or more risk components, 67% had at least one, and only 33% were free of any of the five risk factors, and the number of MetS risk factors increased with age. More importantly, these numbers were worse than the 2009-2011 report on the same subject. Therefore, preventing and

treating MetS is becoming critical for improving the general health of Canadians.

Consequences

The presence of MetS leads to a 1.5- to 2-fold increase in cardiovascular disease (CVD) outcomes (i.e. myocardial infarction, stroke) and 1.5-fold increase in all cause-mortality (Leiter et al., 2011; Mottillo et al., 2010). The CVD risk brought by MetS is beyond the absolute risk calculated using validated algorithms such as the Framingham Risk Score (FRS) (Leiter et al., 2011). Additionally, the risk of developing diabetes tripled in people with MetS compared to those without MetS (Ford, 2005). Overall, it is evident that the presence of MetS is associated with negative health outcomes.

Assessing intermediate outcomes

Each component of MetS can be measured independently using specific tests. Work is ongoing to develop CVD risk scoring algorithms that reflect the heightened CVD risk associated with MetS. Among available tools, the Prospective Cardiovascular Munster (PROCAM) study algorithm is a preferred method as it incorporates more MetS related risk factors into the model, compared with other validated algorithms. The PROCAM score is calculated from eight independent variables including age, LDL-C, HDL-C, triglycerides, smoking, diagnosis of diabetes, family history of MI, and systolic blood pressure (Assmann, Schulte, & Seedorf, 2008). Assmann and colleagues (2008) modified the original PROCAM score with BMI/waist circumference as an additional variable and found the two PROCAM scores were able to predict similar levels of risk for major

coronary events. Development and further testing of CVD risk algorithms is needed as the PROCAM score has been developed in mainly German men. Other risk score tools have been published, but the PROCAM tool is among the best accepted to date.

Overall medical management

There is no single medication to treat MetS as it is a combination of multiple risk conditions. Therefore, each risk component is often treated separately using specific drugs, such as orlistat for weight management, statin for lipid control, or antihypertensive drugs to address elevated blood pressure (Leiter et al., 2011). Management of MetS primarily focuses on reducing CVD risk, and lifestyle modification is recommended as the primary intervention strategy for managing MetS (Grundy et al., 2005; Leiter et al., 2011). Drug therapy is used when absolute CVD risk is high enough (Grundy et al., 2005) and secondary to lifestyle intervention (Leiter et al., 2011).

Lifestyle Modification

Lifestyle intervention mostly consists of counselling with regards to physical activity, dietary modification, and smoking cessation for smokers (Grundy et al., 2005; Leiter et al., 2011). It is the recommended preferred strategy for management of MetS as it can target multiple risk factors all at once, compared with drug therapies which usually only target specific risk factors and may have some undesired side effects (i.e. Thiazide diuretics used for reducing blood pressure may increase risk for development of new diabetes) (Leiter et al., 2011). Lifestyle modification is also relatively inexpensive,

compared to the cost of multiple drugs (Leiter et al., 2011).

Efficacy of lifestyle change

A number of intervention studies involving lifestyle modification for managing MetS have been reported in the literature. In a systematic review and meta-analysis of eight randomized controlled trials (RCTs) that used lifestyle intervention for treating MetS and followed up patients for at least 6 months, Yamaoka and Tango (2012) found that the percentage of patients with resolved MetS in the intervention groups was twice that of the control groups (35% and 17% reverted, respectively). Lifestyle modification interventions significantly reduced risk factors of MetS: SBP by -6.4 mmHg (95% CI: -9.7 to -3.2), triglycerides by -0.14 mmol/L (-12.0 mg/dl; 95% CI: -22.2 to -1.7), waist circumference by -2.7 cm (95% CI: -4.6 to -0.9), and fasting blood glucose by -0.64 mmol/L (-11.5 mg/dl; 95% CI: -22.4 to -0.6). These results provided evidence that lifestyle intervention, including dietary modification only, is effective in reducing components of MetS. Another systematic review by Bassi and colleagues (2014) suggested that lifestyle programs delivered via a team-based, interactive approach were most successful in reducing MetS risk factors, and patients' motivation was a key for achieving long-term adherence to the programs.

Diet as Major Lifestyle Changes

Since the focus of this project was dietary intervention, only the dietary aspects of relevant studies are reviewed.

Dietary modification is an important part of lifestyle intervention. Studies have explored the use of various diets in managing MetS. In the meta-analysis by Yamaoka and Tango (2012), the diet interventions involved in the studies included Mediterranean diet, Dietary Approaches to Stopping Hypertension (DASH diet), low-calorie low-fat diet, and individualized diet advice emphasizing weight loss. Adherence to the DASH diet has been associated with reduced risk of diabetes in white people who had normal or impaired glucose tolerance (Liese, Nichols, Sun, D'Agostino, & Haffner, 2009). Those with higher scores on the Healthy Eating Index (HEI) or Alternate Healthy Eating Index (AHEI) had a lower risk of major chronic diseases, CVD events and diabetes in healthy men and women in a US cohort (Chiuve et al., 2012). Both the HEI and AHEI are 100-point scales of diet quality, based on frequency of consumption of selected foods (such as fruit and vegetables) or selected nutrients (such as sodium). These observational studies with mostly healthy populations have provided evidence that dietary quality could have positive effects on health outcomes, and provided justification for the intervention studies already reviewed.

Although it seemed that different intervention studies used different dietary approaches, which were described in the meta-analysis by Yamaoka and Tango (2012), certain aspects of the interventions were similar, as several types of food advice, such as increasing daily intake of whole grains, fruits and vegetables, and reducing caloric intake, have been dominant. It is not surprising, since the positive effects of these food behaviours have been frequently reported in the literature. For example, whole grain

consumption was associated with a reduced risk of CVD events, diabetes and all-cause mortality (Aune et al., 2016). Fruits and vegetable intakes were also found to have effects on reducing risk of CVD (Buil-Cosiales et al., 2016). Caloric restriction has been reported to be effective in reducing waist circumference in obese men and women, and fasting blood glucose levels in people with type 2 diabetes (Leiter et al., 2011); it is also associated with reduction of TG levels, modest increase in HDL-C levels, as well as modest effect on decreasing systolic and diastolic blood pressure (Leiter et al., 2011).

While the RCT literature provides evidence that dietary modification can improve risk components of MetS, the details of diet interventions have not been adequately evaluated in practice settings with typical patients. It has also not been clear which food behaviours people are most likely to change, since it seems unlikely that people can adopt an entirely new eating pattern such as a Mediterranean or DASH diet.

Relevance to clinical practice

The ultimate goal of these intervention studies is to improve the process of care for MetS patients in clinical practice, as consensus has not been reached on treatment for these patients. In order for the dietary intervention to be replicated in clinical practice, the feasibility and acceptability of the interventions to both care providers and patients should be tested. In particular, two aspects of the intervention need to be addressed:

1. what aspects of diet care providers focused on; and
2. what changes patients made in response to the intervention.

The context is also important, as it may affect the focus of the dietary intervention and the types and degree of dietary changes achieved. Primary care is where most patients with MetS are managed. Primary care in Canada is mainly run as small businesses by family physicians, who often work alone or with limited support and charge set fees for their services to provincial health insurance plans, which are government run. Health care is provincial and primary care in Canada is in transition. Team-based care is increasing, but not yet the norm in all provinces. Alberta, Ontario and Quebec have the most developed team-based models (Hutchison, 2011). Team-based care is mainly being funded using blended funding, with some set support per patient, plus additional incentive funding for selected activities.

Dietary modification is complicated for MetS patients as it targets multiple aspects of their diets. To add to the complexity of behaviour change, the processes of change also differ among patients. Behaviour change is not only influenced by people's intention to change, but also controlled by other factors, including knowledge and skills, salience of the behaviour, environmental constraints, and habits, as suggested in the Integrated Behavioural Model (Glanz, Rimer, & Viswanath, 2008); see Figure 1. Considering that these factors vary from patient to patient, individualized care is essential to meet specific needs of individual patient in clinical practice. The focuses of each dietary counselling intervention will also depend on the circumstances of the patients in terms of social economic status, work and family responsibilities, culture, etc.

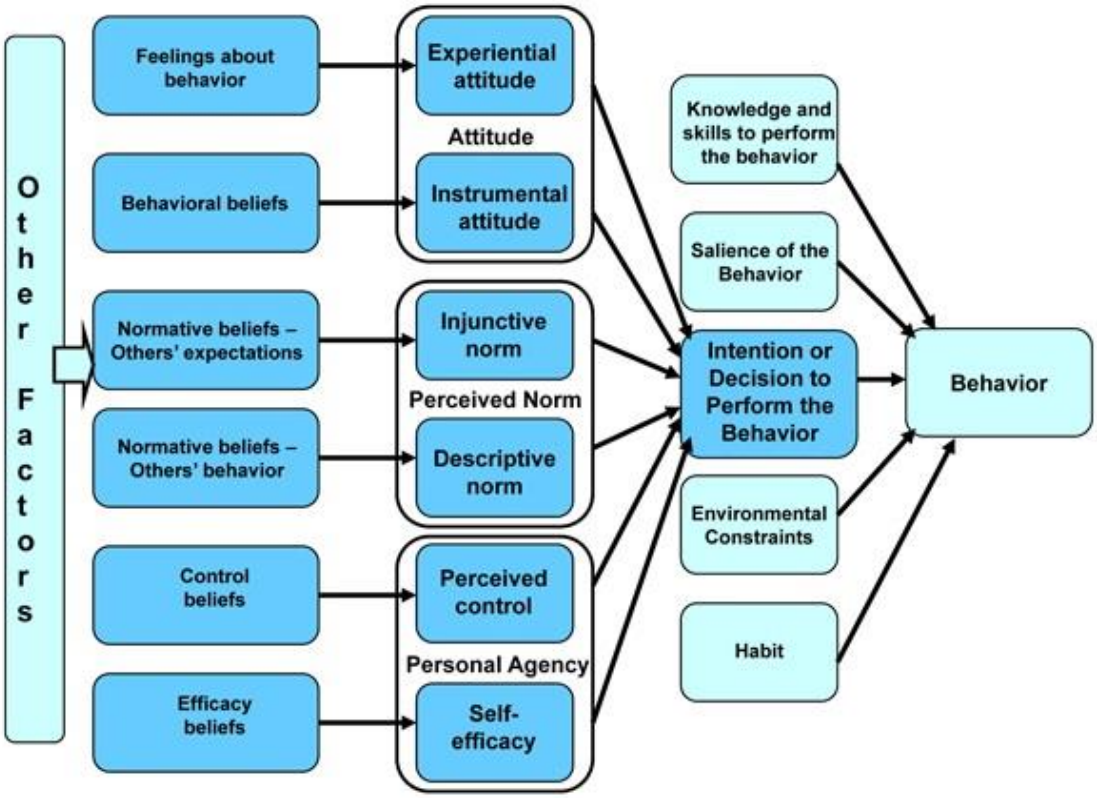


Figure 1 Integrated behavioural model. *Adapted from* Glanz, K., Rimer, B. K., & Viswanath, K. (2008). *Health behavior and health education: Theory, research, and practice* (4th ed.). San Francisco, CA: Jossy-Bass.

Assessing Dietary Changes

Dietary assessment is important in guiding the intervention. First, it provides the nutrition status of patients at baseline, which allows dietitians to adjust intervention to fit individual needs. Second, measuring dietary intakes throughout the intervention provides evidence on where dietary changes take place and allow us to understand the process of change of patients in response to the intervention they receive. It is particularly important in such a complex intervention, as the multiple aspects of diet can be reduced to an acceptable level, making intervention more efficient and effective.

Overall, dietary assessment consists of three levels: the overall dietary pattern, individual food behaviour, and nutrient intake. All three levels of diet have been reviewed and found to have association with risk reduction in relevant studies such as diabetes prevention and management (Ley, Hamdy, Mohan, & Hu, 2014). However, speaking of dietary changes, the majority of nutrition research has reported on the changes at the nutrient level.

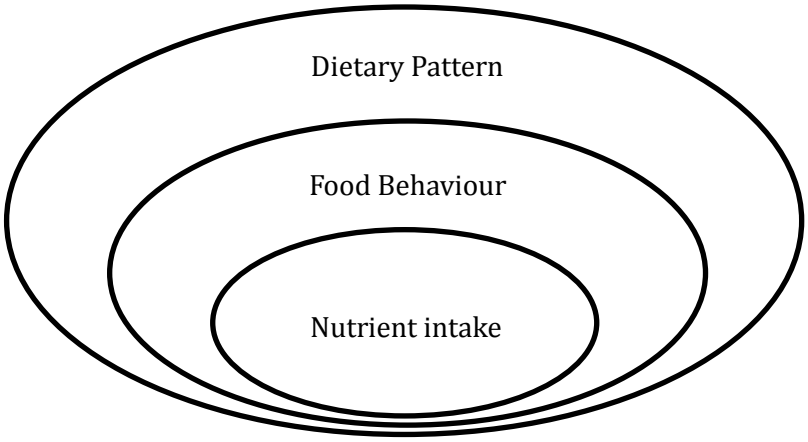


Figure 2 The relationship among dietary pattern, food behaviour, and nutrient intake.

Nutrients are fundamental bioactive components of foods and allow comparisons across studies. While nutrient analysis makes nutrition studies comparable across countries, which is beneficial for international nutrition research and for development of universally acceptable guidelines for treatment, the potential interactions among nutrients and among foods cannot be ignored. It is clear that certain nutrients have significant effects on issues that are less complicated, such as calcium for bone health. Yet, in a

much more complex situation like MetS, there is a need to emphasize food behaviours and dietary patterns to capture an overall picture of diet and health. Similar suggestions were also made by Ley and colleagues (2014) in the area of diabetes prevention and management that quality is more important than quantity regarding macronutrient intake, which spoke in favour of a focus on diet quality in future research.

In research, dietary information may be collected by the use of 24-hour recalls, 3-day food records or food frequency questionnaires (FFQ), which are highly reflective of patients' food behaviour. However, these assessment tools usually require a high degree of cooperation from patients, are labour intensive and time consuming. These tools may not be fully incorporated in clinical practice as the dietitians only meet patients for a limited amount of time and should not take the entire counselling session to assess patients' dietary intake. This observation was confirmed in a recent study of diet assessment in primary care (Bonilla et al., 2016). Therefore, quick and simple assessment tools for assessing patients' diets may be more suitable in primary care settings.

Measuring changes – diet quality as newer tools

Diet quality measures may be a potential substitute for assessing dietary changes in research as well as in clinical practice. The major benefits of diet quality indices over full-length FFQs are that they provide quick and simple assessment of overall intake patterns, which make dietary assessment less burdensome for both patients and dietitians (Kristal & Ollberding, 2013). Diet quality indices are able to capture overall intake

patterns in a wide variety of patient populations and some have established relationships with various chronic diseases and mortality (Liese et al., 2015). Two diet quality indices, the Canadian Healthy Eating Index (HEI-C) and the Mediterranean Diet Score (MDS), are of particular interest in this study and thus are briefly described here.

Canadian Healthy Eating Index

HEI-C is the Canadian version of the 2005 American HEI that has been modified based on recommendations from the 2007 version of Canada's Food Guide (CFG) (Statistics Canada, 2009); see Table 2. The original index was designed to monitor intake patterns of Americans, and since Canadian and American dietary guidelines are generally similar, the modified version is also suitable for measuring the diet quality of the Canadian population. The HEI-C is highly food-oriented as it assesses both the adequacy of food group intakes and moderation of a diet, with independent score for each component and a total score of 100. A total score of 50 or less is considered as low quality; a total score between 50 and 80 is considered as average; and a total score of 80 or more indicates a high quality diet. An increase in the total score of HEI-C may be an indicator of change in dietary behaviour, better adherence to CFG and moderation of selected foods and nutrients. HEI-C is considered to have content validity and construct validity as it captures the key concepts of CFG and scores are consistent with other evidence-supported healthy diets (such as DASH) (Statistics Canada, 2009).

Table 2 Components, range of scores, and scoring criteria for Canadian Healthy Eating Index.

Component	Range of scores	Scoring criteria*
Adequacy*	**0 to 60**	
Total vegetables and fruit	0 to 10	Maximum: 4 to 10 servings[1,2]
Whole fruit	0 to 5	Maximum: 0.8 to 2.1 servings[1-3]
Dark green and orange vegetables	0 to 5	Maximum: 0.8 to 2.1 servings[1-3]
Total grain products	0 to 5	Maximum: 3 to 8 servings[1,2]
Whole grains	0 to 5	Maximum: 1.5 to 4 servings[1,2,4]
Milk and alternatives	0 to 10	Maximum: 2 to 4 servings[1,2]
Meat and alternatives	0 to 10	Maximum: 1 to 3 servings (75 to 225grams)[1,2]
Unsaturated fats	0 to 10	Maximum: 30 to 45 grams[1,2]
Moderation*	**0 to 40**	
Saturated fats	8 to10	7% (score of 10) to 10% (score of 8) of total energy
	0 to 8	10% (score of 8) to 15% (score of 0) of total energy
Sodium	8 to 10	Adequate intake (score of 10) to tolerable upper intake level (score of 8)
	0 to 8	Tolerable upper intake level (score of 8) to twice tolerable (score of 0)
"Other food"	0 to 20	Minimum: 40% or more of total energy intake Maximum: 5% or less of total energy intake

*Proportional scores are given for amounts between the minimum and maximum

[1]Age and gender specific recommendations from CFG

[2]Minimum of 0 serving

[3]21% of recommendation for total vegetables and fruit

[4]50% of recommendation for total grain products

Mediterranean diet score

A number of FFQ for the "Mediterranean diet" have been developed, although diet differs in countries that rim the Mediterranean. Among these the Mediterranean Diet Score (MDS) is designed as a short screener and diet intervention indicator. The most

current and validated version is the Mediterranean Diet Adherence Screener (MEDAS), which is a 14-item assessment tool developed by Schröder and colleagues (2011) for measuring adherence to Mediterranean diet patterns in the PREvención con DIeta MEDiterránea (PREDIMED) study. The MEDAS consists of 9 previously validated items (Martínez-González, Fernández-Jarne, Serrano-Martínez, Wright, & Gomez-Garcia, 2004) with five additional items as listed in Table 3. Each item has specific criteria for achieving a score of 1, summing for a total score of 14. Since the scoring criteria are dichotomous, this tool provides goals for behaviour change. The MEDAS had moderate inter-rater reliability with a 137-item validated semi-quantitative food frequency questionnaire (FFQ) used in the same study (r = 0.52; ICC = 0.51) and thus was suggested as a potential substitute for the full-length FFQ (Schröder et al., 2011).

Table 3 Components and criteria of Mediterranean Diet Score.

Component	Criteria to achieve a score of 1*
Previously validated items (Martínez-González et al., 2004)	
Fruits	≥ 3 servings per day
Vegetables	≥ 4 servings per day; at least 2 servings raw
Red or processed meats	< 2 servings per day
Legumes	≥ 3 servings per week
Fish or seafood	≥ 4 servings per week
Butter or cream	< 1 tbsp per day
Olive oil	≥ 4 tbsp per day
Wine	≥ 7 servings per week
Commercial baked goods	≤ 2 times per week
Additional items (Schroder et al., 2011)	
Olive oil as main cooking fat	Yes
Poultry more often than red meat	Yes
Nuts	≥ 3 servings per week
Sugar-sweetened beverages	< 1 per day
Sofrito sauce	≥ 2 times per week

*Criteria has been adjusted to be consistent with servings size recommendations from Canada's Food Guide

Review of studies to date

While there is limited dietary information available from MetS studies, clinical research in relevant areas such as CVD and diabetes management/prevention may be useful as the target populations are similar to those with MetS. Based on the results from a scoping review of intervention studies in primary care settings in all relevant areas (e.g. CVD prevention, T2DM prevention, hypertension management, and weight management, etc.) between 2003 and 2012 (Olivia O'Young, MSc thesis), a search was done to extract MetS/diabetes prevention studies that examined the dietary changes people made from baseline up to one-year follow-up, resulting in 17 studies; one year was chosen because it was a typical time length for establishing long-term adherence to new behaviours (Absetz

et al., 2007; Bo et al., 2007; Cade et al., 2009; Clark et al., 2004; Eakin et al., 2009; Garcia-Huidobro et al., 2011; Huang et al., 2010; Jackson et al., 2007; Koelewijn-van Loon et al., 2009; Korhonen et al., 2003; Mensink et al., 2003; Sacerdote et al., 2006; Sakane et al., 2011; ter Bogt et al., 2011; Verheijden et al., 2004; Wood et al., 2008; Woollard et al., 2003). The majority of studies were conducted in Europe, predominantly in the UK, Netherlands and Italy; the country where the studies were most frequently conducted outside Europe was Australia. The delivery of interventions included individual face-to-face counselling, group sessions, and telephone consultations. The length of each counselling session ranged from 15 minutes (typical for telephone counselling) to 2 hours (usually for group sessions), and the frequency of the intervention also varied from weekly to quarterly. The foci of studies were predominantly diabetes prevention/management (n=7) and CVD prevention/management (n=6), with one study on MetS in particular. Of those 17 studies, ten studies examined dietary changes at the nutrient level only; one examined both nutrient and behaviour levels; six examined behaviour only. Overall, 15 of the 17 studies found some changes at either nutrient or behaviour levels in the intervention group:

1. At the nutrient level, the most common changes appeared to be decreased total and saturated fat intake. The amount of change varied from -1% to -5% for total fat and from -1% to -3% for saturated fat, depending on the focus of the intervention. Another frequent change reported was decreased total energy intake, with an average reduction of 200 kcal across studies (Bo et al., 2007; Eakin et al.,

2009; Huang et al., 2010; Korhonen et al., 2003; Mensink et al., 2003; Sakane et al., 2011; ter Bogt et al., 2011).

2. At the behaviour level, the most frequent changes observed were increased vegetable and fruit intake, and the changes were usually observed during intervention as well as during the one-year follow-up (Eakin et al., 2009; Jackson et al., 2007; Koelewijn-van Loon et al., 2009; Sacerdote et al., 2006). More details are summarized in Table A1 in Appendix F.

Some studies focused on specific food behaviours and thus there was no doubt that the changes were found in the specified behaviours. Yet, there were two studies that did not find any differences in nutrient intakes or food behaviours between intervention group and control group (Cade et al., 2009; Garcia-Huidobro et al., 2011). In the study by Cade and colleagues (2009), it was possible that the intervention was not tailored to specific disease conditions as only one of the seven counselling sessions was about diabetes management. In the study by Garcia-Huidobro and colleagues (2011), it was possible that the dietary assessment tool was inappropriate as it might have failed to capture a complete picture of dietary change in diabetes management. Studies could also have been conducted with a biased subset of people who already were eating good diets, or the intervention may have been ineffective.

In the PREDIMED trial (Estruch et al., 2013), which aimed to examine the effects of Mediterranean diet on CVD incidence and mortality, 7447 participants who were at high risk of CVD were randomized into three groups. This study has generated significant

attention because they were able to show a 30% reduction in CVD events combined, mostly related to reduction in the number of strokes. One group received a Mediterranean-type diet with supplementation of extra-virgin olive oil; one group received a Mediterranean-type diet with supplementation of mixed nuts; the other group received a control diet which emphasized on reducing dietary fat intake. All three groups received dietary training with dietitians at baseline and completed a validated 14-item dietary screener, MEDAS (Schröder et al., 2011), to assess adherence to the Mediterranean diet. Then, the two intervention groups had quarterly visits with dietitians throughout the study. During each visit, participants from the two intervention groups completed the same MD screener and personalized advice might be provided based on their adherence to Mediterranean diet. Participants from the control group received a yearly leaflet with information on low-fat diet during the first 3 years of the study, and then received personalized advice on low-fat diet with the same frequency. During the visits, participants from the control group were assessed with a separate 9-item dietary screener, which focused on fat intake (Estruch et al., 2013, Appendix Table S3). In addition to these dietary screeners, participants from all three groups completed a 137-item validated FFQ on a yearly basis to calculate energy intake and nutrient intakes. The median follow-up was 4.8 years. At baseline, participants from all three groups had similar adherence to Mediterranean diet (8.7 for the two Mediterranean diet groups and 8.4 for control group) (Estruch et al., 2013). During the 1-year, 3-year and 5-year follow-ups, it was found that participants from both intervention groups had better

adherence to Mediterranean diet compared to those in the control group in all three time points. The two intervention groups improved approximately 2 points in MEDAS total score whereas the control group only improved about 0.7 point (Estruch et al., 2013, Appendix Figure S3). Yet some differences (i.e. “commercial baked goods ≤ 2/week” and “poultry more than red meats”) between the two intervention groups and control group became nonsignificant at 5-year mark (Estruch et al., 2013, Appendix Table S5). Another interesting point to note was that while the dietary advices for the control group did not emphasize intake of vegetables and fruits, the percentage of participants with a positive answer to vegetable component and fruit component of the MDS continued to increase during the follow-ups (Estruch et al., 2013, Appendix Table S5). The actual changes in the daily consumption of vegetables and fruits among the three groups did not differ significantly (Estruch et al., 2013, Appendix Table S6). At the end of the study, participants from the two intervention groups only had slight decrease in energy intake (-85 kcal for MD group with olive oil and -47 kcal for MD group with nuts) while there was a difference of -227 kcal in control group (Estruch et al., 2013, Appendix Table S7). Both intervention groups had a 2% increase in energy intake from fat compared with a 2% decrease in control group. However, the increase in fat intake was predominantly monounsaturated fatty acids for intervention group with extra virgin olive oil whereas the increase in fat intake was dominantly polyunsaturated fatty acids, particularly linoleic acid, in the other intervention group given extra nuts.

In another recent Spanish RCT examining the effect of Mediterranean diet and

exercise on MetS patients (Gomez-Huelgas et al., 2015), 601 MetS patients were randomized to receive either lifestyle intervention, which focused on a Mediterranean-type diet and physical activity, or usual care. All participants in the interventional group had: a) 9 medical visits with the specialist in family practice (two during the first three months, and then quarterly visits during the first year and semi-annual visits during second and third years); and b) 18 nursing visits with the community nurse (four during the first three months, then monthly visits during the first semester and then quarterly visits until the end of the study). Participants in the control group had at least four medical visits and four nursing visits every year. After 3 years, 71% of the intervention group still met criteria for MetS, while 81% of control patients still had MetS. The difference was not statistically significant. It is not clear what degree of reversion was due to more intensive medical care, diet and/or physical activity interventions. The control group was receiving enhanced care compared to usual care for MetS in Canada. The Mediterranean diet in the study emphasized regular consumption of vegetables, fruits, legumes and fish, reducing intake of red meat or sausage and eliminating or reducing dairy products, sugar-sweeten beverages and confectionery. Dietary intake was assessed at baseline and 3-year follow-up using a 14-item validated questionnaire to generate Mediterranean Diet score and a 137-item validated food frequency questionnaire to generate nutrient intake. The MDS at baseline was similar between groups (8.8 for control group and 8.7 for intervention group). At the 3-year follow-up, it was found that the mean Mediterranean diet score increased significantly in

the intervention group, compared to the control group (2.1 and -0.1, respectively, $p < .001$). In addition, a higher monounsaturated-saturated fatty acid ratio, a higher intake of olive oil and a lower cholesterol intake were observed in patients in the intervention group, compared with those in the control group.

To summarize the evidence above, diet quality scores such as MDS could be used to assess dietary changes alongside with analysis on nutrient intake and food behaviours. Changes in several nutrients and food behaviours such as reduced intake of fat and saturated fat and increased consumption of vegetables and fruits could be maintained at least for one year. Since the focuses of these studies were relevant to MetS, there is an opportunity to examine long-term process of changes at both levels of nutrient intake and diet quality/behaviours in MetS patients involved in a real world study to see if similar change patterns were achieved.

CHANGE Overview

The Canadian Health Advanced by Nutrition and Graded Exercise (CHANGE) project was a prospective pre- and post- cohort study of patients with metabolic syndrome from three sites (Edmonton, Toronto, and Laval) across Canada. This project aimed to examine the effects of a diet and exercise intervention program on metabolic syndrome status when delivered by a multidisciplinary team including physicians, dietitians and kinesiologists in primary care settings. The primary outcome was reversion of MetS after one year and reduced reliance on pharmacological drug use.

Participant Recruitment

In order to be enrolled in the CHANGE project, patients had to be over 18 years of age and have at least three of the risk factors of MetS using the harmonized criteria described in Table 1. Patients were excluded if they: were unable to speak, read or understand English and/or French; had a medical or physical condition preventing moderate intensity physical activity; had medical/safety/logistic reasons that prevent adherence to intervention; had Type 1 diabetes, severe or uncontrolled type 2 diabetes, significant co-morbidities, renal failure, cognitive impairment, cancer, or terminal illness; were pregnant/lactating or having intention to be pregnant; had chronic inflammatory disease; or had a body mass index > 35 kg/m^2. Eligible patients were enrolled in the program through their primary care physician.

Study Intervention

Enrolled patients received intervention through individualized diet and exercise plans by working with a dietitian and a kinesiologist for 12 months. The overview of the CHANGE program is described in Appendix A. Since this thesis focuses on dietary modification, only diet part of the intervention will be described in detail. During the first three months of the intervention, patients met with a registered dietitian (RD) weekly; the planned number of visits was 12; more frequent contact was possible as decided by the RD and patient by phone, email or in-person. During the next nine months, patients had monthly meetings with the RD; for a total of 9 planned visits. Throughout the diet

intervention, the RD provided individualized recommendations following the care map framework developed by the research team; see Appendix B for details (Royall et al., 2014). After initial dietary assessment, the patient worked with the RD to set overall goals for diet therapy and determined the food behaviour goals (FBGs) the patient wanted to work on, considering patient's intention and barriers. For most patients, caloric reduction, carbohydrates and other CVD risk factors were all listed as foci. Throughout counselling sessions, the RD used various behaviour change techniques (BCTs) to support patients for behavioural change. Counselling sessions were mainly carried out through individual support; individual support could be in-person, through phone call or via email.

RD Report

The FBGs and BCTs used were recorded by the RDs during each counselling session. The list of FBGs was developed by the research team based on research evidence (Royall et al., 2014). Dietary components that affect weight loss, impaired glucose tolerance, hypertension and/or dyslipidemia were considered. Components from Mediterranean diet, including *Increase olive oil*, *Increase fish*, *Poultry more often than red meat* and *Wine if consuming alcohol*, and components from consensus among RDs, including *Balanced meals*, *Regular meal pattern*, *Increase milk and alternatives*, *Decrease alcohol* and *Mindful eating approaches*, were added to make a final list of 24 FBGs and "other". The BCTs were based on the 'Coventry, Aberdeen & London – Refined' (CALO-RE)

taxonomy of behaviour change techniques (BCTs), which was previously developed in 2008, by Abraham and Michie, and refined by Michie and colleagues in 2011. The original taxonomy included 40 BCTs, and has since been expanded to 93 and clustered into 16 groups in 2013 (Michie et al., 2013). In the CHANGE study, RDs could use as many BCTs as they felt necessary during counselling sessions but were asked to record maximum of 4 BCTs per session. See Appendix C for definitions of the 40 BCTs included in the CALO-RE taxonomy and Appendix D for the complete list of BCTs and FBGs used in counselling sessions.

Dietary Assessment

Dietary assessment was performed at three stages of the intervention. Two 24-hour recalls along with diet quality specific questions were completed at baseline, month three and month twelve. 24-hour recalls were done by multi-pass method developed by the National Cancer Institute (Blanton et al., 2006); food intake within past 24 hours were reported and assessed again one week later, to reduce day-to-day variances in participants' dietary intake. Day of the week was not pre-specified for feasibility reasons. Dietary information from the two 24-hour recalls was analyzed in the Food Processor diet program (ESHA; http://www.esha.com/) at the University of Guelph to generate reports on nutrient intake using mean values. Diet quality specific questions were used to obtain the Canadian Healthy Eating Index (HEI-C) scores and Mediterranean Diet Score (MDS); see Appendix E for the diet quality questionnaire. Scores of some moderation

components of HEI-C, including *Saturated fats, Unsaturated fats* and *Sodium*, were obtained from the nutrient analysis results. MDS was assessed based on the scoring criteria of the MEDAS described previously (See Table 3). However, unlike HEI-C, MDS was not incorporated into the design of the study until 6 months after the study initially started; thus, participants who were enrolled in the study early did not have MDS assessed at baseline.

Summary of Progress in Previous Diet Analyses

The CHANGE project enrolled 305 patients across three sites; 12 of them were excluded as they met one of the exclusion criteria at baseline assessment. Among the 293 patients at baseline, all of them had initial diet assessment with HEI-C scores available for 284 patients and MDS available for 207 patients; 258 patients completed dietary assessment at months 3 follow-up with HEI-C scores available for 256 patients and MDS available for 233 patients; 211 patients completed diet assessment at months 12 follow-up with HEI-C scores and MDS available for 209 patients. The average baseline HEI-C of the study participants was 57.8, which was similar to the average HEI-C score of Canadian population (Statistics Canada, 2009).

Previous graduate students analyzed dietary change from baseline to 3 months (Jennifer Green and Ariellia Rodrigues, MSc theses) and major findings are summarized in the following sections.

Three month changes in nutrient intake

The 3-month report showed significant changes in nutrient intake. Declines were seen in total energy intake (by -138 kcal), carbohydrate intake (by -14.3 g), fat intake (by -8.4g; -1.5% energy from fat) and saturated fat intake (by -4.8 g; -1.6% energy from saturated fat). These findings were similar to the findings in the existing literature. Increases were seen in fibre intake (by 5 g; 3.8g/1000 kcal), vitamin A (by 4566 UI), vitamin C (by 29.7 mg), and magnesium (by 45.5 mg).

Three month changes in HEI-C

At month three, the mean HEI-C total score increased from 57.8 to 68.8 with a significant mean change of 11 points ($p < 0.001$). All component scores of HEI-C, except total grains and unsaturated fats, showed statistically significant changes over the first 3 months. The most promising changes seemed to appear in *Total vegetables and fruit* (from 6.3 to 7.7), *Saturated fats* (from 5.9 to 7.3), *Sodium* (from 6.6 to 7.8), and *Other foods* (from 10.7 to 14.7). If stratifying patients by baseline HEI-C score and PROCAM score, however, changes were predominantly found in patients with lower baseline HEI-C, and more changes were found in patients with lower HEI-C and higher PROCAM scores at baseline. The changes in HEI-C were found to have significant correlations with several key nutrients such as fibre intake, saturated fat intake and protein intake, suggesting that HEI-C was capable of detecting dietary changes in intervention.

Three month changes in MDS

At month three, the mean MDS improved from 4.8 to 6.2, with a statistically significant mean change of 1.3 ($p < 0.001$). The components that had largest improvement (i.e. increased percentage of patients meeting the scoring criteria) were *Baked goods* (25.2%), followed by *Vegetables* (21.5%) and *Poultry more often than red meat* (21.5%), *Nuts* (20.3%), and *Processed Meats* (16.1%).

Behaviour change techniques

It seemed obvious that a group of 6 BCTs were used more frequently than others, including *Review of goals*, *Goal setting*, *Feedback on performance*, *Self-monitoring*, *Action planning* and *Motivational interviewing*, with average used time per participant ranging from 2.7 to 3.9. In contrast, *Social support*, *Environmental restructuring*, *Relapse prevention/coping*, *Behavioural contract* and *Cues/prompts* were least used during the first three months of intervention with average time used per participant close to zero.

Food behaviour goals

Several FBGs seemed dominant throughout the first three months of intervention. The most frequent used one was *balanced meals* (average # times used/person = 5), followed by *increase fruits/vegetables* (average # times used/person = 3). Other frequent used FBGs were *Healthier snacks*, *Regular meal pattern*, *Increase nuts*, *Decrease sodium*, and *Increase fish*, average number of times used per participant ranging from 1.6 to 1.9. Comparing the participants with 4 points or less improvement in HEI-C and those with

17 points or more improvement, some differences in FBGs were evident, namely *Balanced meals* (frequency of use was 5.57 for low change group and 4.47 for high change group, $p < 0.05$) and *Increase fruits/vegetables* (frequency of use was 2.49 for low change group and 3.72 for high change group, $p < 0.001$).

Association between FBGs and food behaviour change

No significant associations between FBGs and HEI-C or MDS scores were found.

Goal of this Thesis

To examine how dietitians counselled and how patient dietary behaviours changed over 12 months in a diet intervention for metabolic syndrome delivered in three primary care settings.

Primary Objective

To determine to what extent each dietary behaviour change was maintained over 12 months by comparing dietary behaviour change at months 12 and months 3.

Secondary Objectives

1. To explore if dietitian counselling foci (i.e. FBGs) were associated with change in diet at months 12;
2. To explore the characteristics and food behaviours of a priori subgroups at baseline and over time by comparing the experience of:
    a) those who did and did not complete follow-up assessment at months 12;

b) those with lower and higher HEI-C scores at baseline;

c) those with lower and higher PROCAM risk scores at baseline.

Hypotheses

Based on previous results, several hypotheses are listed as follows:

1. Some behavioural changes (e.g. fruit and vegetable intake, based on existing literature) are more likely to occur than others at months 3 and be maintained at months 12.
2. Patients with low baseline diet quality will have greater change in diet than patients with high baseline diet quality over 12 months;
3. Patients with a high PROCAM score will have greater change in diet than patients with a low PROCAM score over 12 months;

Methods

Study Design

This study was a secondary analysis of the dietary data from the Canadian Health Advanced by Nutrition and Graded Exercise (CHANGE) study. As previously described, the CHANGE project employed a repeated measures design for analyzing the effects of the diet intervention on patients' diet quality and food behaviour, as the dietary data were collected three times at baseline, 3 months and 12 months. The repeated measures design made it possible to monitor how participants' diet changed over time. By analyzing the

time trajectory of change, changes that were most sustainable over a longer period of time were able to be detected, i.e. which short-term changes (made at month three) were maintained longer-term (at months 12).

Ethics and Data Access

Ethics approval was previously attained for the CHANGE project. Additional ethics approval was not required due to the nature of this study. The data from the CHANGE study is under management of the Clinical Evaluation Research Unit at Queen's University and was accessed through the clinical management software (RedCap) system.

Outcome Measures

The key variables of interest in this thesis were the HEI-C total score, HEI-C component scores, MDS total score and percentage of participants meeting scoring criteria of MDS components. Changes in these variables from baseline to month three, from month three to month twelve and from baseline to month twelve, as well as the overall trajectory of the changes across the three time points, were assessed to examine the effect of the diet intervention over time.

Data Analysis

Statistical analysis was based on available dietary data collected from participants at three time points and was performed by using IBM SPSS 24. Associations were assessed using repeated measures ANOVA for continuous variables (HEI-C scores) and Cochran's

Q test with McNemar tests post hoc for categorical variables (MDS scores). Separate analysis was conducted for each subgroup on HEI-C and MDS scores. For baseline characteristics of participants, continuous variables were analyzed by using Independent *t*-test or one-way ANOVA; categorical variables were analyzed by using the Pearson's chi-square test. Simple analyses on FBGs and BCTs were also done by examining frequency over time as a follow-up to the three-month report (Jennifer Green, MSc thesis). Results were considered significant if *p* values were below 0.05.

The first objective was to determine to what extent each dietary behaviour change was maintained over 12 months by comparing dietary behaviour change at months 12 and months 3.This was examined by assessing the change made in total HEI-C scores and all HEI-C components as well as MDS total scores and percentage of participants meeting scoring criteria of all MDS components over the 12 months, with pairwise comparisons (baseline vs. 3 months, 3 months vs. 12 months, baseline vs. 12 months). If change was successfully maintained at months 12, the mean HEI-C total score, HEI-C component scores, MDS total score and percentage of participants meeting scoring criteria of MDS components should have significant improvement at months 3 and have nonsignificant variation at months 12 compared to the value at months 3. The best case scenario would be that the mean HEI-C total score, HEI-C component scores, MDS total score and percentage of participants meeting scoring criteria of MDS components significantly improved at months 3 and at months 12. Table 4 is a brief summary of criteria to achieve maximum scores for each HEI-C component; please refer to Table A2.1-A2.4 in

Appendix F for detailed conversion of each component score to food equivalents. Criteria to achieve score in MDS component are displayed in Table 3.

Table 4 Age and gender specific criteria to achieve maximum scores for each HEI-C component.

HEI-C component score	Criteria to achieve maximum score			
	Male 19-50yo	**Male 51+**	**Female 19-50**	**Female 50+**
Total vegetables and fruit[1] (0-10)	8	7	7	7
Whole fruit[1] (0-5)	2	1.5	1.5	1.5
Dark green and orange vegetables[1] (0-5)	2	1.5	1.5	1.5
Total grain products[1] (0-5)	8	7	6	6
Whole grains[1] (0-5)	4	3.5	3	3
Milk and alternatives[1] (0-10)	2	3	2	3
Meat and alternatives[1] (0-10)	3	3	2	2
Unsaturated Fats[1] (0-10)	3	3	2	2
Saturated fats[2] (0-10)	7%	7%	7%	7%
Sodium[3] (0-10)	1500 mg	1500 mg	1500 mg	1500 mg
"Other food"[2] (0-20)	5%	5%	5%	5%

[1]Consistent with number of servings recommended in Canada's Food Guide

[2]Percent of total energy

[3]Scores for sodium based on DRIs

The second objective was to explore if counselling foci (i.e. FBGs) are associated with change in diet at months 12. A previous graduate student has already examined the possible associations (correlation) between FBGs and food behaviour in her three-month report, but almost no statistically significant association was found (Jennifer Green, MSc thesis). Therefore visual examination was used instead to assess whether and how participants were taking up the information they got from counselling sessions. In particular, frequency plots of FBGs collected over 12 months were displayed along with mean scores of relevant HEI-C total score, HEI-C components and MDS total score or

with percentage of participants meeting scoring criteria of MDS components at baseline, 3 months and 12 months. Values of frequency of FBGs used at baseline, week 11, week 12 and months 12 were removed from visual demonstration as the low values were mainly an artifact since participants were doing dietary assessment at those time points. Potential associated FBGs and food behaviours (HEI-C and MDS scores) are listed in Table 5 and 6, based on the assumption that certain FBGs are expected to be reflected in improvement of certain food behaviours. The tables have been reviewed and approved by the research group members. Due to the fact that RDs could counsel differently based on their counselling focus, all potential associated FBGs and food behaviours are displayed in combinations.

Table 5 Potential association between food behaviour goals and HEI-C components.

Food behaviour goal	HEI-C component
Balanced meals Regular meal pattern Healthier choices when eating out Eating breakfast	Total HEI score
Increase fruits/vegetables Increase fibre Decrease glycemic index	Total vegetables and fruit Whole fruit Dark green and orange vegetables
Regular meal pattern Eating breakfast	Total grains
Increase fibre	Whole grains
Increase milk and alternatives	Milk and alternatives
Increase nuts Increase fish Increase plant protein Poultry more than red meat	Meat and alternatives
Choosing healthier fats Increase olive oil Decrease total fat Healthier choice when eating out	Unsaturated fats Saturated fats
Decrease sodium	Sodium
Healthier snacks Decrease intake of added sugar Decrease calories	“Other food”

Table 6 Potential association between food behaviour goals and MDS components.

Food behaviour goal	MDS component*
Balanced meals Regular meal pattern Healthier choices when eating out Eating breakfast	Total MDS score
Increase fruits/vegetables Increase fibre Decrease glycemic index	Fruits Vegetables
Poultry more than red meat	Poultry more often than red meat Red or processed meat
Increase plant protein	Legume
Increase nuts Healthier snacks	Nuts
Increase fish	Fish
Choosing healthier fats Decrease total fat Increase olive oil Healthier choice when eating out	Butter and cream Olive oil as main fats Olive oil
Decrease calories Healthier snacks Decrease intake of added sugar	Commercial baked goods
Decrease intake of added sugar	Sugar-sweetened beverages
Wine if consuming alcohol	Wine

*Sofrito sauce was removed because there didn't seem to have any specific FBG linked to Sofrito sauce.

The third objective was to explore the characteristics and food behaviours of a priori subgroups at baseline and over time by comparing the experience of: a) those who completed and did not complete follow-up assessment at months 12; b) those with lower and higher HEI-C scores at baseline; and c) those with lower and higher PROCAM risk scores at baseline. For the first group comparison, baseline characteristics of participants who did and did not complete follow-up assessment at months 12 were compared; comparison of change in HEI-C scores and MDS scores from baseline to 3 months might

be assessed if there were a substantial number of participants who did not complete the study but completed assessment at 3 months.

It is possible that baseline diet might affect success at diet counselling. It could be argued that people with poorer diets might be less or more able to make food changes, compared with those who have higher quality diets. Similarly, the Health Belief model emphasized the role of perceived risk in making health behaviour changes (Glanz & Bishop, 2010; Glanz & Rimer, 1995). In order to assess if baseline diet and/or CVD risk were associated with differences in counselling experiences, participants with complete dietary data were divided into four groups at the median based on participants' HEI-C scores (≤ 60 and > 60) and PROCAM scores (≤ 10% and > 10%) at baseline: lower HEI-C/lower PROCAM, lower HEI-C/higher PROCAM, higher HEI-C/lower PROCAM, and higher HEI-C/higher PROCAM. Median cut-points are common in exploratory analyses. For the second and third group comparisons, baseline characteristics, HEI-C scores and MDS scores were divided into subgroups based on participants'' HEI-C scores and PROCAM risk scores at baseline as described above, and data were compared among these subgroups.

Table 7 Demonstration of a priori subgroup division of participants.

Baseline characteristics used for group division		**PROCAM risk score**	
		≤ 10%	> 10%
HEI-C total score	≤ 60	Low HEI, Low PROCAM	Low HEI, High PROCAM
	> 60	High HEI, Low PROCAM	High HEI, High PROCAM

Normality of Data

Previous studies have tested the normality of HEI-C scores and MDS total score at baseline and 3 months using Kolomogorov-Smirnov (KS) test, Shapiro-Wilk (SW) test, skewness and kurtosis (Ariellia Rodrigues and Jennifer Green, MSc theses), and thus the same methods were used to test the normality of HEI-C scores at 12 months. Values of skewness and kurtosis were assessed using z-scores with a z-score over 3.29 as an indication of non-normal distribution for a medium-sized sample (50<N<300) (Kim, 2013). KS and SW test values were assessed with a significant level of 0.05. Results of the normality tests for continuous variables (HEI-C total and component scores and MDS total score at baseline, 3 months, 12 months, changes made during 0-3 months, 3-12 months and 3-12 months) indicated that the majority of variables from the whole sample were not normally distributed. Parametric and non-parametric tests were then conducted and results were substantially similar regarding statistical significance. Therefore, results of parametric tests are reported. See Table A3 in Appendix F for detailed results of

normality tests.

Results

Participants

Results of the major paper on intervention outcomes have been published elsewhere (Jeejeebhoy et al., 2017). A total of 293 participants were analyzed in the whole study. At 12 months, 253 participants completed final laboratory assessment; the retention rate was approximately 86%. Final dietary assessment was completed by 211 participants, including 209 with assessment on HEI-C. Of these 209 participants, 208 had complete data on HEI-C scores (baseline, 3 months, and 12 months data all available); one of the 209 participants only had HEI-C scores assessed at baseline and 12 months. Due to the fact that MDS was not collected at the beginning of the study, some participants who had complete data on HEI-C did not have MDS assessed at baseline, resulting in a subset of 144 participants with complete data on MDS (baseline, 3 months, and 12 months data all available); 62 participants had MDS assessed at baseline but did not complete final assessment at 12 months.

Baseline characteristics

Approximately 52% of the whole sample (N=293) were female, with a mean age of 59.1±9.7 years and a mean BMI of 31.9±3.3 kg/m^2. When comparing participants with and without 12 months data, participants who had 12 months dietary data on HEI-C were

significantly older (60.0±8.9 years vs. 56.8±11.3 years, p=0.021) and had lower weight (89.3±14.0kg vs. 94.5±15.7kg, p=0.006) as well as BMI (31.4±3.4 kg/m^2 vs. 33.1±2.9 kg/m^2, p<0.001). Regarding health status, participants with 12 months HEI-C data had lower blood glucose (6.46±1.31 mmol/L vs. 6.86±1.52mmol/L, p=0.036) and smaller weight circumference (107.1±9.1cm vs. 110.8±9.6cm, p=0.002) but higher proportion meeting MetS criteria of blood pressure (90.4% vs. 79.8%, p=0.013), compared to those without 12 months HEI-C data. See Table 8 and 9 for the comparisons of major interest and Table A4 in Appendix F for extra demographics. Numbers of participants varied somewhat for assessment of diet and fitness due to missing data.

Table 8 Baseline demographics of participants, displayed as mean (±SD) or no. (%).

Baseline Demographics	Participants with 12 months HEI-C assessment (N=209)	Participants without 12 months HEI-C assessment (N=84)	Whole sample (N=293)	*P* value*
Gender: Female	107 (51.2%)	45 (53.6%)	152 (51.9%)	0.713
Age (year)	60.0±8.9	56.8±11.3	59.1±9.7	**0.021**
Height (m)	1.68±0.10	1.69±0.11	1.68±0.10	0.957
Weight (kg)	89.3±14.0	94.5±15.7	90.8±14.7	**0.006**
BMI (kg/m^2)	31.4±3.4	33.1±2.9	31.9±3.3	**<0.001**
Charleston Co-morbidity index	0.86±0.88	0.80±0.82	0.84±0.86	0.568
PROCAM risk score†	8.61±6.4 (N=205)	7.18±6.46 (N=83)	8.19±6.45 (N=288)	0.099
HEI-C score†	58.5±14.6	55.8±13.1 (N=75)	57.8±14.2 (N=284)	0.177
MDS score†	4.74±1.61 (N=145)	4.71±1.67 (N=62)	4.73±1.62 (N=207)	0.888
VO2 Max†	32.6±6.6 (N=206)	33.6±7.1 (N=81)	32.9±6.8 (N=287)	0.303
Ethnicity:				
Europids, Whites, sub-Saharan Africans, Mediterranean middle east (Arab)	33 (15.8%)	18 (21.4%)	51 (17.4%)	0.549
Asian and South Central American	12 (5.7%)	3 (3.6%)	15 (5.1%)	
US and Canadian Whites	161 (77.0%)	61 (72.6%)	222 (75.8%)	
Ethnicity Unclear	3 (1.4%)	2 (2.4%)	5 (1.7%)	

*Differences between subgroups were analyzed by independent *t*-test for continuous variables and by Pearson Chi-square test for categorical variables.

†Values of these variables were based on participants with available data. Total number of participants used for calculation in each cell was specified in brackets.

Table 9 Baseline values for Metabolic Syndrome criteria of participants in the CHANGE study (N=293), displayed as mean (+SD) or no. (%).

Metabolic syndrome criteria	Participants with 12 months data on HEI (N=209)	Participants without 12 months data on HEI (N=84)	Whole sample (N=293)	*P* value *
a. Blood pressure or pharmacotherapy				
Systolic blood pressure (mmHg)	134.4±15.0	131.3±13.2	133.5±14.5	0.103
Diastolic blood pressure (mmHg)	80.5±9.2	80.9±9.3	80.6±9.1	0.748
Received pharmacotherapy for elevated blood pressure	160 (76.6%)	58 (69.0%)	218 (74.4%)	0.183
Blood pressure ≥ 130/85 mmHg or receiving pharmacotherapy	189 (90.4%)	67 (79.8%)	256 (87.4%)	**0.013**
b. Fasting blood glucose or pharmacotherapy				
Blood glucose (mmol/L)	6.46±1.31	6.86±1.54	6.57±1.39	**0.036**
Received pharmacotherapy for elevated blood glucose levels	91 (43.5%)	38 (45.2%)	129 (44.0%)	0.791
Fasting blood glucose ≥ 5.6 mmol/L or receiving pharmacotherapy	169 (80.9%)	71 (84.5%)	240 (81.9%)	0.461
c. Triglyceride or pharmacotherapy				
Triglyceride level (mmol/L)	2.25±1.92	2.13±0.94	2.21±1.70	0.604
Pharmacotherapy for triglycerides	7 (3.3%)	4 (4.8%)	11 (3.8%)	0.565
Triglyceride level ≥ 1.7 mmol/L or receiving pharmacotherapy	132 (63.2%)	55 (65.5%)	187 (63.8%)	0.709
d. HDL-C				
HDL-C (mmol/L)	1.20±0.29	1.19±0.29	1.20±0.29	0.755
Male patients with an HDL-C level < 1.0 mmol/L or female patients with an HDL-level < 1.3 mmol/L†	98 (46.9%) (n=207)	40 (47.6%)	138 (47.1%) (n=291)	0.966
e. Abdominal circumference				
Waist circumference (cm)	107.1±9.1	110.8±9.6	108.1±9.4	**0.002**
Patients meeting the criteria	197 (94.3%)	80 (95.2%)	277 (94.5%)	0.739

*Statistical differences between participants with and without the 12-month HEI-C scores were analyzed by independent *t*-tests for continuous variables and the Pearson's Chi-square test for categorical variables.
†Values were based on participants with available data. Total number of participants used for calculation in each cell was specified in brackets.

Similarly, when comparing participants with and without complete 12 month data on MDS, the participants with complete data had lower BMI (31.5±3.4kg/m^2 vs.

33.2 ±2.7kg/m^2, p<0.001). However, these two groups did not differ on any MetS criteria. See Table 10 and 11 for major comparisons and Table A5 in Appendix F for extra demographic information.

Table 10 Baseline demographics of participants based on completion of MDS data, displayed as mean (±SD) or no. (%).

Baseline Demographics	**Participants with complete MDS assessment (N=144)**	**Participants with baseline MDS but didn't finish (N=62)***	**All participants (N=206)**	**P Value ****
Gender: Female	75 (52.1%)	35 (56.5%)	110 (53.4%)	0.564
Age (year)	60.0 ±8.9	57.1 ±11.0	59.1 ±9.6	0.068
Height (m)	1.68 ±0.10	1.67 ±0.09	1.68 ±0.10	0.373
Weight (kg)	89.4 ±13.8	92.8 ±13.2	90.4 ±13.7	0.104
BMI (kg/m^2)	**31.5 ±3.4**	**33.2 ±2.7**	32.0 ±3.3	**<0.001**
Charleston Co-morbidity index	0.76 ±0.78	0.63 ±0.68	0.72 ±0.76	0.241
PROCAM risk score†	8.41 ±6.60 (N=143)	7.37 ±6.70	8.10 ±6.63 (N=205)	0.300
HEI-C score†	58.6 ±14.0	54.6 ±13.1	57.4 ±13.8	0.061
MDS score†	4.75 ±1.62	4.71 ±1.66	4.74 ±1.63	0.872
VO2 Max†	32.4 ±6.5 (N=142)	33.5 ±7.5 (N=60)	32.7 ±6.8 (N=202)	0.315
Ethnicity:				0.797
Europids, Whites, sub-Saharan Africans, Mediterranean middle east (Arab)	27 (18.8%)	14 (22.6%)	41 (19.9%)	
Asian and South Central American	7 (4.9%)	2 (3.2%)	9 (4.4%)	
US and Canadian Whites	109 (75.7%)	45 (72.6%)	154 (74.8%)	
Ethnicity Unclear	1 (0.7%)	1 (1.6%)	2 (1.0%)	

*Participants who had baseline MDS but didn't finish the study were chosen as comparison group due to the fact that those without complete MDS were two different groups (one with baseline MDS but didn't finish while other didn't have baseline MDS but may have MDS at final assessment).

**Statistical differences between subgroups were analyzed by independent *t*-test for continuous variables and by the Pearson Chi-square test for categorical variables.

†Values of these variables were based on participants with available data. Total number of participants used for calculation in each cell was specified in brackets.

Table 11 Comparison of baseline values for Metabolic Syndrome criteria between participants with complete MDS data (N=144) and those with baseline MDS but without 12 months assessment (N=62), displayed as mean (±SD) or no. (%).

Metabolic syndrome criteria	Participants with complete MDS (N=144)	Participants with baseline MDS but didn't finish (N=62)	Whole sample (N=206)	P Value*
a. Blood pressure or pharmacotherapy				
Systolic blood pressure (mmHg)	135.4±15.0	131.4±13.0	134.2±14.5	0.068
Diastolic blood pressure (mmHg)	80.4±9.0	79.9±9.0	80.3±8.9	0.700
Received pharmacotherapy for elevated blood pressure	108 (75.0%)	44 (71.0%)	152 (73.8%)	0.546
Blood pressure ≥ 130/85 mmHg or receiving pharmacotherapy	129 (89.6%)	50 (80.6%)	179 (86.9%)	0.081
b. Fasting blood glucose or pharmacotherapy				
Blood glucose (mmol/L)	6.46±1.21	6.66±1.57	6.52±1.33	0.380
Received pharmacotherapy for elevated blood glucose levels	66 (45.8%)	26 (41.9%)	92 (44.7%)	0.606
Fasting blood glucose ≥ 5.6 mmol/L or receiving pharmacotherapy	120 (83.3%)	49 (79.0%)	169 (82.0%)	0.461
c. Triglyceride or pharmacotherapy				
Triglyceride level (mmol/L)	2.16±1.98	2.20±0.86	2.17±1.72	0.866
Pharmacotherapy for triglycerides	4 (2.8%)	3 (4.8%)	7 (3.4%)	0.454
Triglyceride level ≥ 1.7 mmol/L or receiving pharmacotherapy	89 (61.8%)	42 (67.7%)	131 (63.6%)	0.417
d. HDL-C				
HDL-C (mmol/L) with 95% CI	1.24±0.31	1.18±0.30	1.22±0.31	0.175
Male patients with an HDL-C level < 1.0 mmol/L or female patients with an HDL-level < 1.3 mmol/L†	60 (42.0%) (N=143)	33 (53.2%)	93 (45.4%) (N=205)	0.137
e. Abdominal circumference				
Waist circumference (cm)	107.7±9.1	110.1±8.3	108.4±8.9	0.080
Patients meeting the criteria	135 (93.8%)	61 (98.4%)	196 (95.1%)	0.155

*Statistical differences between subgroups were analyzed by independent *t*-tests for continuous variables and the Pearson's Chi-square test for categorical variables

†Values were based on participants with available data. Total number of participants used for calculation in each cell was specified in brackets.

Drop-outs over 12 months

While there were 209 participants with HEI-C score available at 12 months, some participants who missed the final assessment did attend some of the counselling sessions. Figure 3 showed that, throughout the intervention, the number of participants coming to the scheduled meeting with RD dropped smoothly with a loss of 2-5 people each time, except two slightly bigger drops between 4 and 5 months and between 5 and 6 months, which were a drop of 13 people and of 9 people. There was no clear cut point where the majority of participants dropped out. It should be noted that a higher percentage of participants completed scheduled appointments in the main analysis, with a final number of 253 participants coming for laboratory assessment at 12 months (Jeejeebhoy et al., 2017).

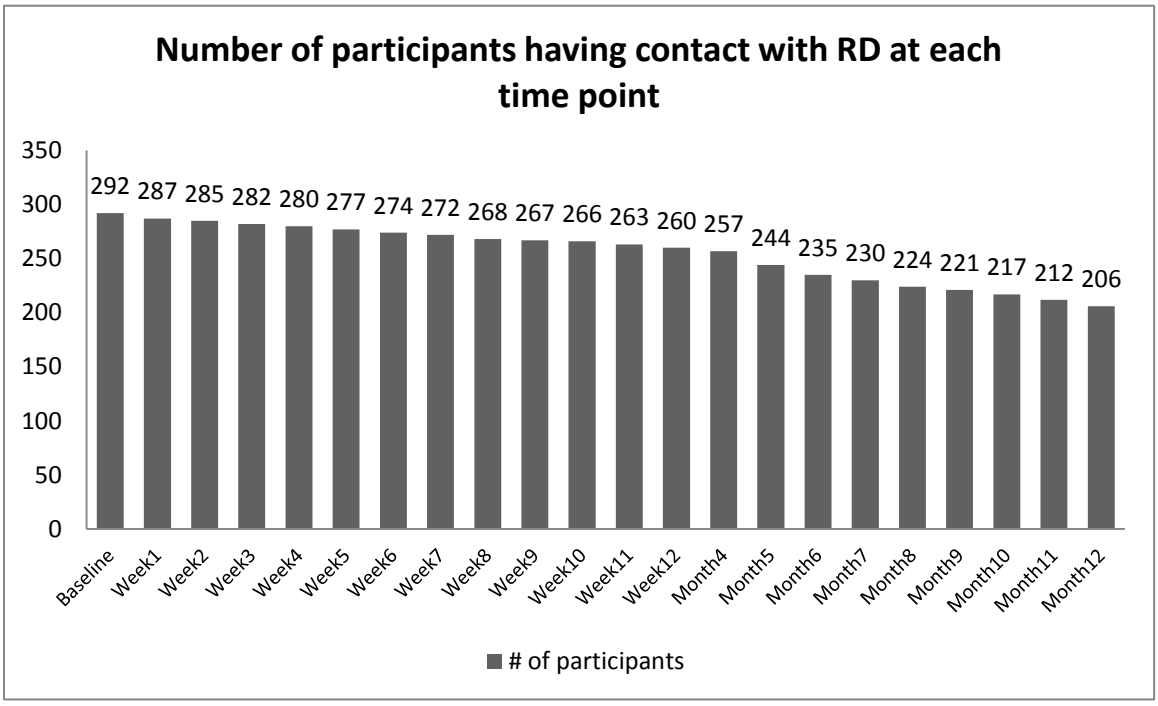


Figure 3 Frequency of contact between participants and registered dietitians for scheduled meeting at each time point.

Behaviour Change Techniques and Food Behaviour Goals

Before examining the changes in participants' diet, it is important to know what dietitians did to assist participants on behaviour change. The analysis on behaviour change techniques (BCTs) and food behaviour goals (FBGs) used by the dietitians in each counselling session allows for better understanding of the counselling practices of the RDs. Based on the intensity of intervention across time, BCTs and FBGs were summarized into two time periods ("first three months" and "4 to 12 months").

Outcome on behaviour change techniques

The total number of BCTs used for all participants in all sessions over 12 months was higher (6867 vs. 4553) whereas the average number of FBGs used per participant per session was lower (1.9 vs. 2.2) during the first three month compared to 4-12 months. It was probably due to the reducing number of participants coming to the sessions over time.

The use of BCTs seemed very distinctive in a way that a group of techniques was used all the time while another group was almost never touched on. As Figure 4 indicated, six BCTs were frequently used during the intervention, including *Review of goals*, *Goal setting*, *Feedback on performance*, *Self-monitoring*, *Motivational interviewing* and *Action planning*. In particular, *Review of goals*, *Feedback on performance* and *Goal setting* were the most frequently used techniques by the RDs throughout the intervention. *Review of goals* dominated both time periods; *Feedback on performance* became more prominent

during 4 to 12 months, while *Goal setting* was more frequently used during the first three months. On the other hand, *Social support*, *Environmental restructuring*, *Relapse prevention/coping*, *Behaviour contract* and *Cues/prompts* were least used throughout the intervention; although there seemed to be increased use of *Relapse prevention/coping* during second period, the frequency was still not comparable to those frequently used techniques.

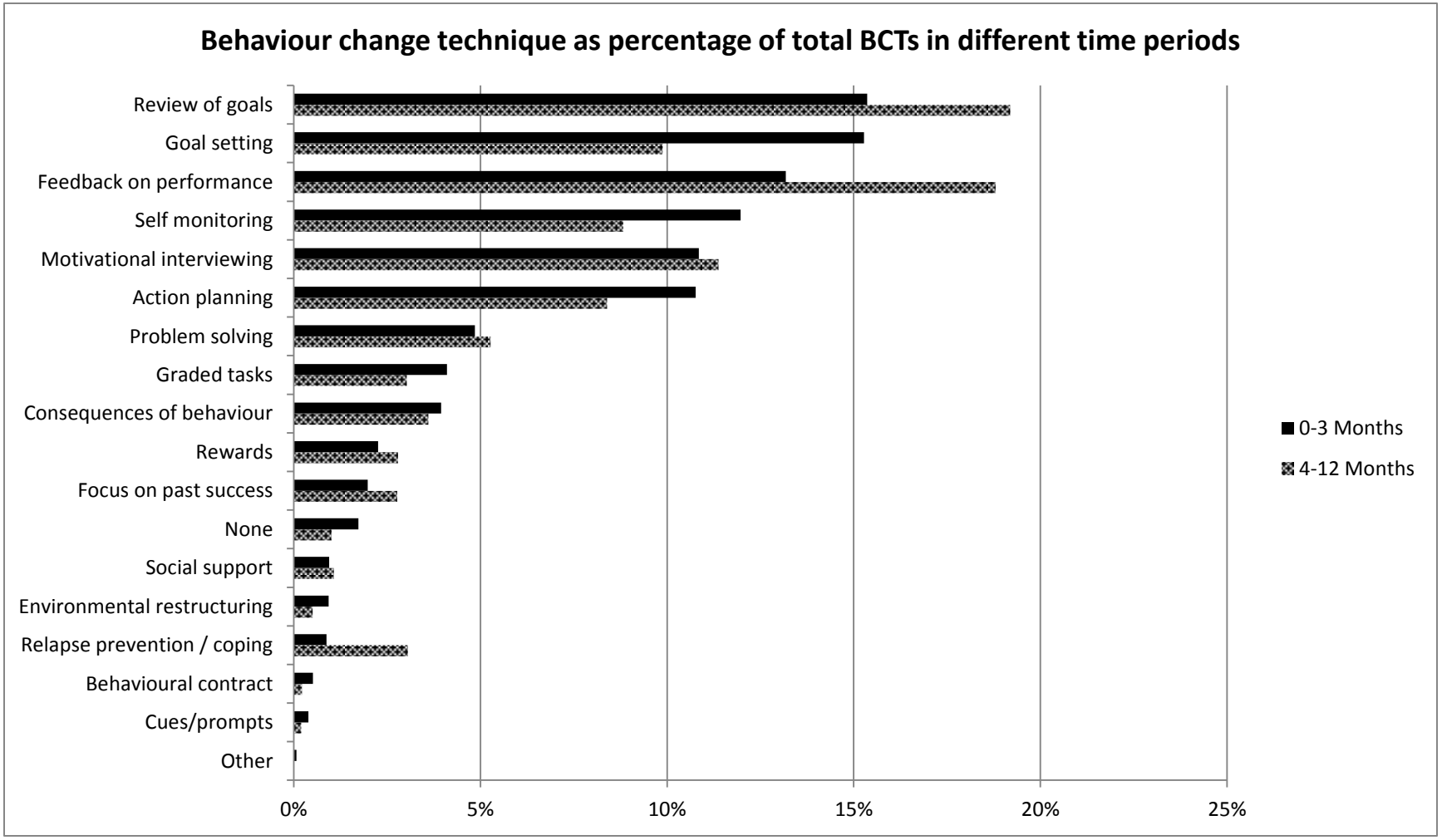


Figure 4 Frequency of each behaviour change technique (BCT) being used by the dietitians during 0-3 months and 4-12 months, displayed as percentage of all BCTs during each period, ranked by percentage calculated over the first three months.

Outcome on food behaviour goals

Similar to BCTs, the total number of FBGs used for all participants in all sessions over 12 months was higher (8607 vs. 6271) but the average number of FBGs used per participant per session was lower (2.4 goals vs. 3.1 goals) during the first three month compared to 4-12 months. This was probably due to the lower number of participants during the 4 to 12 month period.

It was quite obvious that some FBGs were used more often than others. Figure 5 indicated that *Balanced meals* and *Increase fruits/vegetables* were the most frequently used FBGs by RDs throughout the intervention, especially *Balanced meals* which was used approximately 14% of total times when RDs chose a FBG. Although *Balanced meals* was the top FBG used in the intervention, its frequency of use dropped during 4 to 12 months compared to its usage during the first three months. Instead, more FBGs related to specific foods became prominent during 4 to 12 months, such as *Increase fish* and *Increase plant protein*.

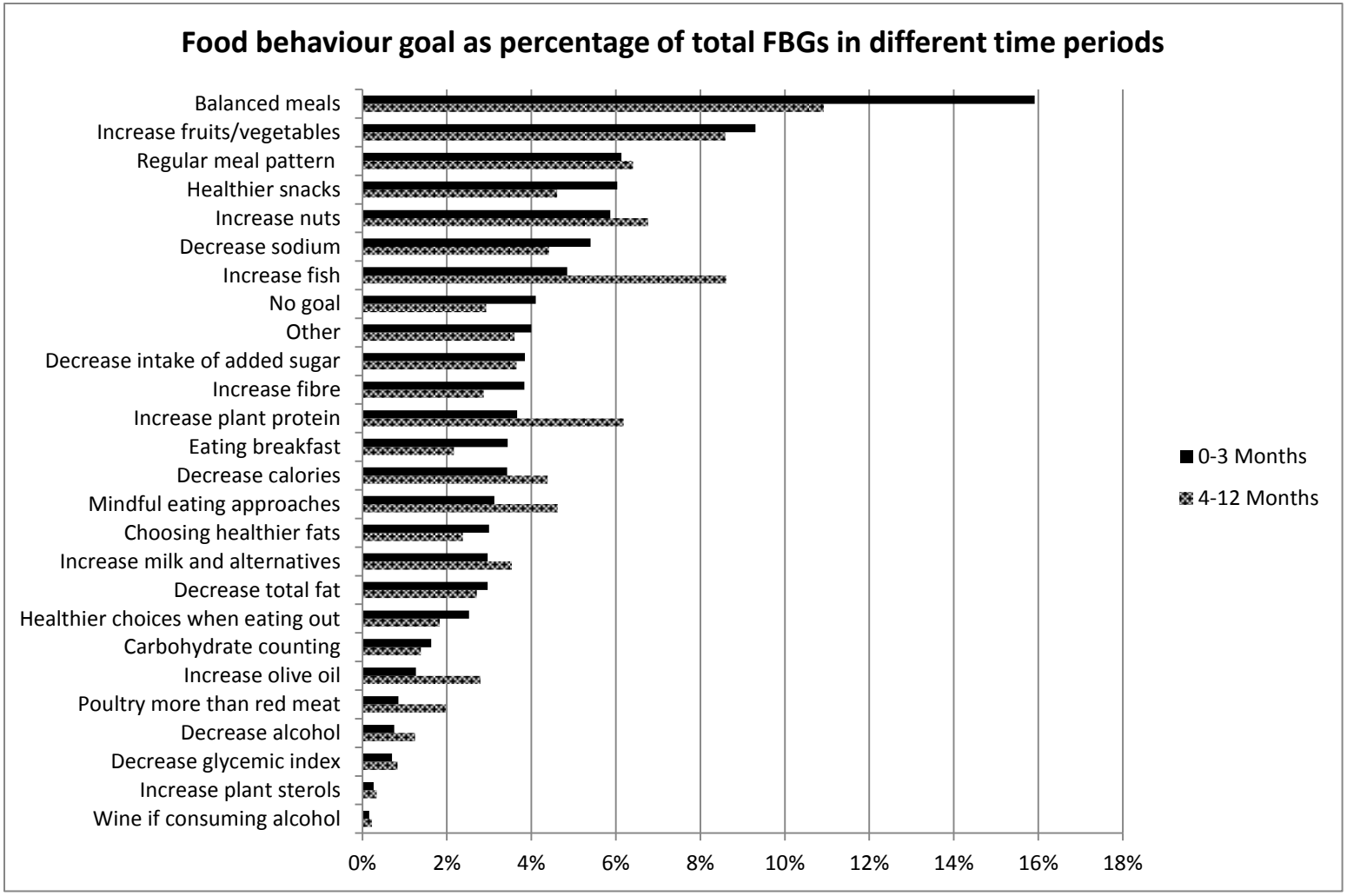


Figure 5 Frequency of each food behaviour goal (FBG) being selected by the dietitians during 0-3 months and 4-12 months, displayed as percentage of all food behaviour goals used during each period, ranked by percentage calculated over the first three months.

Whole Group Analysis on HEI-C and MDS

Changes in HEI-C scores and MDS scores allow for understanding of the effect of diet intervention on participants' food behaviours. It should be acknowledged that analysis in this section was limited to participants with complete data (N=208 for HEI-C scores and N=144 for MDS).

Both total HEI-C score and MDS scores significantly improved at 3 months and were maintained at 12 months. There was a mean improvement of 9.8 points in HEI-C total score and a mean improvement of 1.39 points in total MDS at 12 months. See Table 12.1 for details.

Table 12.1 Mean HEI-C and Mediterranean Diet Score at baseline, 3 Months and 12 Months, and the mean change, for the whole group, based on participants with complete 12 months data.

	Baseline (SD)	**3 Months (SD)**	**12 Months (SD)**	**Mean Change (SE)**		
				0-3 Months	**3-12 Months**	**0-12 Months**
Mean total HEI Score (N=208)	58.4 (14.6)	69.4 (12.1)	68.2 (14.0)	**10.9*** (1.03)**	-1.2 (0.98)	**9.8*** (1.04)**
Mean total MDS (N=144)	4.75 (1.62)	6.22 (1.92)	6.14 (1.83)	**1.47*** (0.16)**	-0.08 (0.16)	**1.39*** (0.16)**

Statistically significant changes (by repeated measures ANOVA) over time are bolded with significance levels as follows: *p<0.05, **p<0.01, ***p<0.001

Outcome on HEI-C components

Most HEI-C components significantly improved from baseline at 3 months and were maintained at 12 months, except *Total Grains, Milk and Alternatives* and *Unsaturated Fats*. Some of the most promising changes included *Total Fruit and Vegetables* (overall

mean improvement of 1.17, corresponding to 0.8–0.9 CFG serving), *Saturated Fat* (overall mean improvement of1.72, corresponding to reduction of ~1.1% energy intake from saturated fats), *Sodium* (overall mean improvement of 1.33, corresponding to reduction of ~384mg of sodium) and *Other Foods* (overall mean improvement of 3.19, corresponding to reduction of ~5.6% energy intake from other foods). Please refer to Table A2.1-A2.4 in Appendix F for conversion of points to food equivalents. In components that did not follow the change pattern, *Milk and Alternatives* had a significant increase at 3 months; however, most improvement was reversed by 12 months. *Total Grains* decreased slightly, but it was understandable as *Whole Grains* increased correspondingly. *Unsaturated Fats* did not change over time whereas *Saturated Fats* seemed to be improving throughout the intervention, although the increase from 3 to 12 months was small and nonsignificant. See Table 12.2 for details.

Table 12.2 Mean change in HEI-C component scores for the whole group, based on participants with complete 12 months data on HEI-C (N=208).

HEI Component score	Baseline (SD)	3 Months (SD)	12 Months (SD)	Mean Change (SE)		
				0-3 Months	3-12 Months	0-12 Months
Total Fruit and Vegetables (0-10)	6.58 (2.62)	7.92 (2.21)	7.75 (2.53)	**1.34*** (0.18)**	-0.17 (0.19)	**1.17*** (0.21)**
Whole Fruit (0-5)	3.60 (1.87)	4.29 (1.36)	4.22 (1.50)	**0.70*** (0.13)**	-0.07 (0.12)	**0.62*** (0.14)**
Dark Green and Orange Vegetables (0-5)	2.68 (2.04)	3.69 (1.65)	3.63 (1.73)	**1.00*** (0.15)**	-0.05 (0.14)	**0.95*** (0.17)**
Total Grains (0-5)	3.36 (1.28)	3.01 (1.29)	3.09 (1.25)	**-0.35** (0.11)**	0.07 (0.10)	**-0.28* (0.11)**
Whole Grains (0-5)	2.69 (1.92)	3.28 (1.63)	3.22 (1.69)	**0.59*** (0.15)**	-0.06 (0.13)	**0.53** (0.15)**
Milk and Alt. (0-10)	4.79 (3.15)	5.56 (3.09)	4.98 (2.92)	**0.77** (0.24)**	**-0.58* (0.23)**	0.19 (0.22)
Meat and Alt. (0-10)	8.05 (2.39)	8.52 (2.23)	8.86 (1.94)	**0.47*(0.18)**	0.35 (0.20)	**0.81*** (0.20)**
Unsaturated Fat (0-10)	3.29 (3.33)	3.14 (3.05)	2.85 (3.04)	-0.15 (0.26)	-0.29 (0.26)	-0.44 (0.30)
Saturated Fat (0-10)	5.84 (3.49)	7.43 (2.91)	7.56 (2.98)	**1.59*** (0.28)**	0.14 (0.26)	**1.72*** (0.28)**
Sodium (0-10)	6.52 (3.17)	7.91 (2.24)	7.85 (2.29)	**1.40*** (0.23)**	-0.06 (0.17)	**1.33*** (0.22)**
Other Foods (0-20)	11.02 (6.41)	14.61 (5.27)	14.20 (5.79)	**3.60*** (0.49)**	-0.41 (0.41)	**3.19*** (0.47)**

Statistically significant changes (by repeated measures ANOVA) over time are bolded with significance levels as follows: *p<0.05, **p<0.01, ***p<0.001

Outcome on MDS components

Half of the MDS components significantly improved and were maintained at 12 months, namely *Poultry more often than red meat* (23.6% increase overall), followed by

Nuts (21.6% increase overall) and *Red or processed meats* (19.4% increase overall). See Table 12.3 for details. It should be noted that a large percentage of participants already achieved criteria for some components, such as *Butter or cream* and *Sugar-sweetened beverages*, at baseline. There seemed to be a discrepancy between *Olive oil* and *Olive oil as main cooking fat* as slightly more participants, although nonsignificant, used olive oil as main cooking fat at 12 months, compared small but significant decline in participants consuming more than 4 tbsp of olive oil per day. This indicated that consuming such amount of olive oil would not be usual practice for people in a non-Mediterranean country, although they could switch their choice of fat from other types of fat (e.g. butter, margarine, etc.) to olive oil.

It was apparent that many participants were able to make some food changes which occurred relatively quickly at 3 months and stayed stable, including *Vegetables*, *Red or processed meats*, *Poultry more often than red meat*, *Nuts*, *Butter or cream*, and *Commercial baked goods*. Some food behaviours did not change, such as *Olive oil*, *Olive oil as main cooking fat*, *Sofrito sauce (tomato-based sauce)*, and *Wine*. Some food behaviours were hard to change but might be eventually changed on the long run, such as *Fish* and *Legumes*; they continued to improve over time, especially *Fish*, and overall p-values were close to 0.05.

Table 12.3 Percentage of participants (n) meeting scoring criteria for each MDS component at baseline, 3 months and 12 months, in participants with complete 12 months data (N=144).

MDS Component	Criteria to achieve a score of 1*	Baseline	3 Months	12 Months	Cochran's Q	P value
Fruits	**≥ 3 servings per day**	28.5[a] (41)	34.0[a] (49)	36.1[a] (52)	2.732	0.255
Vegetables	**≥ 4 servings per day; at least 2 servings raw**	**14.6[a] (21)**	**31.3[b] (45)**	**30.6[b] (44)**	15.361	**<0.001**
Red or processed meats	**< 2 servings per day**	**68.8[a] (99)**	**86.8[b] (125)**	**88.2[b] (127)**	22.523	**<0.001**
Poultry more often than red meat	**Yes**	**53.5[a] (77)**	**74.3[b] (107)**	**77.1[b] (111)**	29.6	**<0.001**
Legumes	**≥ 3 servings per week**	**6.9[a] (10)**	11.8[a,b] (17)	**15.3[b] (22)**	5.892	0.053
Fish or seafood	**≥ 4 servings per week**	13.2[a] (19)	21.5[a] (31)	21.5[a] (31)	5.647	0.059
Nuts	**≥ 3 servings per week**	**34.0[a] (49)**	**57.6[b] (83)**	**55.6[b] (80)**	25.927	**<0.001**
Butter or cream	**< 1 tbsp per day**	**70.8[a] (102)**	**85.4[b] (123)**	**85.4[b] (123)**	15.207	**<0.001**
Olive oil	**≥ 4 tbsp per day**	**4.9[a] (7)**	2.1[a,b] (3)	**0[b] (0)**	8.222	**0.016**
Olive oil as main cooking fat	**Yes**	36.8[a] (53)	45.1[a] (65)	39.6[a] (57)	2.909	0.234
Wine	**≥ 7 servings per week**	7.6[a] (11)	6.3[a] (9)	2.8[a] (4)	5.2	0.074
Commercial baked goods	**≤ 2 times per week**	**47.2[a] (68)**	**68.8[b] (99)**	**63.2[b] (91)**	22.853	**<0.001**
Sugar-sweetened beverages	**< 1 per day**	**88.2[a] (127)**	**95.1[b] (137)**	**97.9[b] (141)**	17.333	**<0.001**
Sofrito sauce	**≥ 2 times per week**	0[a] (0)	1.4[a] (2)	0.7[a] (1)	3.0	0.223

*Criteria values were adjusted to servings from Canada's Food Guide.

[a,b] Proportions in a row with same superscript did not differ from each other at significance level of $p < .05$.

Relationship between FBGs and food behaviour changes

Analysis on the relationship between FBGs and changes in food behaviour allows identification of potential important components of counselling since a successful food recommendation would have resulted in improvement of associated food intake. Visual examination was used to better understand how participants were taking up the information from the counselling sessions. After reviewing the results of HEI-C and MDS, some food behaviours (i.e. HEI-C component *Total Grains*, which had significant decrease at 12 months) were removed from the association tables as the major interest was improvement of food behaviours.

Overall it was visually confirmed that participants were able to take up the FBGs and change specific behaviours. For instance, FBG *Increase fruit/vegetables* was frequently used throughout the intervention, and the HEI-C component score *Total vegetables and fruits* improved from baseline at 3 months and was maintained at 12 months (See Figure 6). However, considering the complexity of counselling and other factors that may affect participants' behaviour, they did not always change exactly as counselled. For example, Figure 7 displayed the mean score of *Milk and alternatives* along with FBG *Increase milk and alternatives* over time; it was obvious that RDs slowly counselled participants more on this FBG throughout the intervention, but the intake improved and then got reversed, which did not follow the pattern of that FBG. See Figure A1-A15 in Appendix F for additional comparison graphs. Two of the graphs were interesting as they showed a pattern of gradual and continued increase over time that contrasted with other food

behaviours. These two FBGs, *Increase fish* and *Increase plant protein*, continued to increase over time and similar pattern was shown in the MDS components *Fish or seafood* and *Legume* as they slowly improved throughout the intervention (see Figures 8 and 9).

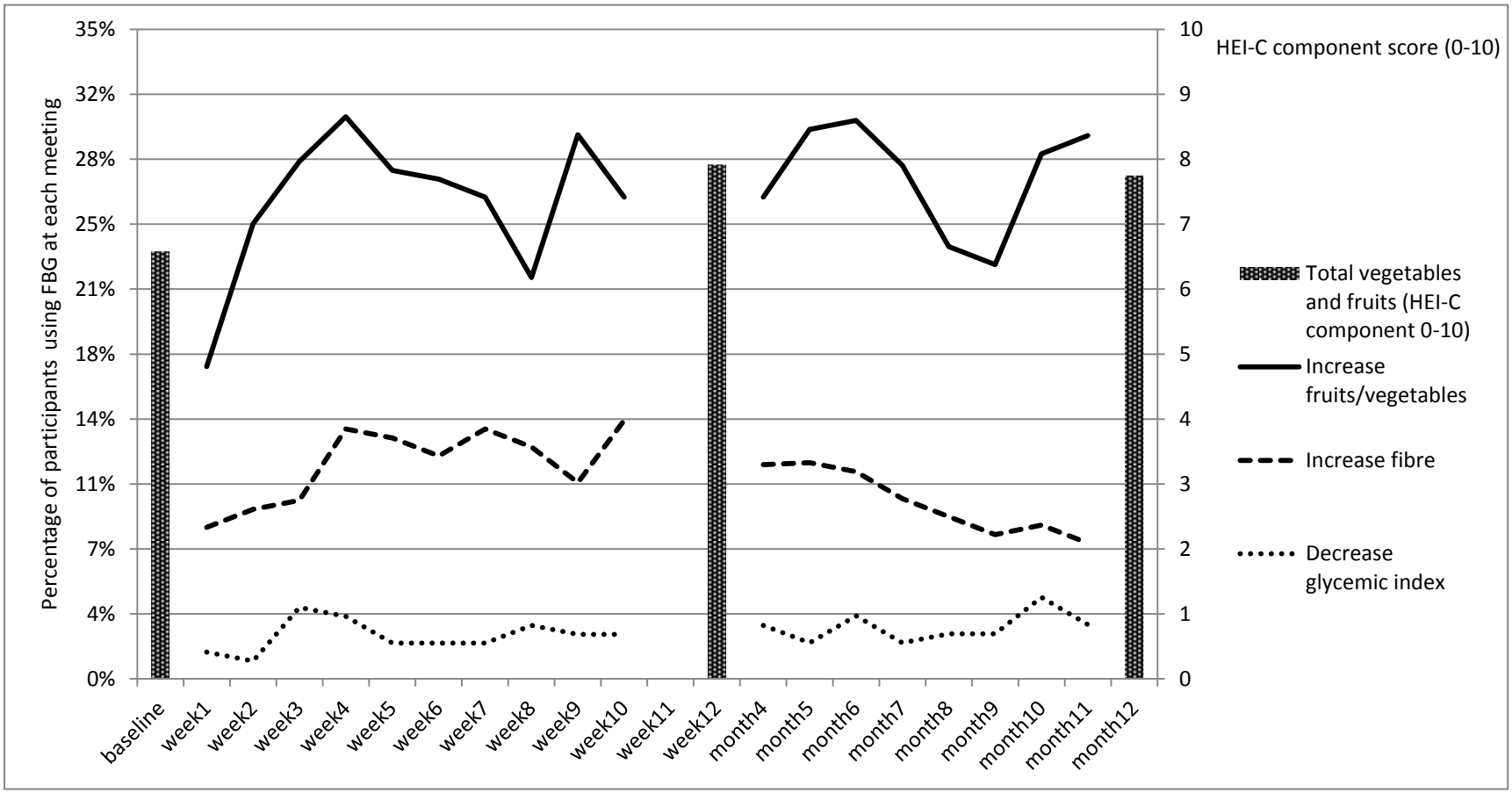


Figure 6 Percentage of participants receiving advice on *Increase fruits/vegetables*, *Increase fibre* and *Decrease glycemic index* over the 12 months, combined with mean score on HEI-C component *Total vegetables and fruits*, in participants with complete 12 months data (N=208).

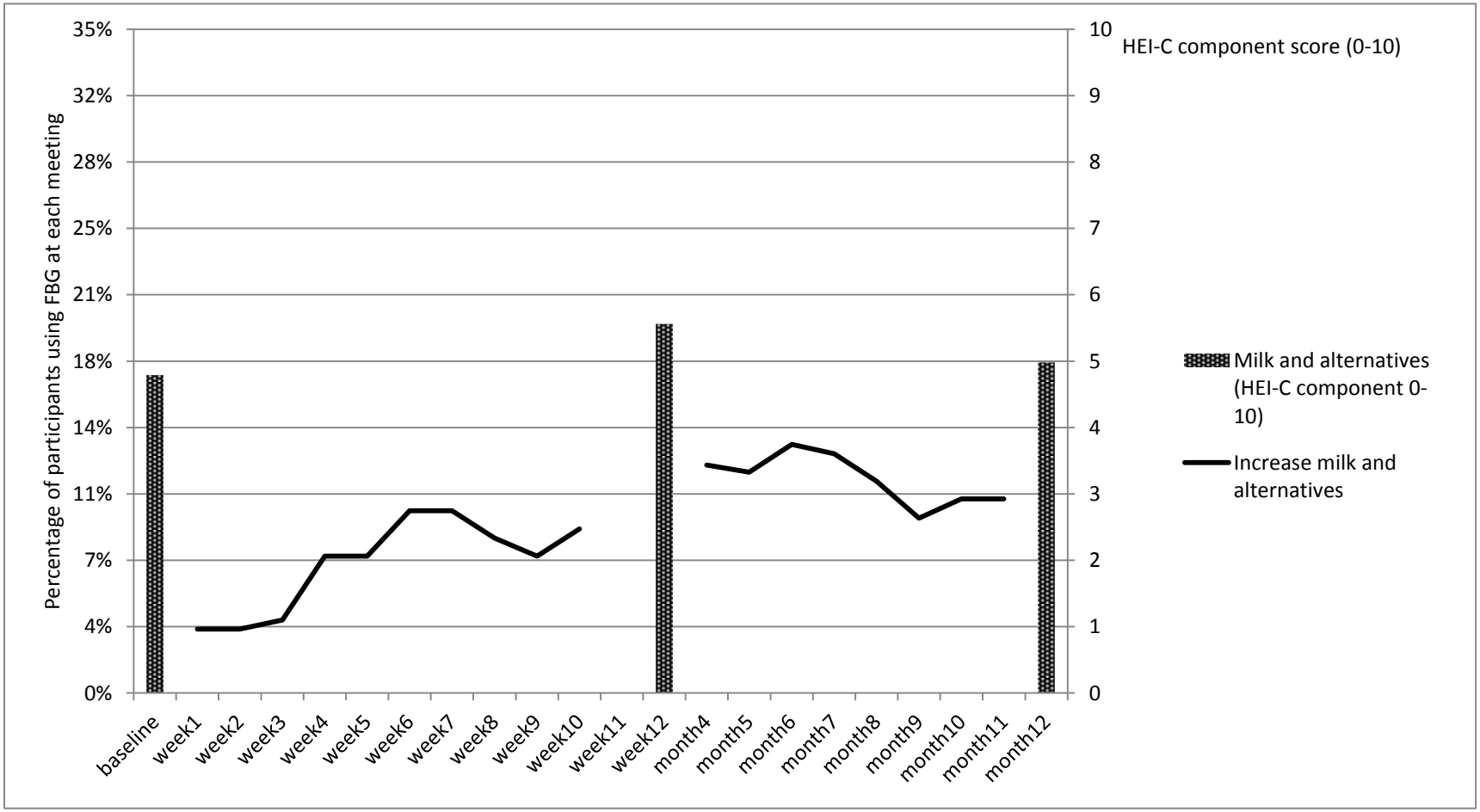


Figure 7 Percentage of participants receiving advice on *Increase milk and alternatives* over the 12 months, combined with mean score on HEI-C components *Milk and alternatives*, in participants with complete 12 months data (N=208).

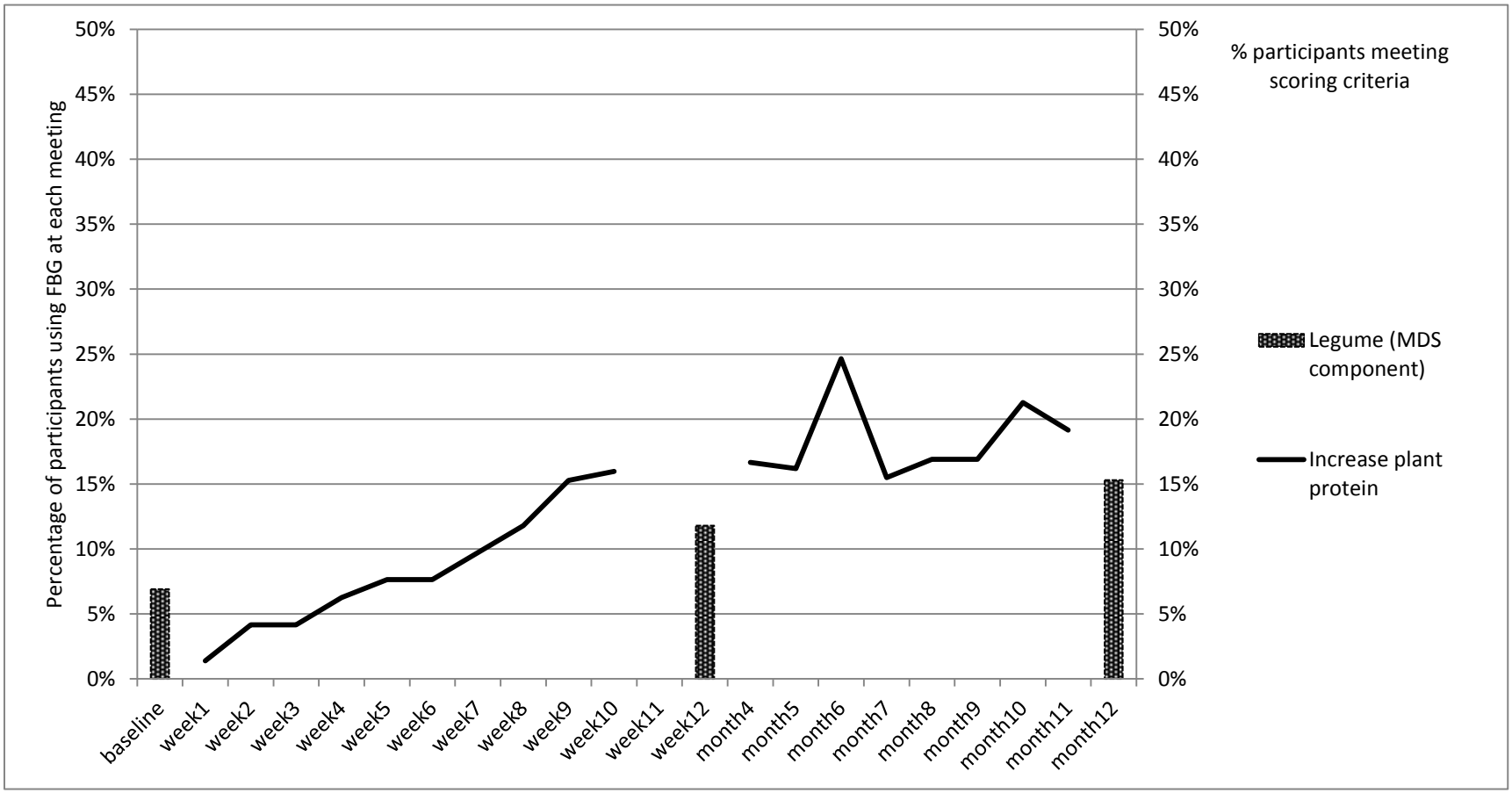


Figure 8 Percentage of participants receiving advice on *Increase plant protein* over the 12 months, combined with percentage of participants meeting scoring criteria of 1 on Mediterranean Diet Score component *Legume*, in participants with complete 12 months data on MDS (N=144).

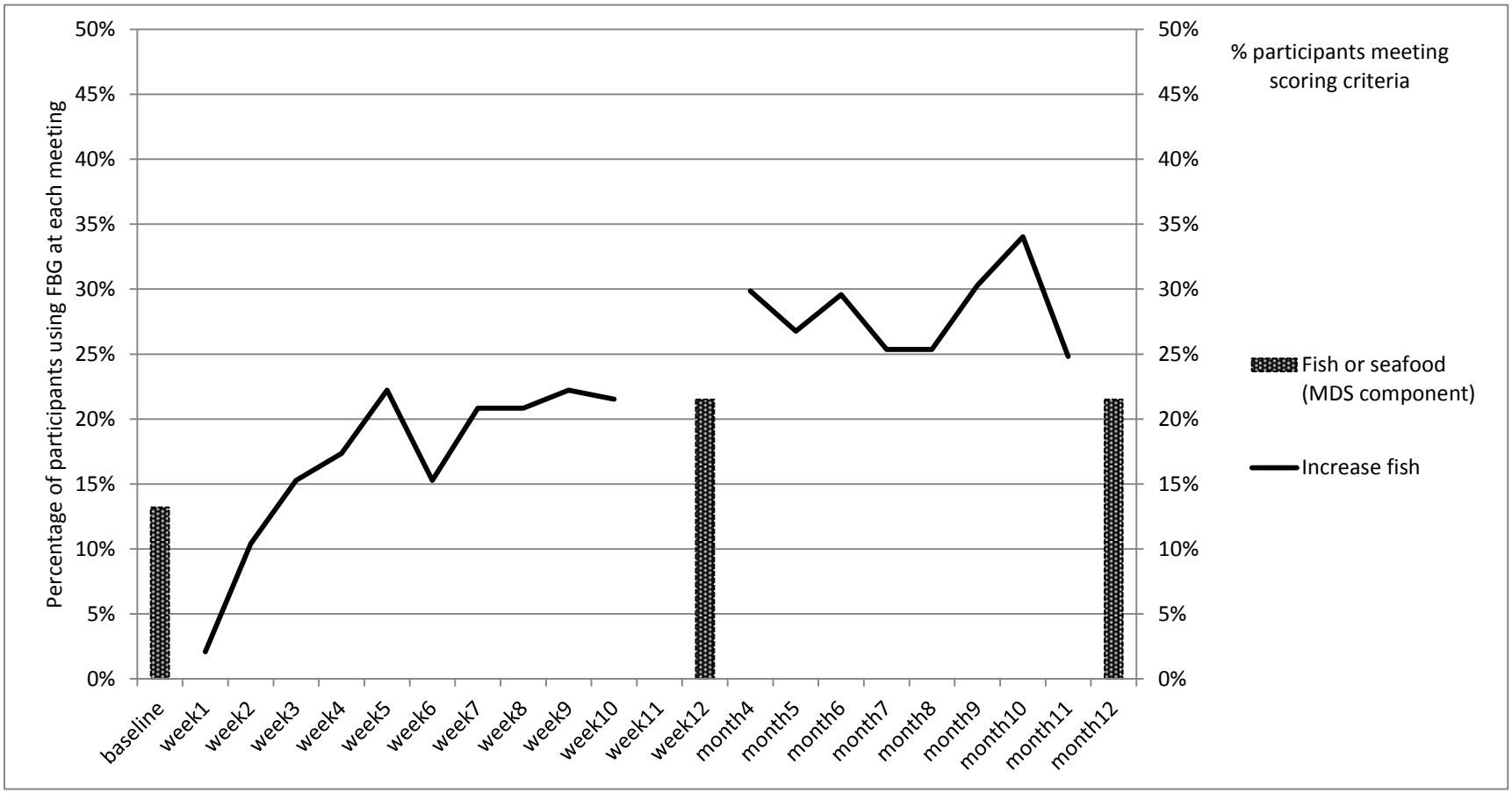


Figure 9 Percentage of participants receiving advice on *Increase fish* over the 12 months, combined with percentage of participants meeting scoring criteria of 1 on Mediterranean Diet Score component *Fish or seafood*, in participants with complete 12 months data on MDS (N=144).

Subgroup Analysis on HEI-C and MDS

Despite how participants may change their food behaviour in relation to the FBGs they received, they may differ in the magnitude of changes based on their profiles. Therefore, it is important to analyze food behaviour changes separately in participants with different baseline dietary status and health status. Median split of HEI-C scores (≤60 and >60) and PROCAM risk scores (≤10% and >10%) was accomplished in subgroup stratification. This subgroup division included 204 of the 208 participants with complete dietary data on HEI-C as the remaining 4 did not have PROCAM risk scores assessed at baseline.

Before diets were analyzed, baseline characteristics of subgroups were compared. Most baseline characteristics were similar among groups, except age. The participants in Low HEI, Low PROCAM group were significantly younger than those in High HEI, High PROCAM group (58.1 ±10.9 years vs. 63.0 ±5.4 years, p=0.017). Regarding MetS criteria, the high and low PROCAM groups differed somewhat in each category except blood glucose. The high HEI, High PROCAM group differed on MetS criteria more than either of the two low PROCAM groups or the Low HEI, High PROCAM group. See Table 13 and 14 for main comparisons and Table A6 in Appendix F for extra demographic information.

Table 13 Baseline demographics of participants (±SD) separated by their HEI-C score (≤60 and >60) and PROCAM risk score (≤10% and >10%) at baseline (N=204), displayed as mean (±SD) or no. (%).

Baseline Demographics	**Low HEI, High PROCAM (N=34)**	**Low HEI, Low PROCAM (N=76)**	**High HEI, High PROCAM (N=39)**	**High HEI, Low PROCAM (N=55)**	**P value***
Gender: Female	17 (50.0%)	34 (44.7%)	23 (59.0%)	32 (58.2%)	0.353
Age (year)	62.3±7.1[a,b]	**58.1±10.9[a]**	**63.0±5.4[b]**	59.7±8.0[a,b]	**0.017**
Height (m)	1.69±0.10	1.69±0.10	1.66±0.09	1.69±0.10	0.489
Weight (kg)	91.2±13.8	90.6±13.2	84.4±11.7	89.2±15.8	0.108
BMI (kg/m^2)	31.9±2.8	31.7±3.2	30.6±3.6	31.1±3.9	0.278
Charleston Co-morbidity index	0.59±0.74	1.01±0.97	0.82±0.89	0.84±0.76	0.124
PROCAM risk score†	**14.8±5.6[a]**	**4.7±2.3[b]**	**15.5±6.5[a]**	**5.1±2.4[b]**	**<0.001**
HEI-C score†	**45.5±10.2[a]**	**48.3±9.3[a]**	**71.1±7.5[b]**	**70.2±7.8[b]**	**<0.001**
MDS score‡	**3.76±1.34[a]** (N=21)	**4.16±1.42[a]** (N=55)	**5.37±1.31[b]** (N=27)	**5.60±1.58[b]** (N=40)	**<0.001**
VO2 Max‡	31.4±5.3	33.4±6.8 (N=74)	31.6±6.5	32.5±6.9 (N=54)	0.373
Ethnicity:					
Europids, Whites, sub-Saharan Africans, Mediterranean middle east (Arab)	5 (14.7%)	9 (11.8%)	10 (25.6%)	9 (16.4%)	0.367
Asian and South Central American	1 (2.9%)	3 (3.9%)	2 (5.1%)	6 (10.9%)	
US and Canadian Whites	28 (82.4%)	62 (81.6%)	26 (66.7%)	40 (72.7%)	
Ethnicity Unclear	0 (0%)	2 (2.6%)	1 (2.6%)	0 (0%)	

*Statistical differences between subgroups were analyzed by one-way ANOVA for continuous variables and by the Pearson Chi-square test for categorical variables.

†Based on the nature of subgroup division, there should be differences across groups in these two variables.

‡Values of these variables were based on participants with available data. Total number of participants used for calculation in each cell was specified in brackets.

[a,b] Bolded numbers with same superscript letter in the same row were not significantly different from each other.

Table 14 Baseline values for Metabolic Syndrome criteria of participants based on baseline HEI-C score and PROCAM risk score (N=204), displayed as mean (±SD) or no. (%).

Metabolic syndrome criteria	Low HEI, High PROCAM (N=34)	Low HEI, Low PROCAM (N=76)	High HEI, High PROCAM (N=39)	High HEI, Low PROCAM (N=55)	P value*
a. Blood pressure or pharmacotherapy					
Systolic blood pressure (mmHg)	**143.7 ±15.4[a]**	**128.8 ±13.3[b]**	**140.0 ±14.4[a,c]**	132.3 ±13.6[b,c]	**<0.001**
Diastolic blood pressure (mmHg)	81.5 ±10.8	78.7 ±9.7	81.6 ±6.1	80.8 ±8.8	0.285
Received pharmacotherapy for elevated blood pressure	26 (76.5%)	61 (80.3%)	29 (74.4%)	42 (76.4%)	0.893
Blood pressure ≥ 130/85 mmHg or receiving pharmacotherapy	32 (94.1%)	67 (88.2%)	35 (89.7%)	51 (92.7%)	0.715
b. Fasting blood glucose or pharmacotherapy					
Blood glucose (mmol/L)	6.65 ±1.40	6.30 ±1.33	6.33 ±1.43	6.63 ±1.38	0.365
Received pharmacotherapy for elevated blood glucose levels	13 (38.2%)	38 (50.0%)	15 (38.5%)	23 (41.8%)	0.541
Fasting blood glucose ≥ 5.6 mmol/L or receiving pharmacotherapy	28 (82.4%)	62 (81.6%)	28 (71.8%)	48 (87.3%)	0.302
c. Triglyceride or pharmacotherapy					
Triglyceride level (mmol/L)	2.16 ±0.81[a,b]	**1.87 ±0.82[a]**	**2.46 ±0.97[b]**	**1.91 ±0.99[a]**	**0.006**
Pharmacotherapy for triglycerides	2 (5.9%)	2 (2.6%)	1 (2.6%)	2 (3.6%)	0.835
Triglyceride level ≥ 1.7 mmol/L or receiving pharmacotherapy	25 (73.5%)	43 (56.6%)	30 (76.9%)	29 (52.7%)	**0.035**
d. HDL-C					
HDL-C (mmol/L)	**1.13 ±0.25[a]**	1.23 ±0.31[a,b]	**1.12 ±0.18[a]**	**1.29 ±0.32[b]**	**0.014**
Male patients with an HDL-C level < 1.0 mmol/L or female patients with an HDL-level < 1.3 mmol/L	17(50.0%)[a,b,c]	**30 (39.5%)[c]**	**27 (69.2%)[b]**	**21 (38.2%)[a,c]**	**0.010**

Metabolic syndrome criteria	Low HEI, High PROCAM (N=34)	Low HEI, Low PROCAM (N=76)	High HEI, High PROCAM (N=39)	High HEI, Low PROCAM (N=55)	P value*
e. Abdominal circumference					
Waist circumference (cm)	109.0 ±8.9[a,b]	**108.5 ±8.3[a]**	**103.8 ±7.3[b]**	105.9 ±11.0[a,b]	**0.027****
Patients meeting the criteria	33 (97.1%)	75 (98.7%)	34 (87.2%)	51 (92.7%)	0.058

*Statistical differences between subgroups were analyzed by one-way ANOVA for continuous variables and the Pearson's Chi-square test for categorical variables.

**Significant difference was found between Low HEI, Low PROCAM group and High HEI, High PROCAM group with Tukey HSD adjustment (p = 0.046); p-value was 0.056 if using Bonferroni adjustment.

[a,b,c] Values with same superscript letters were not different from each other at p-value of .05.

Subgroup outcome on HEI-C scores

Figure 10 and Table 15.1 showed that total HEI-C score significantly improved at 3 months and was maintained at 12 months in two Low HEI groups, with the Low HEI, High PROCAM group having the greatest improvement over 12 months (mean overall increase of 19.5). Similar to total scores, most changes in HEI-C components also occurred in two Low HEI groups. It seemed that the Low HEI, Low PROCAM group had the greatest number of HEI-C components improved, whereas the Low HEI, High PROCAM group had greatest amount of improvement in most components with significant change. It should also be noted that the Low HEI, Low PROCAM group had largest number of participants among all subgroups. The two High HEI groups did not have significant change after the intervention, except in *Sodium*: it improved significantly from 3 to 12 months in High HEI, High PROCAM group with an overall improvement of 0.76, which corresponds to a reduction of ~219mg sodium intake. See Table 15.2 for detailed comparisons in each HEI-C component and Figure 11-16 for trajectories. Additional trajectory graphs are included in Figure A16-A20 in Appendix F.

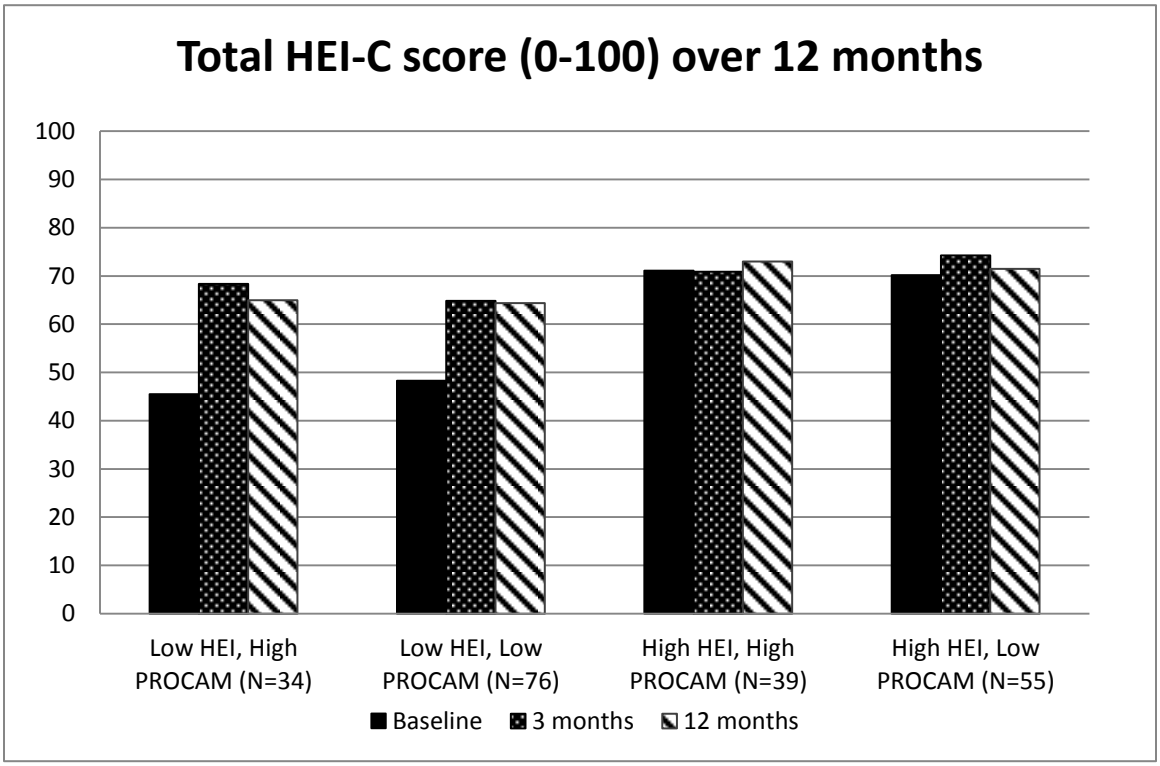


Figure 10 Mean total HEI-C score of participants at baseline, 3 months and 12 months, displayed by subgroups.

Table 15.1 Mean change in total HEI-C for the four subgroups defined by baseline HEI-C score (≤60 and >60) and baseline PROCAM risk score (≤10% and >10%), based on participants with complete 12 months data (N=204).

	Low HEI, High PROCAM (N=34)			**Low HEI, Low PROCAM (N=76)**			**High HEI, High PROCAM (N=39)**			**High HEI, Low PROCAM (N=55)**			**P-value interaction b/w time and group**
	Mean change (SE)			**Mean change (SE)**			**Mean change (SE)**			**Mean change (SE)**			
	0-3 months	**3-12 months**	**0-12 months**	**0-3 months**	**3-12 months**	**0-12 months**	**0-3 months**	**3-12 months**	**0-12 months**	**0-3 months**	**3-12 months**	**0-12 months**	
Mean total HEI-C Score (0-100)	**22.9*** (2.69)**	**-3.4 (2.60)**	**19.5*** (2.84)**	**16.6*** (1.50)**	**-0.59 (1.76)**	**16.0*** (1.47)**	-0.20 (1.76)	2.0 (2.30)	1.8 (1.69)	**4.1** (1.32)**	-2.9 (1.60)	1.2 (1.65)	**<0.001**

Statistically significant changes (by repeated measures ANOVA) over time are bolded with significance levels as follows: *p<0.05, **p<0.01, ***p<0.001

Table 15.2 Mean change in HEI-C component scores for the four subgroups defined by baseline HEI-C score (≤60 and >60) and baseline PROCAM risk score (≤10% and >10%), based on participants with complete 12 months data (N=204).

HEI-C Component Score	**Low HEI, High PROCAM (N=34)**			**Low HEI, Low PROCAM (N=76)**			**High HEI, High PROCAM (N=39)**			**High HEI, Low PROCAM (N=55)**			**P-value interaction b/w time and group**
	Mean change (SE)			**Mean change (SE)**			**Mean change (SE)**			**Mean change (SE)**			
	0-3 months	**3-12 months**	**0-12 months**	**0-3 months**	**3-12 months**	**0-12 months**	**0-3 months**	**3-12 months**	**0-12 months**	**0-3 months**	**3-12 months**	**0-12 months**	
Total Fruit and Vegetables (0-10)	**2.21** (0.58)**	-0.13 (0.51)	**2.09** (0.56)**	**1.84*** (0.29)**	0.14 (0.31)	**1.98*** (0.34)**	0.40 (0.36)	0.05 (0.41)	0.45 (0.37)	**0.84** (0.24)**	-0.69 (0.34)	0.15 (0.36)	**<0.001**

HEI-C Component Score	Low HEI, High PROCAM (N=34)			Low HEI, Low PROCAM (N=76)			High HEI, High PROCAM (N=39)			High HEI, Low PROCAM (N=55)			P-value interaction b/w time and group
	Mean change (SE)			Mean change (SE)			Mean change (SE)			Mean change (SE)			
	0-3 months	3-12 months	0-12 months	0-3 months	3-12 months	0-12 months	0-3 months	3-12 months	0-12 months	0-3 months	3-12 months	0-12 months	
Whole Fruit (0-5)	1.05 (0.42) P=0.05	-0.34 (0.34)	0.71 (0.45)	**1.09*** (0.22)**	0.11 (0.21)	**1.20*** (0.24)**	0.34 (0.25)	-0.21 (0.26)	0.13 (0.26)	0.23 (0.19)	-0.05 (0.19)	0.17 (0.24)	**0.014**
Dark Green and Orange Vegetables (0-5)	**1.70*** (0.37)**	0.43 (0.37)	**2.13*** (0.39)**	**1.49*** (0.26)**	-0.25 (0.22)	**1.25*** (0.28)**	0.11 (0.34)	0.11 (0.30)	0.21 (0.39)	0.58 (0.27)	-0.17 (0.27)	0.41 (0.27)	**<0.001**
Total Grains (0-5)	-0.48 (0.26)	0.09 (0.22)	-0.39 (0.29)	-0.27 (0.18)	0.05 (0.17)	-0.22 (0.19)	**-0.83** (0.25)**	0.29 (0.23)	-0.54 (0.28)	-0.09 (0.19)	-0.07 (0.16)	-0.17 (0.19)	0.408
Whole Grains (0-5)	**1.04* (0.41)**	-0.21 (0.27)	0.83 (0.38)	**0.96** (0.26)**	0.05 (0.24)	**1.02*** (0.25)**	-0.14 (0.32)	0.15 (0.30)	0.01 (0.33)	0.33 (0.28)	-0.31 (0.24)	0.02 (0.28)	**0.025**
Milk and Alt. (0-10)	1.15 (0.24)	-0.15 (0.62)	1.01 (0.54)	0.89 (0.42)	-0.66 (0.41)	0.23 (0.39)	0.90 (0.55)	-0.64 (0.39)	0.26 (0.48)	0.34 (0.44)	-0.59 (0.43)	-0.25 (0.42)	0.756
Meat and Alt. (0-10)	**1.74** (0.46)**	0.66 (0.33)	**2.40*** (0.49)**	0.26 (0.33)	0.20 (0.36)	0.46 (0.33)	0.02 (0.43)	0.88 (0.45)	0.90 (0.44)	0.35 (0.28)	-0.15 (0.38)	0.20 (0.34)	**0.005**
Unsaturated Fat	0.98 (0.57)	0.07 (0.71)	1.05 (0.74)	-0.13 (0.43)	-0.26 (0.39)	-0.39 (0.47)	-0.66 (0.57)	-0.30 (0.61)	-0.96 (0.69)	-0.42 (0.54)	-0.53 (0.53)	-0.95 (0.64)	0.317

HEI-C Component Score	Low HEI, High PROCAM (N=34)			Low HEI, Low PROCAM (N=76)			High HEI, High PROCAM (N=39)			High HEI, Low PROCAM (N=55)			P-value interaction b/w time and group
	Mean change (SE)			Mean change (SE)			Mean change (SE)			Mean change (SE)			
	0-3 months	3-12 months	0-12 months	0-3 months	3-12 months	0-12 months	0-3 months	3-12 months	0-12 months	0-3 months	3-12 months	0-12 months	
(0-10)													
Saturated Fat (0-10)	**3.42*** (0.73)**	-0.93 (0.64)	**2.49** (0.74)**	**2.38*** (0.48)**	0.54 (0.47)	**2.92*** (0.51)**	0.06 (0.59)	0.33 (0.57)	0.39 (0.51)	0.55 (0.46)	-0.04 (0.46)	0.51 (0.43)	**<0.001**
Sodium (0-10)	**2.76*** (0.60)**	**-1.17** (0.35)**	1.59 (0.67) P=0.07	**2.26*** (0.43)**	-0.14 (0.34)	**2.12*** (0.41)**	-0.03 (0.36)	**0.79* (0.29)**	**0.76* (0.28)**	0.25 (0.33)	0.12 (0.26)	0.37 (0.31)	**<0.001**
Other Foods (0-20)	**7.31*** (1.13)**	-1.68 (1.13)	**5.63*** (1.23)**	**5.83*** (0.88)**	-0.38 (0.72)	**5.45*** (0.84)**	-0.37 (0.89)	0.59 (0.98)	0.22 (0.73)	1.14 (0.74)	-0.36 (0.67)	0.78 (0.75)	**<0.001**

Statistically significant changes (by repeated measures ANOVA) over time are bolded with significance levels as follows: *p<0.05, **p<0.01, ***p<0.001

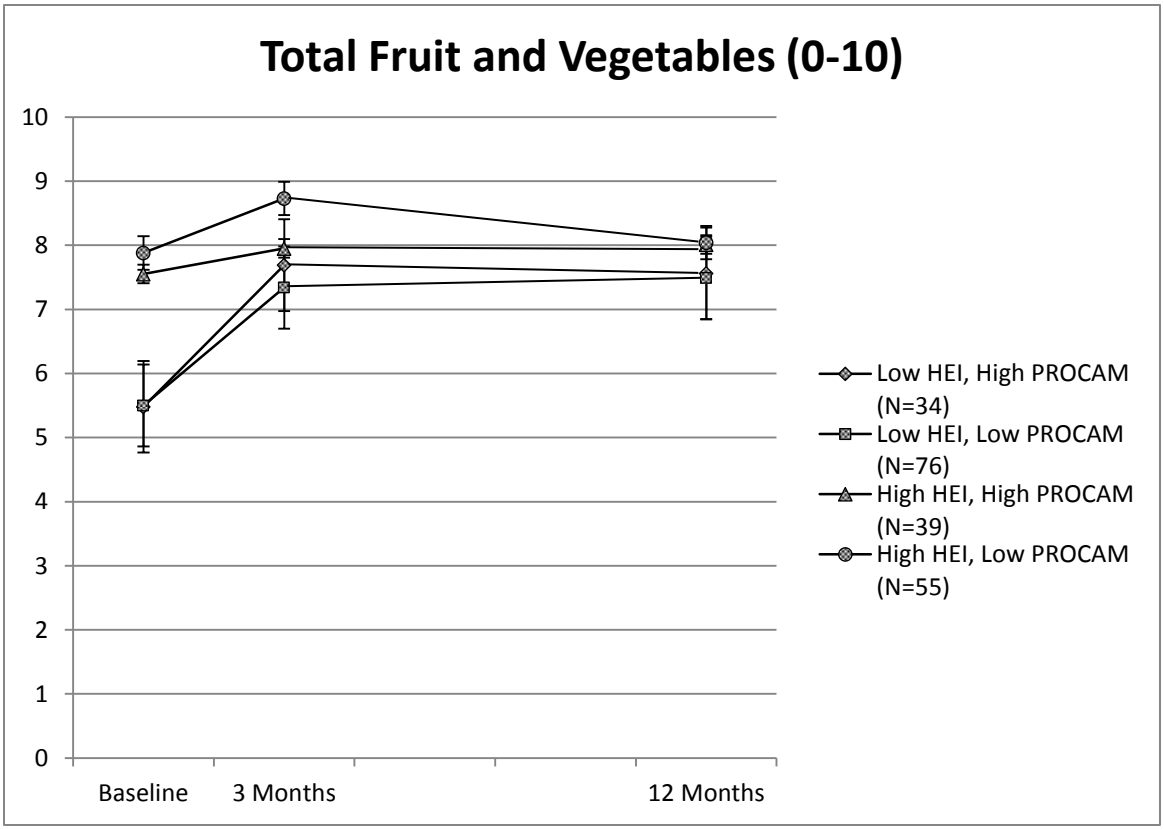


Figure 11 Trajectory graph of *Total Fruit and Vegetables*, displayed by subgroups.

As Figure 11 shows, the Low HEI, High PROCAM group had an overall improvement of 2.09 points, which was equivalent to an overall increase of 1.5 to 1.7 CFG servings of fruit and vegetables; the Low HEI, Low PROCAM group had an overall improvement of 1.98 points, which was equivalent to an overall increase of 1.4 to 1.6 CFG servings of fruit and vegetables.

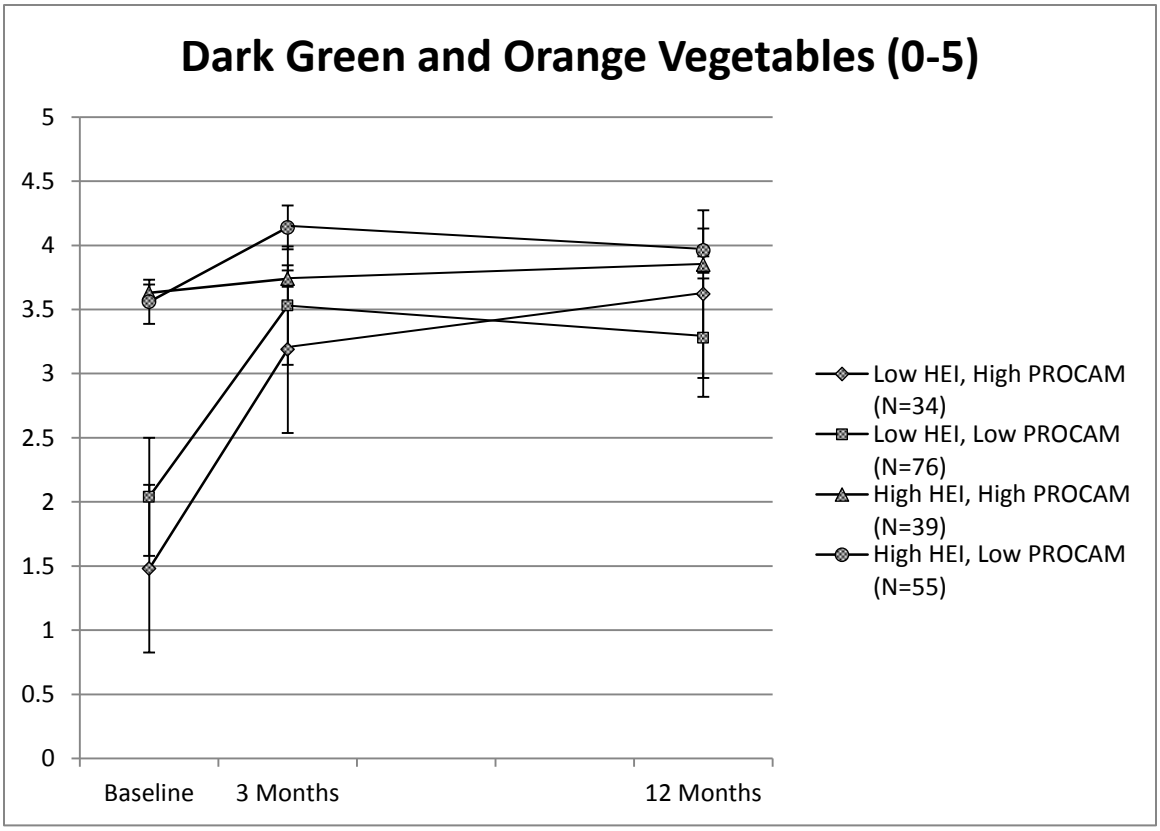


Figure 12 Trajectory graph of *Dark Green and Orange Vegetables*, displayed by subgroups.

As Figure 12 shows, the Low HEI, High PROCAM group had an overall improvement of 2.13 points, which was equivalent to an overall increase of 0.6 to 0.8 CFG serving of dark green and orange vegetables; the Low HEI, Low PROCAM group had an overall improvement of 1.25 points, which was equivalent to an overall increase of 0.4 to 0.5 CFG serving of dark green and orange vegetables.

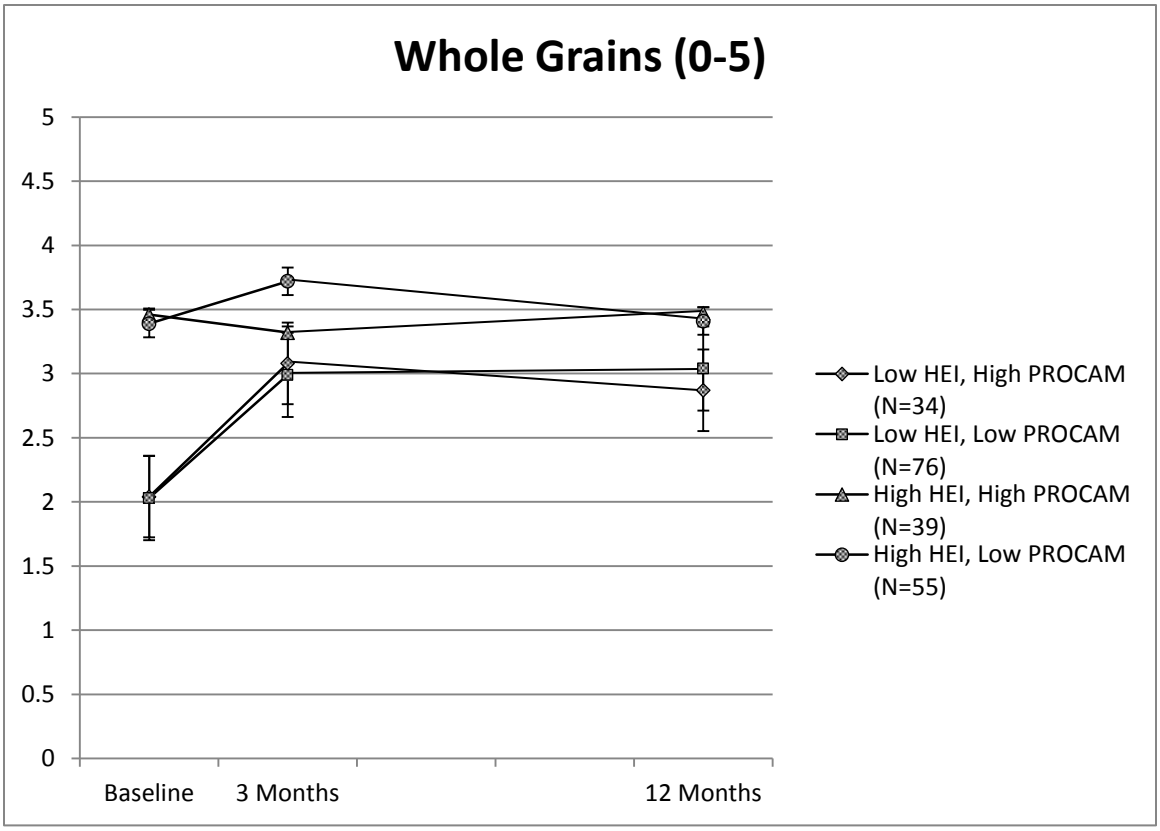


Figure 13 Trajectory graph of *Whole Grains*, displayed by subgroups.

As Figure 13 shows, the Low HEI, High PROCAM group had an overall improvement of 0.83 point, although nonsignificant, which was equivalent to an overall increase of 0.5 to 0.7 CFG serving of whole grains; the Low HEI, Low PROCAM group had an overall improvement of 1.02 points, which was equivalent to an overall increase of 0.6 to 0.8 CFG serving of whole grains.

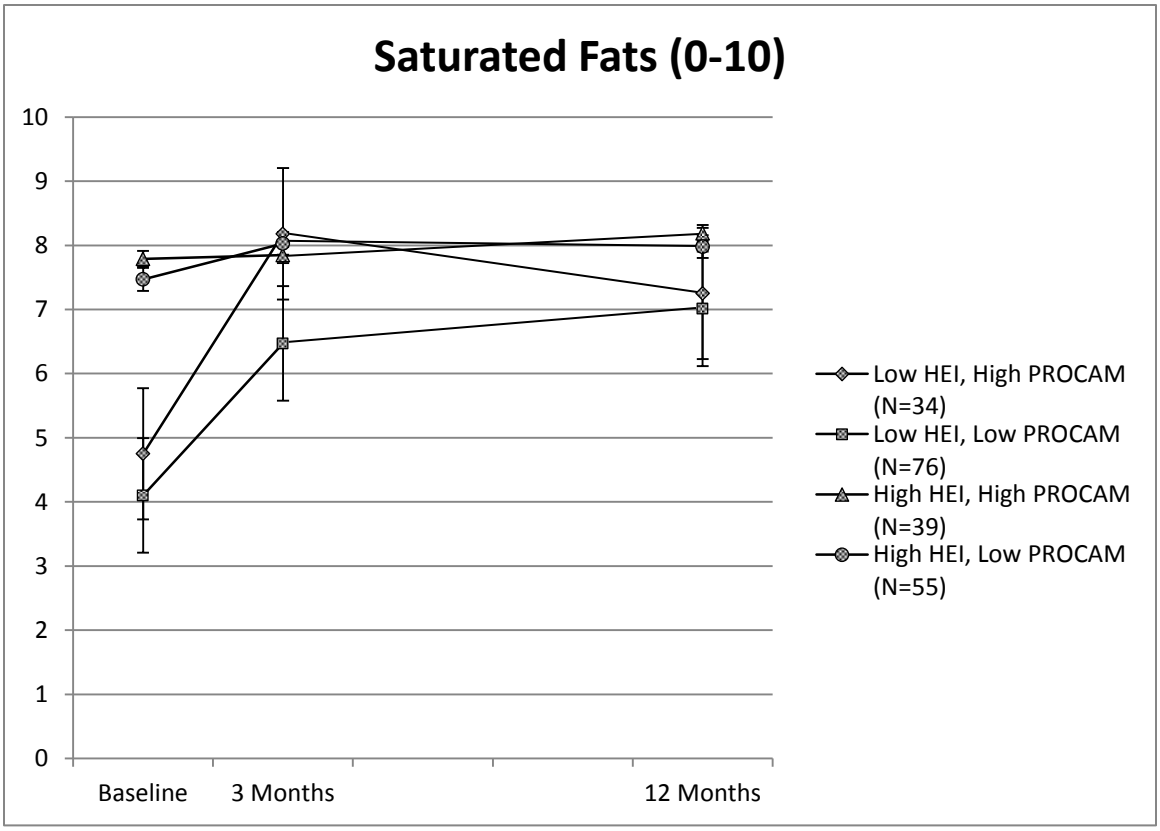


Figure 14 Trajectory graph of *Saturated Fats*, displayed by subgroups.

As Figure 14 shows, the Low HEI, High PROCAM group had an overall improvement of 2.49 points, although nonsignificant, which was equivalent to an overall decrease of ~1.6% total energy intake from saturated fat; the Low HEI, Low PROCAM group had an overall improvement of 2.92 points, which was equivalent to an overall decrease of ~1.8% total energy intake from saturated fat.

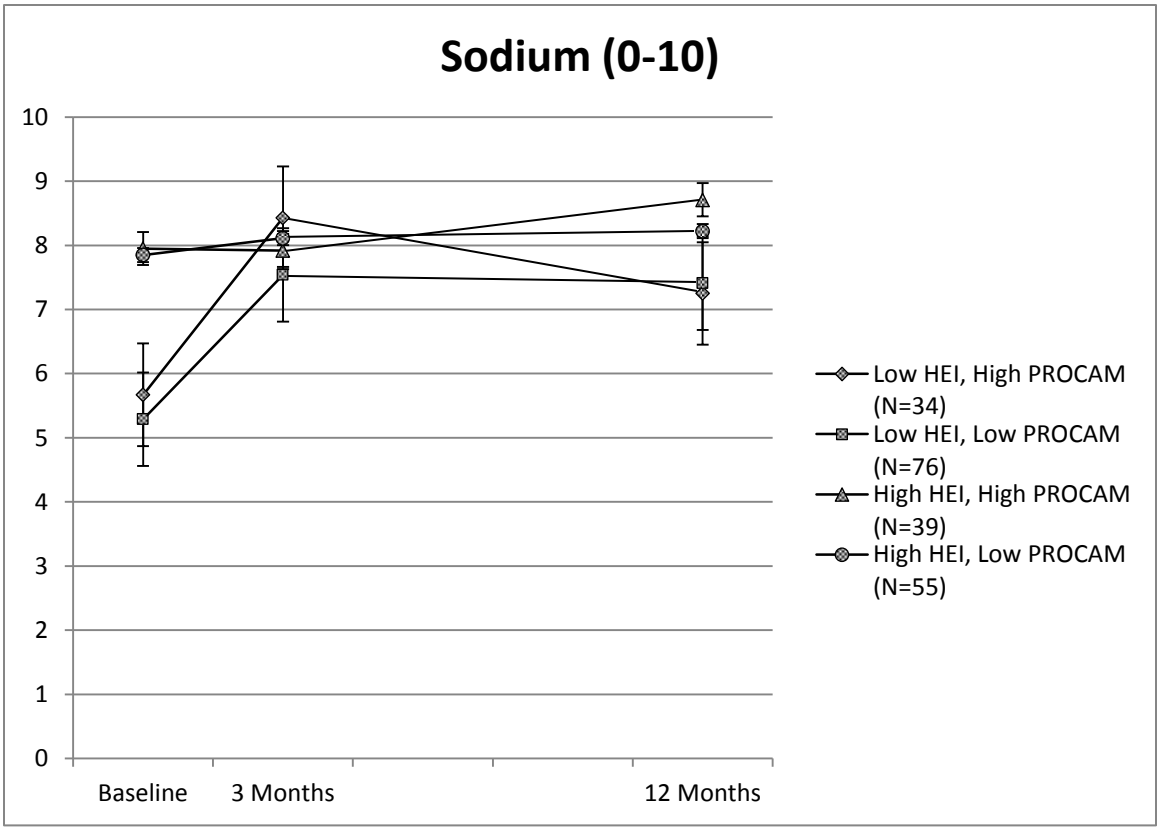


Figure 15 Trajectory graph of *Sodium*, displayed by subgroups.

As Figure 15 shows, the Low HEI, High PROCAM group had an overall improvement of 1.59 points, which was almost significant ($p = 0.07$) and equivalent to approximately 459mg reduction of sodium intake; the Low HEI, Low PROCAM group had an overall improvement of 2.12 points, which was equivalent to approximately 612mg reduction of sodium intake; the High HEI, High PROCAM group had an overall improvement of 0.76 point, which was equivalent to approximately 219mg reduction of sodium intake.

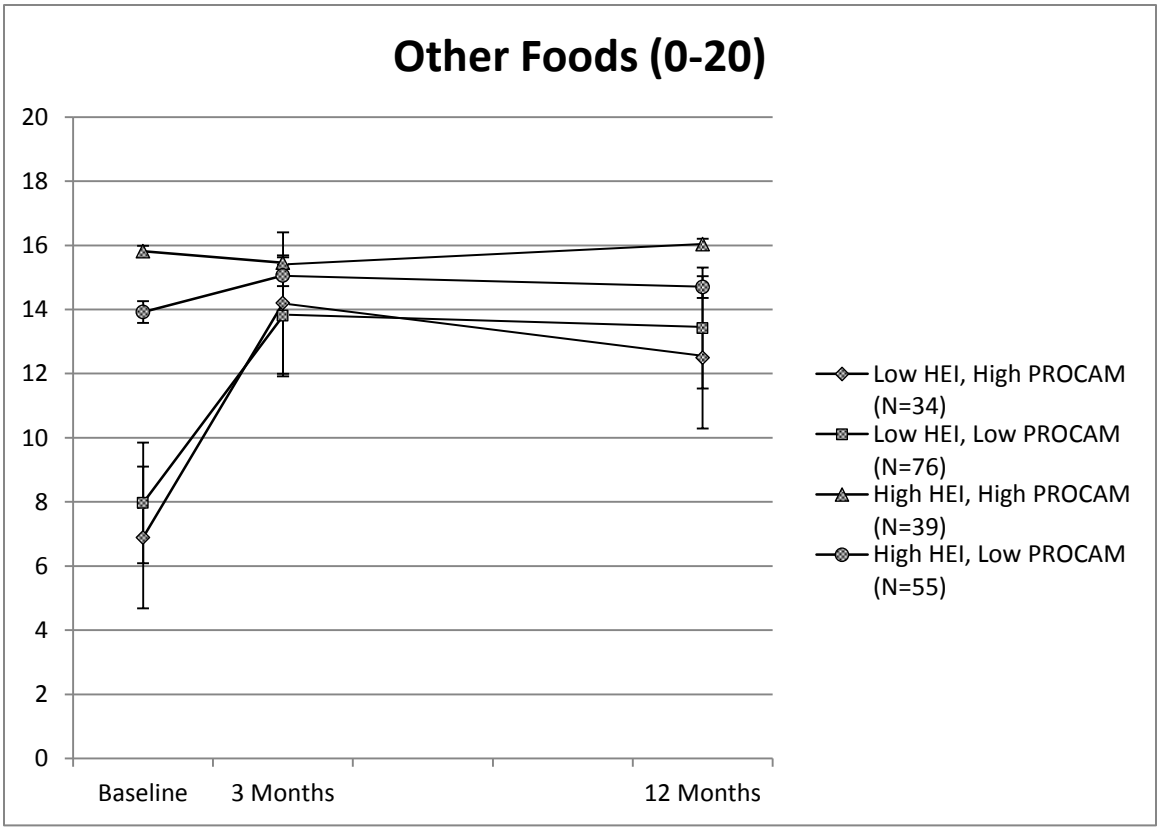


Figure 16 Trajectory graph of *Other Foods*, displayed by subgroups.

As Figure 16 shows, the Low HEI, High PROCAM group had an overall improvement of 5.63 points, which was equivalent to an overall decrease of 9.8% total energy intake from other foods; the Low HEI, Low PROCAM group had an overall improvement of 5.45 points, which was equivalent to an overall decrease of 9.5% total energy intake from other foods.

Subgroup outcome on MDS score

Figure 17 and Table 15.3 showed that total MDS improved at 3 months and was maintained at 12 months in most subgroups, except in High HEI, High PROCAM group, with the Low HEI, Low PROCAM group having the greatest improvement over the 12 months (mean improvement of 1.78 points). Similar to changes in HEI-C components,

most changes in MDS components also occurred in the two Low HEI groups, especially the Low HEI, Low PROCAM group. See Table 15.4 for detailed comparisons in MDS components. Regarding the top three improvements from whole group analysis:

1. Improvement in *Poultry more often than red meat* was found in three groups, except the Low HEI, High PROCAM group;
2. *Nuts*: two Low HEI groups had improvement only at 3 months while the High HEI, Low PROCAM had improvement only at 12 months;
3. Improvement in *Red or processed meat* was found in two Low PROCAM groups.

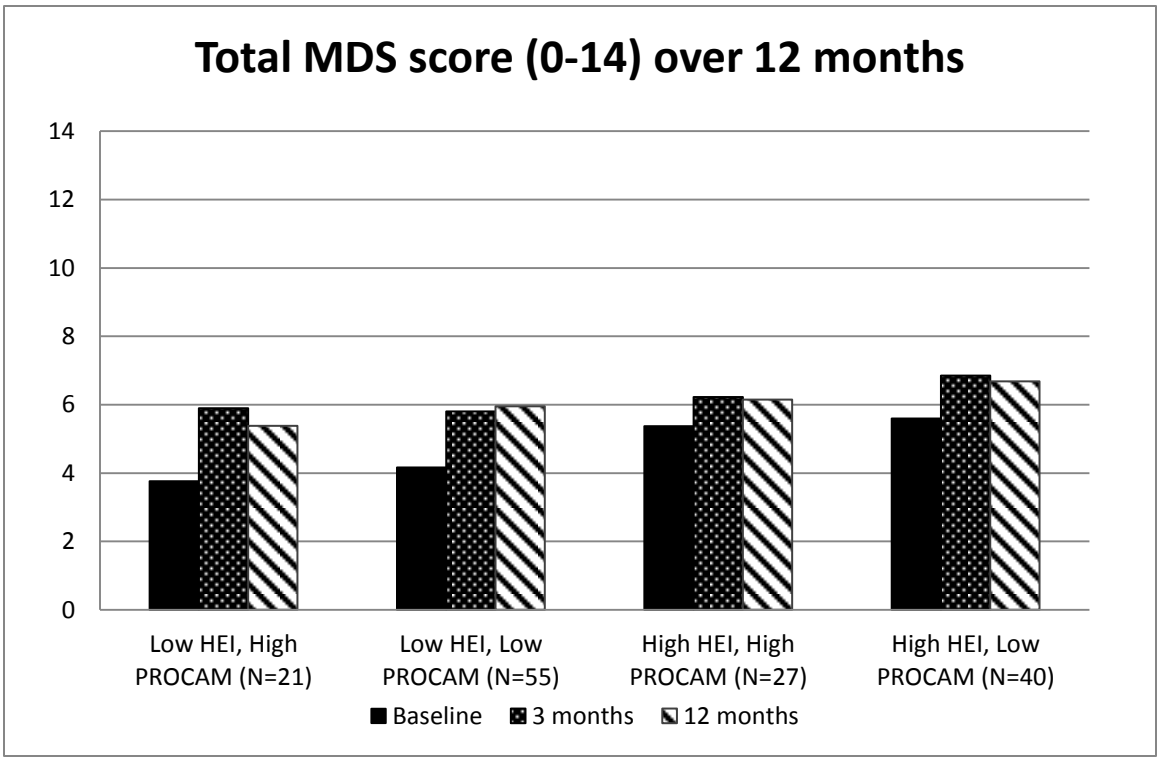


Figure 17 Mean total MDS score of participants at baseline, 3 months and 12 months, displayed by subgroups.

Table 15.3 Mean change in Mediterranean Diet Score for the four subgroups defined by baseline HEI-C score (≤60 and >60) and baseline PROCAM risk score (≤10% and >10%), based on participants with complete 12 months data (N=144).

	Low HEI, High PROCAM (N=21)			**Low HEI, Low PROCAM (N=55)**			**High HEI, High PROCAM (N=27)**			**High HEI, Low PROCAM (N=40)**			**P-value interaction b/w time and group**
	Mean change (SE)			**Mean change (SE)**			**Mean change (SE)**			**Mean change (SE)**			
	0-3 months	**3-12 months**	**0-12 months**	**0-3 months**	**3-12 months**	**0-12 months**	**0-3 months**	**3-12 months**	**0-12 months**	**0-3 months**	**3-12 months**	**0-12 months**	
Mean total MDS (0-14)	**2.14** (0.47)**	-0.52 (0.44)	**1.62*** (0.35)**	**1.64*** (0.24)**	0.15 (0.24)	**1.78*** (0.26)**	0.85 (0.42)	-0.07 (0.42)	0.78 (0.43)	**1.25*** (0.25)**	-0.18 (0.28)	**1.08** (0.28)**	0.121

Statistically significant changes (by repeated measures ANOVA) over time are bolded with significance levels as follows: *p<0.05, **p<0.01, ***p<0.001

Table 15.4 Percentage of participants (n) meeting scoring criteria for each MDS component at baseline, 3 months and 12 months, in participants with complete 12 months data, separated by HEI-C score (≤60 and >60) and PROCAM risk score (≤10% and >10%) at baseline (N=144).

MDS component	**Criteria to achieve a score of 1***	**Low HEI, High PROCAM (N=21)**			**Low HEI, Low PROCAM (N=55)**			**High HEI, High PROCAM (N=27)**			**High HEI, Low PROCAM (N=40)**		
		Baseline	3 Months	12 Months	Baseline	3 Months	12 Months	Baseline	3 Months	12 Months	Baseline	3 Months	12 Months
Fruits	**≥ 3 servings per day**	4.8[a] (1)	33.3[a] (7)	19.0[a] (4)	18.2[a] (10)	29.1[a] (16)	32.7[a] (18)	40.7[a] (11)	33.3[a] (9)	29.6[a] (8)	45.0[a] (18)	40.0[a] (16)	52.5[a] (21)
Vegetables	**≥ 4 servings per day; at least 2**	**0[a] (0)**	19.0[a,b] (4)	**38.1[b] (8)**	**9.1[a] (5)**	**27.3[b] (15)**	**30.9[b] (17)**	14.8[a] (4)	25.9[a] (7)	29.6[a] (8)	27.5[a] (11)	45.0[a] (18)	25.0[a] (10)

MDS component	Criteria to achieve a score of 1*	Low HEI, High PROCAM (N=21)			Low HEI, Low PROCAM (N=55)			High HEI, High PROCAM (N=27)			High HEI, Low PROCAM (N=40)		
		Baseline	3 Months	12 Months	Baseline	3 Months	12 Months	Baseline	3 Months	12 Months	Baseline	3 Months	12 Months
	servings raw												
Red or processed meats	**< 2 servings per day**	76.2[a] (16)	90.5[a] (19)	81.0[a] (17)	**63.6[a] (35)**	**89.1[b] (49)**	**87.3[b] (48)**	74.1[a] (20)	77.8[a] (21)	81.5[a] (22)	**67.5[a] (27)**	87.5[a,b] (35)	**97.5[b] (39)**
Poultry more often than red meat	**Yes**	61.9[a] (13)	81.0[a] (17)	66.7[a] (14)	**52.7[a] (29)**	**69.1[b] (38)**	**76.4[b] (42)**	**44.4[a] (12)**	**70.4[b] (19)**	**81.5[b] (22)**	**55.0[a] (22)**	**80.0[b] (32)**	**80.0[b] (32)**
Legumes	**≥ 3 servings per week**	0[a] (0)	19.0[a] (4)	4.8[a] (1)	7.3[a] (4)	9.1[a] (5)	18.2[a] (10)	7.4[a] (2)	14.8[a] (4)	22.2[a] (6)	10.0[a] (4)	7.5[a] (3)	10.0[a] (4)
Fish or seafood	**≥ 4 servings per week**	4.8[a] (1)	23.8[a] (5)	28.6[a] (6)	10.9[a] (6)	14.5[a] (8)	18.2[a] (10)	22.2[a] (6)	29.6[a] (8)	25.9[a] (7)	15.0[a] (6)	25.0[a] (10)	17.5[a] (7)
Nuts	**≥ 3 servings per week**	**28.6[a] (6)**	**66.7[b] (14)**	47.6[a,b] (10)	**29.1[a] (16)**	**56.4[b] (31)**	49.1[a,b] (27)	33.3[a] (9)	48.1[a] (13)	51.9[a] (14)	**45.0[a] (18)**	60.0[a,b] (24)	**70.0[b] (28)**
Butter or cream	**< 1 tbsp per day**	**52.4[a] (11)**	**90.5[b] (19)**	**85.7[b] (18)**	**63.6[a] (35)**	**80.0[b] (44)**	78.2[a,b] (43)	81.5[a] (22)	92.6[a] (25)	88.9[a] (24)	82.5[a] (33)	85.0[a] (34)	92.5[a] (37)
Olive oil	**≥ 4 tbsp per day**	0[a,NA] (0)	4.8[a,b] (1)	0[b,NA] (0)	5.5[a] (3)	1.8[a] (1)	0[a] (0)	3.7[a,b] (1)	0[a,NA] (0)	0[b,NA] (0)	7.5[a] (3)	2.5[a] (1)	0[a] (0)
Olive oil as main cooking fat	**Yes**	33.3[a] (7)	28.6[a] (6)	38.1[a] (8)	29.1[a] (16)	32.7[a] (18)	29.1[a] (16)	51.9[a] (14)	59.3[a] (16)	40.7[a] (11)	40.0[a] (16)	60.0[a] (24)	52.5[a] (21)
Wine	**≥ 7 servings**	4.8[a,b]	0[a,NA]	0[b,NA]	9.1[a]	3.6[a]	3.6[a]	7.4[a]	7.4[a]	3.7[a]	7.5[a]	12.5[a]	2.5[a]

MDS component	Criteria to achieve a score of 1*	Low HEI, High PROCAM (N=21)			Low HEI, Low PROCAM (N=55)			High HEI, High PROCAM (N=27)			High HEI, Low PROCAM (N=40)		
		Baseline	3 Months	12 Months	Baseline	3 Months	12 Months	Baseline	3 Months	12 Months	Baseline	3 Months	12 Months
	per week	(1)	(0)	(0)	(5)	(2)	(2)	(2)	(2)	(1)	(3)	(5)	(1)
Commercial baked goods	**≤ 2 times per week**	33.3[a] (7)	47.6[a] (10)	33.3[a] (7)	**38.2[a] (21)**	**69.1[b] (38)**	**70.9[b] (39)**	59.3[a] (16)	66.7[a] (18)	63.0[a] (17)	**57.5[a] (23)**	**80.0[b] (32)**	67.5[a,b] (27)
Sugar-sweetened beverages	**< 1 per day**	76.2[a] (16)	81.0[a] (17)	85.2[a] (20)	**80.0[a] (44)**	**98.2[b] (54)**	**100[b] (55)**	96.3[a] (26)	96.3[a] (26)	96.3[a] (26)	100[a] (40)	97.5[a] (39)	97.5[a] (39)
Sofrito sauce	**≥ 2 times per week**	0[a,NA] (0)	4.8[a,b] (1)	0[b,NA] (0)	0[NA] (0)	0[NA] (0)	0[NA] (0)	0[NA] (0)	0[NA] (0)	0[NA] (0)	0[a] (0)	2.5[a] (1)	2.5[a] (1)

*Criteria values were adjusted to servings from Canada's Food Guide.

[a,b] Proportions in a row (within the subgroup) with same superscript did not differ from each other (by McNemar test) at significance level of $p<.05$.

[NA] used where the two proportions in paired comparison were both zero.

Discussion

The primary purpose of this study was to examine if food behaviour changes were maintained after active counselling over 12 months in the diet intervention portion of a lifestyle program delivered in three primary care settings. By utilizing data on participants' dietary behaviour and dietitians' reports on counselling sessions, this research was able to demonstrate how participants change their dietary behaviours over a long period of time. It also provides novel evidence on how they change in relation to dietary counselling in the Canadian context. Several key findings from this study are summarized as follows:

1. Some food behaviours were readily changed in the short-term (at 3 months) and maintained in the longer-term (at 12 months), i.e. fruits and vegetables, nuts, meat, other foods; some food behaviours are more difficult to change but may be eventually changed in the longer run, i.e. fish, legume; and some food behaviour are very hard to change, i.e. wine, olive oil, sofrito sauce.
2. Trajectories of food behaviour change were different among four a priori subgroups and only the Low HEI-C groups improved substantially.
3. Some FBGs were more frequently used than others, namely *Balanced meals* and *Increase fruits and vegetables*. For BCTs, it seemed a group of BCTs were frequently used throughout the intervention while another group of BCTs were almost never used.

The discussion below will focus mainly on the key findings of this study and comparison to existing literature. Some of the results are novel as no previous studies

have attempted to examine diet counselling in such detail, and thus the discussion regarding these findings will mainly focus on the interpretation of the novel findings and insight for future studies. Strengths and limitations will also be mentioned at the end of the section.

Participant Characteristics, Drop-outs

Baseline characteristics of participants are important factors to consider when interpreting results as well as when comparing results among relevant studies. Several characteristics, such as age, BMI, ethnicity, etc., are frequently used for comparison between sample populations across studies. In the CHANGE study, the average age of the sample population at baseline was 59.1±9.7 years. When compared to the mean ages in some well-known lifestyle intervention studies for chronic disease, mean age was similar to the Look AHEAD trial (58.6±6.8 years in the intervention group) (Look AHEAD Research Group, 2013), but higher than the mean age in the Diabetes Prevention Program (DPP) study (50.6±11.3 years in the lifestyle intervention group) (DPP Research Group, 2000) and lower than the mean age in the PRDIMED study (average 67±6 years in two intervention groups) (Estruch et al., 2013). The mean age in the DPP was particularly younger than other studies probably because the main purpose of the DPP was disease prevention while others were disease management.

The average BMI of the CHANGE study participants was 31.9±3.3 kg/m^2. It was slightly lower than the mean BMI reported in the DPP (33.9±6.8 kg/m^2 in the lifestyle

intervention group) (DPP Research Group, 2000) and the Look AHEAD trial (35.9±6.0 kg/m^2 in intervention group) (Look AHEAD Research Group, 2013) with a smaller standard deviation. This slight difference was probably due to the fact that the two US studies did not set an upper limit of BMI for participant eligibility (DPP Research Group, 2000; Look AHEAD Research Group, 2013) whereas people with a BMI greater than 35kg/m^2 were excluded in CHANGE study. The mean BMI in the PREDIMED study (average of 29.8±3.8 in two intervention groups) was close to the BMI in CHANGE as it also excluded people with extreme BMI (> 40kg/m^2) during recruitment (Estruch et al., 2013); the slightly smaller value was probably due to differences in BMI between the Spanish and Canadian populations. Participants in the CHANGE study were predominantly white (approximately 76% of the whole sample), whereas the participants in the two US studies, the DPP and the Look AHEAD trial, were more representative of the US population as the samples included substantial proportions of African Americans, Hispanic, American Indians and Asians (DPP Research Group, 2000; Look AHEAD Research Group, 2013). With regards to ethnicity, the participants in the PREDIMED study were Spanish, while the CHANGE participants had more diverse ethnic backgrounds, reflecting the Canadian reality (Estruch et al., 2013).

Drop-outs

The number of participants coming to the meetings decreased gradually over time, which was reflective of real world counseling. Although no previous studies have

reported the flow of participants throughout intervention, it is typical to lose some people over time in a longer program. The drop-out rate of CHANGE participants reported in the main report was 14% at one-year follow-up (Jeejeebhoy et al., 2017), which was higher than other studies (8% in DPP at one-year follow-up, 4% in the Look AHEAD trial over a median follow-up of 9.6 years, and average of 5% in two intervention groups in PREDIMED for over 2 years) (Mayer-Davis et al., 2004; Look AHEAD Research Group, 2013; Estruch et al., 2013); however, those studies were efficacy studies which were more intensive and had more resource to keep participants involved. A recent systematic review on translation of the DPP protocol to “real-world” settings found that the attendance rate of such studies in primary care settings was 80% to 96% and attrition rate was 7% to 28% (Whittemore, 2011). The CHANGE study was more comparable to these values.

In the CHANGE study, participants who did not complete final assessment were significantly younger (about 3.2 years) with higher BMI (about 1.7kg/m^2), compared to those who completed final assessment. The PREDIMED study also reported differences between participants who did and did not drop out. Those who dropped out were approximately 1.4 years younger with 0.4kg/m^2 higher BMI (Estruch et al., 2013). These findings were similar to the CHANGE study; the smaller values were probably due to the fact that PREDIMED participants were older with a slightly smaller BMI than CHANGE participants at baseline.

Outcomes on Dietary Behaviour Change

Change in HEI-C scores

Baseline HEI-C total score was 57.8, which was similar to the Canadian average of 58.8 (Statistics Canada, 2009). At 12 months, overall mean improvement in HEI-C total score was approximately 10. There were only a few intervention studies reported changes in HEI scores as it was only recently that studies started to use HEI (mainly HEI-1995 or HEI-2005) as a measure of dietary assessment. Based on a systematic review on utilization of HEI tools in intervention studies by previous graduate student (Ariellia Rodrigues, MSc thesis), the change in HEI total score varied from 5 to 17 with varied study lengths (ranging from 8 weeks to 2 years) and study foci (Carpenter et al., 2004; Demark-Wahnefried et al., 2012; Falciglia, 2005; Fitzgibbon et al., 2012; Glanz et al., 2012; Manios et al., 2007; Mecca et al., 2012; Petrogianni et al., 2013; Sallit et al., 2009; Stolley et al., 2009). Two of these studies reported change on HEI at 12 months, which were approximately 5 to 7 using HEI-2005 (Demark-Wahnefried et al., 2012) and 9 using HEI-1995 (Falciglia et al., 2005); the change in HEI-C total score in the CHANGE study was comparable to the result of these two studies since they were all based on 100-point scales. Another two of these studies focused specifically on cardiometabolic concerns and the improvement in HEI score was 5.5 points (by HEI-2005) over 3 months in a Greek sample (Petrogianni et al., 2013) and approximately 17 points (converted from a 120-point scale (HEI Brasil) to a 100-point scale) over 10 weeks in a Brazilian sample

(Mecca et al., 2012). Considering that the effect of intervention would generally decrease over time as reflected on reversal of HEI score over time, which was evident in a study by Sallit and colleagues (2009) that participants in the intervention group improved total HEI-1995 score from 60.4 to 75.9 after 12 weeks of intervention and about 11 points of improvement remained at 9-month follow-up, 10 points of improvement in HEI-C score at one year in CHANGE participants was very promising. Considering those participants with poorer dietary status at baseline, approximately 16-20 points of improvement at one year was a very positive result.

Total fruit and vegetables was one of the most promising changes in HEI-C components with an overall improvement of 1.17 points at 12 months in CHANGE participants, corresponding to almost 1 CFG serving of vegetables and fruit. While there was no current study to compare with based on the HEI component scores, the change in food equivalence was consistent with existing literature: successful improvement of vegetable and fruit intake at one year was frequently reported in intervention studies of relevant areas delivered in primary care settings, with changes ranging from 0.7 to 1.5 servings (Jackson et al., 2007; Koelewijn-van Loon et al., 2009; Sacerdote et al., 2006).

Saturated fat was another promising change in HEI-C components of CHANGE participants with an overall improvement of 1.72 at 12 months, corresponding to a reduction of ~1.1% energy intake from saturated fats. It was also similar to the findings from other lifestyle intervention studies conducted in primary care settings: although those studies did not report change in saturated fat intake in the form of HEI component,

a reduction of 1% to 3% energy intake from saturated fat was comparable to the value converted from HEI-C component of saturated fats in the CHANGE study (Bo et al., 2007; Huang et al., 2010; Korhonen et al., 2003; Eakin et al., 2009).

While most HEI-C components showed improvement throughout the intervention, a paradoxal pattern was observed in the trajectories of total grains and whole grains. HEI-C score of whole grains increased whereas total grains changed in the opposite direction, and food equivalence indicated that participants increased whole grain intake by approximately 0.4 serving while decreasing total grain intake by almost same amount. It may be explained by the fact that people can only consume certain quantity of foods, and increasing intake of multiple healthy foods such as fruits and vegetables, whole grains, etc. at same time would possibly be compromised by decreased intake of other foods. It seemed likely that participants substituted grains with whole grain products.

Change in Mediterranean diet score

MDS in this study was assessed based on the 14-item MEDAS tool developed in the PREDIMED study (Martinez-González, 2012); therefore the results for MDS change can be compared with PREDIMED as well as another Spanish RCT using the MEDAS tool (Gomez-Huelgas et al., 2015). The baseline total MDS in the two Spanish studies (average of 8.7 in two intervention groups of PREDIMED and 8.7 in intervention group in the study by Gomez-Huelgas et al.) were very similar, and both were higher than the baseline value of 4.75 in CHANGE participants. This large difference was possibly due

to cultural differences between Spain and Canada. The MEDAS tool is a measure of adherence to the Mediterranean diet, and several food behaviours including olive oil, wine, and sofrito sauce are routine practice of people in Spain. Some food behaviours, however, were less commonly practiced by Canadians, which was evident in the scoring of three MDS components (*Olive oil, Wine* and *Sofrito sauce*) in the CHANGE study, with almost no participants meeting the scoring criteria for these components at baseline and over 12 months. Other than that, the overall improvement in MDS total score in CHANGE study (approximately 1.4 points) was close to the overall improvement in PREDIMED study (approximately 2 points in two intervention groups) (Estruch et al., 2013) and in the study by Gomez-Huelgas et al. (approximately 2.1 points in intervention group) (2015). The slightly greater improvement in the two Spanish studies could also be the fact that people living in Mediterranean area were more readily adapted to Mediterranean-type diet, compared to those living in non-Mediterranean countries. The PREDIMED research group also provided foods (extra-virgin olive oil and nuts) to study participants during intervention (Estruch et al., 2013, Appendix pg.6), which can be considered as a form of incentives, while the CHANGE study was solely based on counselling. This could be another reason explaining the difference in the improvement of MDS total score.

With regards to improvement in MDS components, it was recognizable that food behaviour changes happened at three different levels. At the first level, some food behaviours were easily changed in the short-term and maintained in the long-term, which

was evident in the improvement of MDS components *Vegetables*, *Poultry more than red meat*, *Red or processed meat*, *Nuts*, *Butter or cream* and *Commercial baked foods*. These food behaviours can be easily targeted in interventions as various healthy diets (e.g. Mediterranean diet, DASH, etc.) focus on similar recommendations such as increasing vegetables and fruit intake and reducing saturated fat intake, and should continue to be addressed in interventions. At the second level, some food behaviours slowly improved over time, which was evident in MDS components *Fish* and *Legume*; for example, the change in percentage of participants meeting the scoring criteria of fish was not significant at 3 months but became significant at 12 months. Due to the prolonged length of time it took for change to be effective, this type of food behaviour changes might not have been detected if the intervention only ran for a short period of time. However, such food behaviours have great potential for improvement, and future research could work on how to change these behaviours more effectively. At the third level, some food behaviours had no change throughout intervention, including the three components mentioned before (*Olive oil*, *Wine* and *Sofrito sauce*). As discussed before, these food behaviours were less common in Canadians compared to people living in Spain who were culturally more exposed to Mediterranean-type diet. Changes in such behaviours in the Canadian population would also be harder, which was reflected in the scores for MDS components with very few participants meeting the scoring criteria throughout the intervention. Regarding such food behaviours, future studies may want to promote them in a way that is more readily adapted by people in non-Mediterranean countries. However,

multiple factors should also be considered since promoting them would mean increasing the fat content of diet (olive oil) and alcohol intake (wine), which are discouraged in the current version of CFG (Health Canada, 2011). It may be better to find food substitutions that are equally beneficial as olive oil and wine but are more common in the Canadian context.

Subgroup analysis on HEI-C and MDS

It was evident that dietary changes differed by baseline diet among participants. Results from a priori subgroup analysis indicated that most changes in HEI-C and MDS scores were found in poorer HEI-C groups. This finding confirmed the hypothesis that people with poorer baseline diet would make more changes than those with better baseline diet. It was understandable because people who were eating less healthily at baseline had more space for improvement, whereas people who already had a good diet would be counselled to maintain their healthy eating behaviours. It was surprising, however, that people with high PROCAM risk scores at baseline did not show better improvement compared to those with low PROCAM risk scores at baseline, since one might expect that people with greater health risk would seek more improvement to regulate health status. One HEI-C component, sodium, was distinctive as its improvement was significant in participants with high PROCAM risk scores regardless of baseline HEI-C scores. More interestingly the changes happened in reversed sequence: the Low HEI, High PROCAM group had greatest improvement at 3 months and approximately

half of the effect remained at 12 months, whereas the High HEI, High PROCAM group only showed change from 3 months to 12 months. It may be interesting to know what happened since the dietary intervention did not emphasize sodium intake specifically. Due to the small sample sizes of these two subgroups, however, it could be due to outliers, e.g. several participants who were classified with higher risk were salty snack eaters and reduced intake of these foods during the intervention. Thus, individual diets would need to be analyzed for understanding the paradoxical patterns.

Overall, the CHANGE study revealed that patients changed specific behaviours regarding their diet, rather than changing the whole diet. They were also able to improve some food behaviours and maintained them for a long period of time. A recent systematic review on translation of DPP indicated that studies implementing the DPP protocol which focused on weight loss generally found decreased effect on weight loss over time, but some behaviours, such as dietary modification, were able to be maintained (Tabak et al., 2015). While the CHANGE study did not heavily focus on weight loss, this was also confirmed in this research and the majority of food behaviour changes were maintained at the one-year mark.

Behaviour Change Techniques

The list of BCTs for RDs to choose from was based on the CALO-RE taxonomy (Michie et al., 2011), and the CHANGE study is one of the first studies to use this taxonomy in dietary counselling. During the intervention, multiple BCTs might be used

and RDs could choose a maximum of 4 BCTs; yet the number reported was actually fewer (1.9 in the first three months and 2.2 in 4–12 months). It could be possibly due to the fact that the CALO-RE taxonomy is still new to RDs, and they might have only chosen what they felt most familiar with. Another explanation could be that RDs used some techniques that were not listed in the case report form (Appendix D) and thus did not record them.

Analysis on frequency of use of BCTs revealed that a group of 6 BCTs were more popular than others, including *Review of goals*, *Goal setting*, *Feedback on performance*, *Self-monitoring*, *Motivational interviewing* and *Action planning*. These BCTs focused mostly on individuals, and it seemed likely that these were the most familiar techniques to the study RDs. The fluctuations among these BCTs seemed logical as the first three months focused more on building new behaviours while the rest of the intervention focused more on maintaining the behaviours. It also made sense when linked back to the trends of change in HEI-C scores and MDS scores, as most improvement was made during the first three months and there were mostly no changes between 3 months and 12 months.

What's more interesting is that the top four BCTs (*Review of goals*, *Goal setting*, *Feedback on performance* and *Self-monitoring*) could all impact self-efficacy, which is the core determinant of eating behaviour based on Bandura's Social Cognitive Theory (Bandura, 1986). Although the associations between BCTs and food behaviour changes were not analyzed in this study, this finding implied that BCTs might not influence food

behaviour changes directly; rather, they impacted food behaviour changes indirectly through determinants of eating behaviour. Yet, without measuring those determinants, it would be difficult to know if the use of specific BCTs actually increased specific determinants which then led to heathy eating behaviour.

It was also important to note that a group of BCTs, including *Social support*, *Environmental restructuring*, *Cues/prompts*, were almost never used by the RDs throughout the intervention. These BCTs were more related to factors other than individual themselves, such as friends and family members, the environment they lived in, etc. Such techniques definitely have great potential for use as social and environmental factors have been frequently reported to have effects on behaviour change in the literature (Verheijden, Bakx, van Weel, Koelen, & van Staveren, 2005; Oliveira-Brochado, Oliveira-Brochado, & Brito, 2010). Therefore, more training and resources regarding such techniques may be needed to support RDs on using these techniques in future practice.

Food Behaviour Goals

Analysis on frequency of FBG use revealed that some FBGs were more popular than others, namely *Balanced meals* and *Increase fruits/vegetables*. Balanced meals dominated the whole intervention, but the frequency of use declined over time. Instead, more goals targeting specific behaviour became prominent as the intervention continued, such as *Increase fish* and *Increase plant protein*. Previous graduate students analyzed FBGs usage

from baseline to 3 months and reported that general FBGs were more frequently used at the beginning of the intervention whereas more specific FBGs started to increase as intervention continued (Jennifer Green, MSc thesis). This finding was further confirmed in this analysis that the intervention began with general goals and more specific goals were promoted by RDs as time passed. Use of this order in counselling can be tested to see if it is the most effective strategy, compared to focusing on specific foods from the beginning among the majority of patients.

It was evident that RDs had strong preferences for certain FBGs such as *Balanced meal* and *Increase fruits/vegetables*. Balanced meal has not been reported in the literature; this FBG was added to the FBG list based on consensus from the RDs and came out to be the top FBG used during the intervention. One explanation could be that the plate model was used by RDs to explain the concept of balanced meals; the plate model plus food models were easy visual guides for the patients, allowing for easy understanding. Increasing fruit and vegetables was also a safe choice for intervention as fruit and vegetables are associated with multiple health benefits (Watson & Preedy, 2009). It may be an easier choice for people as well instead of restricting or avoiding less healthy eating behaviours (such as eating less red meat, less butter, etc.), as avoiding such foods may eventually result in relapse to old behaviour (Kristal et al., 1992).

In contrast, some FBGs were not popular with RDs, such as *Decrease glycemic index*, *Increase plant sterols*, etc. Reasons for lack of use of these food behaviours are not known, but it could be possible that the concepts of such behaviours were difficult to

explain to patients who generally lack training in nutrition, foods are not as readily available, not traditional in RD practice or require too much time to explain and teach. Reduced glycemic index, for example, has been the subject of much research; thus it was surprising that it was not a focus. Further research on why some approaches were or were not selected, even when efficacious, needs to be further examined.

Association between FBGs and Food Behaviour Changes

The previous graduate student had found no specific association between FBGs and HEI-C/MDS scores using correlation analysis (Jennifer Green, MSc thesis). Using visual exploratory method instead, it seemed obvious that the use of some FBGs were reflected in the changes in associated HEI-C and MDS scores at some level. The trends seemed similar as they increased alongside each other. Having visual confirmation of association at some level speaks to the complexity of counselling since patients did not always take up behaviours they were counselled on. It is well recognized that behaviour change is affected by multiple factors, but it would be helpful to better understand why people who had committed to lifestyle change and were attending counselling still took up some changes more easily than others. Therefore, the observation that extended counselling was associated with increased uptake of fish and legumes was a novel and potentially important finding, since these foods are core to Mediterranean eating pattern and have favourable nutrient profiles.

Strengths

Several strengths of the CHANGE study should be mentioned. The sample size of the CHANGE study was relatively large, allowing significant changes to be detected. The study was conducted in three primary care settings in different provinces, which increased potential generalizability to Canadian primary care. Medical care, diet and exercise were all equally promoted to patients, multiple outcomes were assessed and overall reversion of MetS was significant (~19%) (Jeejeebhoy et al., 2017).

The diet portion of the CHANGE study was based on current RD practice, utilized multiple methods to assess dietary intake and focus on specific foods and nutrients, not just the diet as a whole, because people tended to change certain aspects of their diet, not the whole diet at once. While report on nutrient changes can be used for comparison among other studies in relevant areas, results on specific food behaviour change, especially the most promising ones, can be translated for use by the RDs more easily since they mostly counsel clients on food intake. Diet was assessed centrally at the University of Guelph, with strong quality control processes in place. RDs in the field were consulted regularly on completion of food recalls.

Besides general strengths of CHANGE, this study had additional value as it confirmed that 12 months results were maintained, including results in a priori subgroups. Unique to the literature was the novel approach to examine the association between FBGs and food behaviour change. This is a unique contribution to the literature since no previous studies have examined patients' behaviour change in relation to the food

recommendations they received from RDs. Although no statistical association was available, the visual confirmation of association between certain FBGs and food behaviours at some levels, along with the reports on FBGs and BCTs used by the RDs throughout the intervention, provided hints on what components of diet counselling interventions might be important and necessary for future interventions. Fourteen RDs were involved in the diet counselling aspects of this study, so results from this study can help optimize the process of care for MetS in the primary care system and has provided excellent avenues for further studies to improve counselling effectiveness.

Limitations

Several limitations of the study should also be considered when interpreting the results. The sample size was relatively large; however, when participants were divided into subgroups, some groups had a fairly small number (especially when dividing participants with complete MDS data into a priori subgroups), which might not have enough power for significant differences to be detected. Furthermore, while the participants were enrolled from three sites in different provinces to increase the representativeness of the sample to Canadian population, it was also a limitation since each of the three sites had unique features that did not represent the primary care services of the province it was located in (e.g. mainly Russian patients in fee-for-service clinic in Toronto, French-speaking university-affiliated primary care practice in Quebec City and English-speaking Primary Care Network practice in Edmonton). Considering of the

distribution of ethnicity across Canada, a sample of predominantly white people was probably not representative of Canadian population as well.

The CHANGE study was observational in nature. It had three assessment time points which allowed changes to be detected within the group across time, but it did not have a control group to be compared to. It was unknown to what degree the changes were a result of counselling from the dietitians and/or the rest of the team, especially the influence of the physician, or by chance. Review of the large RCTs indicates that some patients are able to change diet to some degree on their own (Fitzgibbon et al., 2012; Glanz et al., 2012; Sallit et al., 2009; Stolley et al., 2009). The fact that some patients in CHANGE already had excellent diets confirms this. Equally interesting, however, was that only patients with initially poorer diets benefits from counselling. Yet it could also be the fact of regression to the mean, since the patients with poorer and better diets at baseline eventually reached similar scores in majority of HEI-C component scores and MDS total score at the end of study. Therefore, future research may want to reproduce the intervention program with a control group receiving usual care limited to patients with initially poor diets, so that the actual effects of intervention on food behaviour change can be detected.

As a measure of dietary assessment, MDS was not initially incorporated in the study. While there were promising results from participants with complete MDS data, it was unknown whether the participants who were enrolled in the study early without MDS assessed at baseline behaved similarly as those 144 participants with complete MDS data.

Caution should also be made as the number of participants with complete MDS data was only about half of the total sample.

There was also limitation on measures. The case report forms, which were used for collecting information on FBGs and BCTs, were created by the research team based on clinical evidence (for part of FBGs) and existing literature (for FBGs and BCTs) and thus were not previously validated. In fact, there were no validated tools since no studies have explored details of dietary counselling in this condition, and thus the validity of this instrument might be a concern. Inter-rater reliability was addressed as standard training was provided to RDs across sites on how to complete the forms and further consultation with the research team was encouraged through regular teleconferences among the RDs involved in the study. Additional consultation was available if needed. Considering that the details of counselling may be important in further improving effectiveness of the process of care, future studies need to further assess the validity and reliability of tools. Some groups now routinely video-tape interventions, but there are also problems with analysis of counselling using these methods, with respect to inter-rater reliability of observed interaction.

It was intended that RDs would have access to the results of the diet assessment in doing counselling. Unfortunately, they often did not submit the records in a timely way so that they proceeded with counselling based on their experience and qualitative assessment, rather than data. However, since few RDs ever do detailed diet assessment in their patients, so this limitation mimicked typical practice.

Since this study was mostly exploratory in nature and following the basic analysis by previous graduate students on short-term food behaviour changes, some baseline characteristics (e.g. ethnicity, work status, other factors related to social economic status, etc.) that might have effect on the long-term results were not included in the analysis. Additional regression may be an alternative option to further examine the potential roles of these characteristics on food behaviour change. It could be possible, though, that those baseline characteristics would not affect the results since they were not different among groups. However, two most relevant characteristics have been considered in the study. Analysis was done separately on participants with better/poorer dietary status and better/poorer health risk at baseline and significant differences were found among the subgroups.

Another limitation in analysis was that the visual demonstration of association between FBGs and food behaviour change cannot be confirmed with any statistical tests to date. In addition to that, the expected possible associations of potentially associated FBGs and food behaviour changes were defined based on the consensus of research team with expertise in dietetics, but this represented the opinions of a small group. Additional work on defining what food behaviour changes can be expected when counselling on selected FBG is in early stages of development. Such clarity is needed to make progress on improving counselling effectiveness.

Implication for Practice and Future Research

The analysis on HEI-C and MDS revealed that participants were able to change multiple aspects of their diet and maintain the newly built behaviours over a considerable length of time. When taking baseline dietary status and baseline health status into consideration, the changes were more prominent in the two groups of participants with lower quality of diet at baseline. While the main paper indicated that this program seemed to be most beneficial to patients who had highest risk of myocardial infarction at baseline (Jeejeebhoy et al., 2017), evidence from this research suggested that the dietary part of the intervention should target individuals with poorer lifestyle, although still taking their disease conditions into consideration.

Furthermore, food behaviours were changed at different levels. There were several suggestions for future practice. Food behaviours that were easily changed were frequently addressed in current practice already, and should be continued in the future. Food behaviours that were changed slowly had a great potential for modification, but more research is needed to figure out how to address them more effectively in interventions. Food behaviours that were hardly changed were probably not relevant in the study population as the tool assessing these behaviours (in this case the MDS) was developed in a population that were culturally different from the study population. Future studies may need to modify counselling assessment tools to suit the population and the focus of counselling to make them more relevant and adapted to the target population, the condition being addressed and the focus of counselling. The concept of one generic tool,

namely the HEI-C, did not provide sufficient information for assessing Mediterranean diet, but did aid in assessing fat and salt intakes, which have the foci of many North American studies. More work is needed to develop diet assessment tools for diet counselling in MetS.

Besides the changes made in food behaviours, the novel exploration of association between FBGs and food behaviour change allowed better understanding on how patients changed in relation to what they received from the RDs. In order to optimize the process of care for MetS patients, it is important to understand the process of change in patients as well as the details of counselling by the RDs, and the association between FBGs and food behaviour change in conjunction with the reports on FBGs and BCTs used by the RDs could provide hints on what components of the intervention were important and necessary. There is definitely a need for determining specific links between food behaviours and selected FBGs, and future studies are warranted to take a more in-depth approach to understand the relationship between specific food behaviours and dietitian counselling foci. The results are important as they can improve the effectiveness of counselling for patients with complicated health conditions like MetS.

Conclusion

This exploratory research is a follow-up to a previous study on 3-month report. It provides unique evidence to the literature regarding dietitian counselling practice and the levels of change MetS patients were able to make and maintain regarding their food

behaviours over the long-term in the dietary part of a complex lifestyle intervention in the Canadian primary care context. Analysis revealed that patients changed specific food behaviours, e.g. increasing fruit and vegetable intake, adding nuts, eating more poultry than red meat, etc., rather than change the whole diet. They were also able to improve some food behaviours and maintained them for at least one year, such as increasing fruit and vegetables, whole grains, reducing intake from saturated fats, sodium and other foods. On the other hand, food behaviours were changed at three different levels: some were readily changed in the short-term and maintained in the long-term, e.g. fruits and vegetables, meat, other foods; some were more difficult to change but may be eventually changed at long run, e.g. fish, legume; and some were very hard to change, e.g. wine, olive oil, sofrito sauce. Attempting modification on these food behaviours may be considered in separate ways in future practice. Most importantly, food behaviour changes were mostly prominent in patients with poorer dietary status at baseline, regardless of their baseline health status. This evidence suggested that, while lifestyle intervention could benefit patients with complicated health conditions such as MetS, dietary modification should target people with poorer dietary habits specifically. This research also took a novel approach on examining dietitian counselling practice by the use of FBG and BCT, and revealed that dietitians mainly focused on a group of FBGs (e.g. *Balanced meal*, *Increase fruit and vegetables, etc.*) and BCTs (e.g. *Review of goals*, *Goal setting*, *Feedback on performance*, etc.) whereas the rest of them were seldom used throughout intervention. Especially in BCTs, several techniques (e.g. *Social support*, *Environmental*

restructuring, *Cues/prompts*, etc.) were almost never used during counselling. Those least used techniques definitely have great potential for use and more training and resources may be needed to support dietitians on using those techniques. Lastly, the visual demonstration of patients' food behaviour changes in relation to dietitian counselling on FBGs suggested that there seemed to be indirect association between certain FBGs and food behaviour changes. Due to the lack of statistical test on this exploratory analysis, the indirect associations cannot be confirmed. Future research is warranted to take a more in-depth approach to better understand patient dietary behaviour and dietitian counselling together, which will allow identification of key elements of dietitian counselling that are most readily changed by the majority of patients and will improve overall effectiveness of diet counselling in primary care settings.

References

Abraham, C., & Michie, S. (2008). A taxonomy of behavior change techniques used in interventions. *Health Psychology, 27*(3), 379.

Absetz, P., Valve, R., Oldenburg, B., Heinonen, H., Nissinen, A., Fogelholm, M., Ilvesmäki, V., Talja, M., & Uutela, A. (2007). Type 2 diabetes prevention in the "real world". *Diabetes Care, 30*, 2465-70.

Alberti, K., Eckel, R. H., Grundy, S. M., Zimmet, P. Z., Cleeman, J. I., Donato, K. A., Fruchart, J., James, W., Loria, C. M., & Smith, S. C. (2009). Harmonizing the metabolic syndrome: A joint interim statement of the International Diabetes Federation Task Force on Epidemiology and Prevention; National Heart, Lung, and Blood Institute; American Heart Association; World Heart Federation; International Atherosclerosis Society; and International Association for the Study of Obesity. *Circulation, 120*, 1640-45.

Aune, D., Keum, N., Giovannucci, E., Fadnes, L. T., Boffetta, P., Greenwood, D. C., Tonstad, S., Vatten, L. J., Riboli, E., & Norat, T. (2016). Whole grain consumption and risk of cardiovascular disease, cancer, and all cause and cause specific mortality: Systematic review and dose-response meta-analysis of prospective studies. *BMJ, 353*, i2716.

Bandura, A. (1986). *Social foundations of thoughts and action: A social cognitive theory.* Englewood Cliffs, NJ: Prentice-Hall.

Bassi, N., Karagodin, I., Wang, S., Vassallo, P., Priyanath, A., Massaro, E., & Stone, N. J. (2014). Lifestyle modification for metabolic syndrome: A systematic review. *The American Journal of Medicine, 127*, 1242e1-10.

Blanton, C. A., Moshfegh, A. J., Baer, D. J., & Kretsch, M. J. (2006). The USDA automated multiple-pass method accurately estimates group total energy and nutrient intake. *The Journal of Nutrition, 136*(10), 2594-9.

Bo, S., Ciccone, G., Baldi, C., Benini, L., Dusio, F., Forastiere, G., Lucia, C., Nuti, C., Durazzo, M., Cassader, M., Gentile, L., & Pagano, G. (2007). Effectiveness of a lifestyle intervention on metabolic syndrome. A randomized controlled trial. *Journal of General Internal Medicine, 22*(12), 1695-703.

Bonilla, C., Brauer, P., Royall, D., Keller, H., Hanning, R. M., & Dicenso, A. (2016). Interprofessional dietary assessment practices in primary care: A mixed-methods study. *Journal of Interprofessional Care, 30*(1), 77-82.

Buil-Cosiales, P., Toledo, E., Salas-Salvadó, J., Zazpe, I., Farràs, M., Basterra-Gortari, F. J., Diez-Espino, J., Estruch, R., Corella, D., Ros, E., Marti, A., Gómez-Garcia, E., Ortega-Calvo, M., Arós, F., Moñino, M., Serra-Majem, L., Pintó, X., Lamuela-Raventós, R. M., Babio, N., Gonzalez, J. I., Fitó, M., & Martínez-González, M. A., for the PREDIMED Investigators. (2016). Association between dietary fibre intake and fruit, vegetable or whole grain consumption and the risk of CVD: Results

from the PREvención con Dieta MEDiterránea (PREDIMED) trial. *British Journal of Nutrition, 116*(3), 534-46.

Cade, J. E., Kirk, S. F. L., Nelson, P., Hollins, L., Deakin, T., Greenwood, D. C., & Harvey, E. L. (2009). Can peer educators influence healthy eating in people with diabetes? Results of a randomized controlled trial. *Diabetic Medicine, 26*, 1048-54.

Carpenter, R.A., Finley, C., & Barlow, C.E. (2004). Pilot test of a behavioural skill building intervention to improve overall diet quality. *Journal of Nutrition Education and Behavior, 36*, 20-6.

Chiuve, S. E., Fung, T. T., Rimm, E. B., Hu, F. B., McCullough, M. L., Wang, M., Stampfer, M. J., & Willett, W. C. (2012). Alternative dietary indices both strongly predict risk of chronic disease. *Journal of Nutrition, 142*(6), 1009-18.

Clark, M., Hampson, S. E., Avery, L., & Simpson, R. (2004). Effects of a tailored lifestyle self-management intervention in patients with Type 2 diabetes. *British Journal of Health Psychology, 9*, 365-79.

Demark-Wahnefried, W., Morey, M.C., Sloane, R., Snyder, D.C., Miller, P.E., Hartman, T.J., …, & Cohen, H.J. (2012). Reach out to enhance wellness home-based diet-exercise intervention promotes reproducible and sustainable long-term improvements in health behaviours, body weight, and physical functioning in older, overweight/obese cancer survivors. *Journal Clinical Oncology, 30*(19), 2354-61.

Eakin, E., Reeves, M., Lawler, S., Graves, N., Oldenburg, B., Der Mar, C., Wilke, K., Winkler, E., & Barnett, A. (2009). Telephone counseling for physical activity and diet in primary care patients. *American Journal of Preventive Medicine, 36*(2), 142-9.

Estruch, R., Ros, E., Salas-Salvadó, J., Covas, M., Corella, D., Arós, F., Gómez-Garcia, Ruiz-Gutiérrez, V., Fiol, M., Lapetra, J., Lamuela-Raventos, R. M., Serra-Majrm, L., Pintó, X., Basora, J., Muñoz, M. A., Sorlí, J. V., Martínez, J. A., & Martínez-González, M. A., for the PREDIMED Study Investigators. (2013). Primary prevention of cardiovascular disease with a Mediterranean diet. *The New England Journal of Medicine, 368*(14), 1279-90.

Falciglia, G.A., Whittle, K.M., Levin, L.S., & Steward, D.L. (2005). A clinical-based intervention improves diet in patients with head and neck cancer at risk for second primary cancer. *Journal of the American Dietetic Association, 105*, 1609-12.

Fitzgibbon, M.L., Stolley, M.R., Schiffer, L., Sharp, L.K., Singh, V., & Dyer, A. (2010). Obesity Reduction Black Intervention Trial (ORBIT): 18-month results. *Obesity, 18*(12), 2317-25.

Fung, T. T., McCullough, M. L., Newby, P., Manson, J. E., Meigs, J. B., Rifai, N., Willett, W. C., & Hu, F. B. (2005). Diet-quality scores and plasma concentrations of markers of inflammation and endothelial dysfunction. *The American Journal of Clinical Nutrition, 82*, 163-73.

García-Huidobro, D., Bittner, M., Brahm, P., & Puschel, K. (2011). Family intervention to control type 2 diabetes: A controlled clinical trial. *Family Practice, 28*, 4-11.

Glanz, K, & Bishop, D. B. (2010). The role of behavioural science theory in development

and implementation of public health interventions. *Annual Review of Public Health, 31*, 399-418.

Glanz, K., Herser, J., Cates, S., Muth, M., Creel, D., Nicholls, J., … & Zaripheh, S. (2012). Effect of a Nutrient Rich Foods consumer education program: Results from the nutrition advice study. *Journal of the Academy of Nutrition and Dietetics, 112*(1), 56-63.

Glanz, K., & Rimer, B. K. (1995). *Theory at a glance: A guide to health promotion practice* (2nd ed.). Bethesda, MD: National Cancer Institute.

Gomez-Huelgas, R., Jansen-Chaparro, S., Baca-Osorio, A. J., Mancera-Romero, J., Tinahones, F. J., & Bernal-López. (2015). Effects of a long-term lifestyle intervention program with Mediterranean diet and exercise for the management of patients with metabolic syndrome in a primary care setting. *European Journal of Internal Medicine, 26*(5), 317-23.

Green, J. (2016). *Dietitian counselling practices, and food behaviour changes in the first three months of a primary care intervention for metabolic syndrome* (Master thesis). University of Guelph, Guelph.

Grundy, S. M., Cleeman, J. I., Daniels, S. R., Donato, K. A., Eckel, R. H., Franklin, B. A., Gordon, D. J., Krauss, R. M., Savage, P. J., Smith, S. C., Spertus, J. A., & Costa, F. (2005). Diagnosis and management of the metabolic syndrome: An American Heart Association/National Heart, Lung, and Blood Institute scientific statement. *Circulation, 112*(17), 2735-52.

Health Canada. (2011). *Eating Well with Canada's Food Guide – A resource for educators and communicators* [Catalogue no. H164-38/2-2011E-PDF; HC Publication no. 4667]. Retrieved April 7, 2017 from Health Canada website: http://www.hc-sc.gc.ca/fn-an/pubs/res-educat/res-educat-eng.php

Huang, M., Hsu, C., Wang, H., & Shin, S. (2010). Prospective randomized controlled trial to evaluate effectiveness of registered dietitian-led diabetes management on glycemic and diet control in a primary care setting in Taiwan. *Diabetes Care, 33*, 233-9.

Hutchison, B., Levesque, J., Strumpf, E., & Coyle, N. (2011). Primary health care in Canada: Systems in motion. *The Milbank Quarterly, 89*(2), 256-88.

Jackson, C., Coe, A., Cheater, F. M., & Wroe, S. (2007). Specialist health visitor-led weight management intervention in primary care: Exloratory evaluation. *Journal of Advanced Nursing, 58*(1), 23-34.

Jacobs Jr., D. R., Sluik, D., Rokling-Andersen, M. H., Anderssen, S. A., & Drevon, C. A. (2009). Association of 1-y changes in diet pattern with cardiovascular disease risk factors and adipokines: Results from the 1-y randomized Oslo diet and exercise study. *The American Journal of Clinical Nutrition, 89*, 509-17.

Jeejeebhoy, K., Dhaliwal, R., Heyland, D. K., Leung, R., Day, A. G., Brauer, P., Royall, D., Tremblay, A., Mutch, D. M., Pliamm, L., Rhéaume, C., & Klein, D. (2017). Family physician-led, team-based, lifestyle intervention in patients with metabolic syndrome: Results of a multicenter feasibility project. *CMAJ, 5*(1), E229-36.

Kim, H. (2013). Statistical notes for clinical researchers: Assessing normal distribution (2) using skewness and kurtosis. Restorative Dentisty & Endodontics, 38(1), 52-4.

Koelewijn-van Loon, M. S., van der Weijden, T., van Steenkiste, B., Ronda, G., Winkens, B., Severens J. L., Wensing, M., Elwyn, G., & Grol, R. (2009). Involving patients in cardiovascular risk management with nurse-led clinics: A cluster randomized controlled trial. *CMAJ, 181*(12), E267-74.

Korhenen, M., Kastarinen, M., Uusitupa, M., Puska, P., & Nissinen, A. (2003). The effect of intensified diet counseling on the diet of hypertensive subjects in primary health care: A 2-year open randomized controlled trial of lifestyle intervention against hypertension in Eastern Finland. *Preventive Medicine, 36*, 8-16.

Kristal, A. R., & Ollberding, N. J. (2013). Evaluation of Nutrition Interventions. In Coulston, A. M., Boushey, C. J., Ferruzzi, M. G. (Eds.), *Nutrition in the Prevention and Treatment of Disease* (pp. 191-208). London, UK: Elsevier.

Kristal, A. R., White, E., Shattuck, A. L., Curry, S., Anderson, G. L., Fowler, A., & Urban, N. (1992). Long-term maintenance of a low-fat diet: Durability of fat-related dietary habits in the Women's Health Trial. *Journal of the American Dietetic Association, 92*(5), 553-9.

Leiter, L. A., Gilbert, R. E., Mancini, G. B. J., Teoh, H., Camelon, K., Cox, J. I., Harris, S. B., Lewanczuk, R., McPherson, R., Rabasa-Lhoret, R., Steele, A. W., & Tardif, J. (2011). Cardiometabolic risk in Canada: A detailed analysis and position paper by the Cardiometabolic Risk Working Group. *Canadian Journal of Cardiology, 27*, e1-33.

Liese, A. D., Krebs-Smith, S. M., Subar, A. F., George, S. M., Harmon, B. E., Neuhouser, M. L., Boushey, C. J., Schap, T. R., & Reedy, J. (2015). The Dietary Pattern Methods Project: Synthesis of findings across cohorts and relevance to dietary guidance. *The Journal of Nutrition, 145*, 393-402.

Liese, A. D., Nichols, M., Sun, X., D'Agostino, R. B. Jr., Haffner, S. M. (2009). Adherence to the DASH diet is inversely associated with incidence of type 2 diabetes: The insulin resistance atherosclerosis study. *Diabetes Care. 32*(8), 1434-6.

Ley, S. H., Hamdy, O., Mohan, V., & Hu, F. B. (2014). Prevention and management of type 2 diabetes: Dietary components and nutritional strategies. *Lancet, 383*, 1999-2007.

Manios, Y., Moschonis, G., Katsaroli, I., Grammatikaki, E., & Tanagra, S. (2007). Changes in diet quality score, macro- and micronutrients intake following a nutrition education intervention in postmenopausal women. *Journal of Human Nutrition and Dietetics, 20*(2), 126-31.

Martinez-González, M. A., Fernández-Jarne, E., Serrano-Martínez, M., Wright, M., & Gomez-Garcia, E. (2004). Development of a short dietary intake questionnaire for the quantitative estimation of adherence to a cardioprotective Mediterranean diet. *European Journal of Clinical Nutrition, 58*, 1550-2.

Martinez-González, M. A., García-Arellano, A., Toledo, E., Salas-Salvadó, J., Buil-Cosiales, P., Corella, D., Covas, M. I., Schröder, H., Arós, F., Gómez-Gracia, E.,

Fiol, M., Ruiz-Gutiérrez, V., Laprtra, J., Lamuela-Raventos, R. M., Serra-Majem, L., Pintó, X., Muñoz, M. A., Wärnberg, J., Ros, E., & Estruch, R., for the PREDIMED Study Investigators. (2012). A 14-item Mediterranean diet assessment tool and obesity indexes among high-risk subjects: The PREDIMED trial. *PLoS ONE, 7*(8), e43134.

Mecca, M.S., Moreto, F., Burini, F.H.P., Falanesi, R.C., McLellan, K.C.P., & Burini, R.C. (2012). Ten-week lifestyle changing profram reduces several indicators for metabolic syndrome in overweight adults. *Diabetology & Metabolic Syndrome, 4*(1), 1.

Mensink, M., Blaak, E. E., Corpeleijn, E., Saris, W. H., de Bruin, T. W., & Feskens, E. J. (2003). Lifestyle intervention according to general recommendations improves glucose tolerance. *Obesity Research, 11*(12), 1588-96.

Michie, S., Ashford, S., Sniehotta, F. F., Dombrowski, S. U., Bishop, A., & French, D. P. (2011). A refined taxonomy of behaviour change techniques to help people change their physical activity and healthy eating behaviours: The CALO-RE taxonomy. *Psychology & Health, 26*(11), 1479–98.

Michie, S., Richardson, M., Johnston, M., Abraham, C., Francis, J., Harderman, W., Eccles, M., et al. (2013). The behaviour change technique taxonomy (v1) of 93 hierarchically clustered techniques: Building an international consensus for the reporting of behaviour change interventions. *Annuals of Behavioral Medicine, 46*, 81-95.

Mottillo, S., Filion, K. B., Genest, J., Joseph, L., Pilote, L., Poirier, P., Rinfret, S., Schiffrin, E. L., & Eisenberg, M. J. (2010). The metabolic syndrome and cardiovascular risk: A systematic review and meta-analysis. *Journal of the American College of Cardiology, 56*(14), 1113-32.

Newby, P. K., Hu, F. B., Rimm, E. B., Smith-Warner, S. A., Feskanich, D., Sampson, L., & Willett, W. C. (2003). Reproducibility and validity of the Diet Quality Index Revised as assessed by use of a food-frequency questionnaire. *American Journal of Clinical Nutrition, 78*, 941-9.

Oliveira-Brochado, A., Oliveira-Branchado, F., & Brito, P. Q. (2010). Effects of personal, social and environmental factors on physical activity behavior among adults. *Revista Portuguesa de Saúde Pública, 28*(1), 7-17.

Petrogianni, M., Kanellakis, S., Kallianioti, K., Argyropoulou, D., Pitsavost, C., & Manios, Y. (2013). A multicomponent lifestyle intervention produces favourable changes in diet quality and cardiometabolic risk indices in hypercholesterolaemic adults. *Journal of Human Nutrition and Dietetics, 26*(6), 596-605.

Riediger, N. D., & Clara I. (2011). Prevalence of metabolic syndrome in the Canadian adult population. *Canadian Medical Association Journal, 183*(15), E1127-34.

Rodrigues, A. (2016). *Diet quality indices as measures of food and nutrient intake change in a lifestyle intervention for metabolic syndrome* (Master thesis). University of Guelph, Guelph.

Sacerodote, C., Fiorini, L., Rosato, R., Audenino, M., Valpreda, M., & Vineis, P. (2006).

Randomized controlled trial: Effect of nutritional counselling in general practice. *International Journal of Epidemiology, 25*, 409-15.

Sakane, N., Sato, J., Tsushita, K., Tsujii, S., Kotani, K., Tsuzaki, K., Tominaga, M., Kawazu, S., Sato, Y., Usui, T., Kamae, I., Yoshida, T., Kiyohara, Y., Sato, S., & Kuzuya, H., for the Japan Diabetes Prevention Program (JDPP) Research Group. (2011). Prevention of type 2 diabetes in a primary healthcare setting: Three-year results of lifestyle intervention in Japanese subjects with impaired glucose tolerance. *BMC Public Health, 11*(1), 40.

Sallit, H.M., Ciccazzo, M., & Dixon, Z. (2009). A cognitive-behavioural weight control program improves eating and smoking behaviours in weight-concerned female smokers. *Journal of the American Dietetic Association, 109*(8), 1398-1405.

Schröder, H., Fitó, M., Estruch, R., Martínez-González, M. A., Corella, D., Salas-Salvadó, J., Lamuela-Raventós, R., Ros, E., Salaverría, I., Fiol, M., Lapetra, J., Vinyoles, E., Gómez-Garcia, E., Lahoz, C., Serra-Majem, L., Pintó, X., Ruiz-Gutierrez, V., & Covas, M. (2011). A short screener is valid for assessing Mediterranean diet adherence among older Spanish men and women. *The Journal of Nutrition, 141*, 1140-5.

Statistics Canada. (2009). *Diet quality in Canada* [Catalogue no. 82-003-X]. Retrieved April 5, 2017 from Statistics Canada website: http://www.statcan.gc.ca/pub/82-003-x/2009003/article/10914/findings-resultats-eng.htm

Statistics Canada. (2012). *Metabolic syndrome in Canadians, 2009 to 2011* [Catalogue no. 82-625-X]. Retrieved April 5, 2017 from Statistics Canada website: http://www.statcan.gc.ca/pub/82-625-x/2012001/article/11735-eng.pdf

Statistics Canada. (2015). *Metabolic syndrome in Canadians, 2012 to 2013* [Catalogue no. 82-625-X]. Retrieved April 5, 2017 from Statistics Canada website: http://www.statcan.gc.ca/pub/82-625-x/2014001/article/14123-eng.htm

Stolley, M.R., Fitzgibbon, M.L., Schiffer, L., Sharp, L.K., Singh, V., Van Horn, L., … & Dyer, A. (2009). Obesity Reduction Black Intervention Trial (ORBIT): Six-month results. *Obesity, 17*(1), 100-6.

Tabak, R. G., Sinclair, K. A., Baumann, A. A., Racette, S. B., Kuhlmann, A. S., Johnson-Jennings, M. D., & Brownson, R. C. (2015). A review of diabetes prevention program translations: use of cultural adaptation and implementation research. *TBM, 5*, 401-14. doi: 10.1007/s13142-015-0341-0.

ter Bogt, M., Milder, I., Bemelmans, W., Beltman, F. W., Broer, J., Smit, A. J., & van der Meer, K. (2011). Changes in lifestyle habits after counselling by nurse practitioners: 1-year results of the Groningen Overweight and Lifestyle study. *Public Health Nutrition, 14*(6), 995-1000.

The Diabetes Prevention Program Research Group. (2000). The diabetes prevention program: Baseline characteristics of the randomized cohort. *Diabetes Care, 23*(11), 1619-29.

The Look AHEAD Research Group. (2013). Cardiovascular effects of intensive lifestyle intervention in type 2 diabetes. *The New England Journal of Medicine, 369*, 145-54.

Verheijden, M. W., Bakx, J. C., van Weel, C., Koelen, M. A., & van Staveren, W. A. (2005). Role of social support in lifestyle-focused weight management interventions. *European Journal of Clinical Nutrition, 59*(Suppl 1), S179-86.

Verheijden, M. W., Van der Veen, J. E., Bakx, J. C., Akkermans, R. P., Van den Hoogen, H. J., Van Staveren, W. A., & Van Weel, C. (2004). Stage-matched nutrition guidance: Stages of change and fat consumption in Dutch patients at elevated cardiovascular risk. *Journal of Nutrition Education and Behavior, 36*(5), 228-37.

Watson, R. R., & Preedy, V. (Ed.). (2009). *Bioactive foods in promoting health: Fruits and vegetables* (1st ed.). Boston, MA: Academic Press.

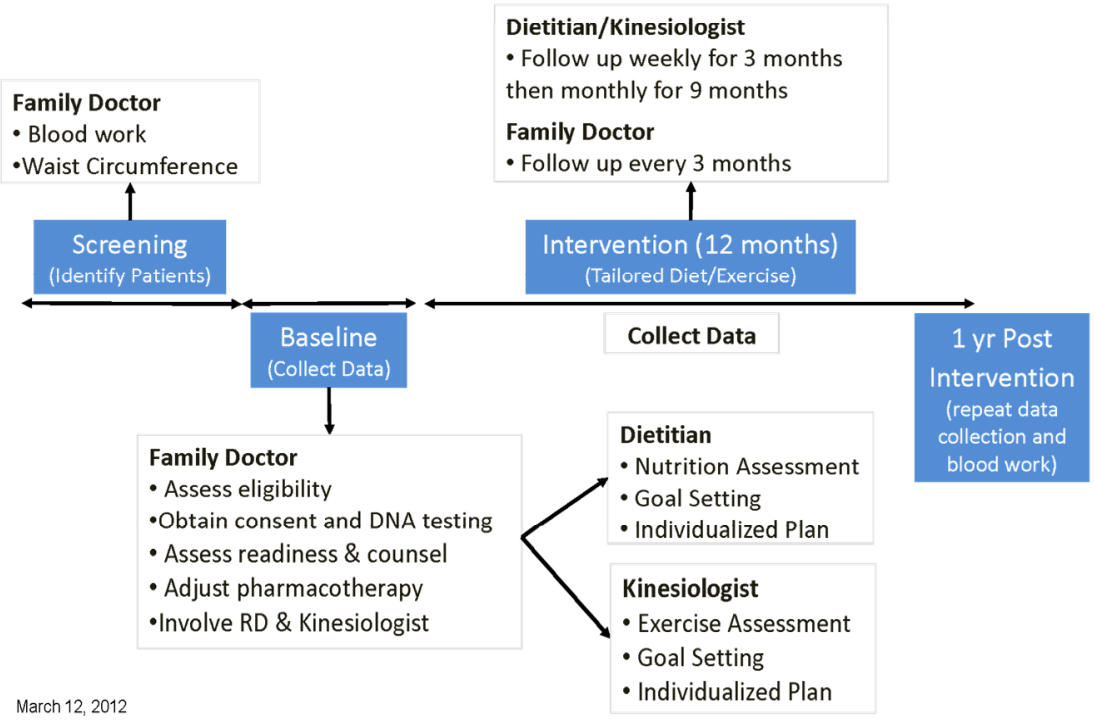
Whittemore, R. (2011). A systematic review of the translational research on the Diabetes Prevention Program. *TBM, 1*, 480-91.

Wood, D. A., Korseva, K., Connolly, S., Jennings, C., Mead, A., Jones, J., Holden, A., De Bacquer, D., Collier, T., De Backer, G., Faergeman, O, on behalf of EUROACTION Study Group. (2008). Nurse-coordinated multidisciplinary, family-based cardiovascular disease prevention programme (EUROACTION) for patients with coronary heart disease and asymptomatic individuals at high risk of cardiovascular disease: A paired, cluster-randomised controlled trial. *Lancet, 371*, 1999-2012.

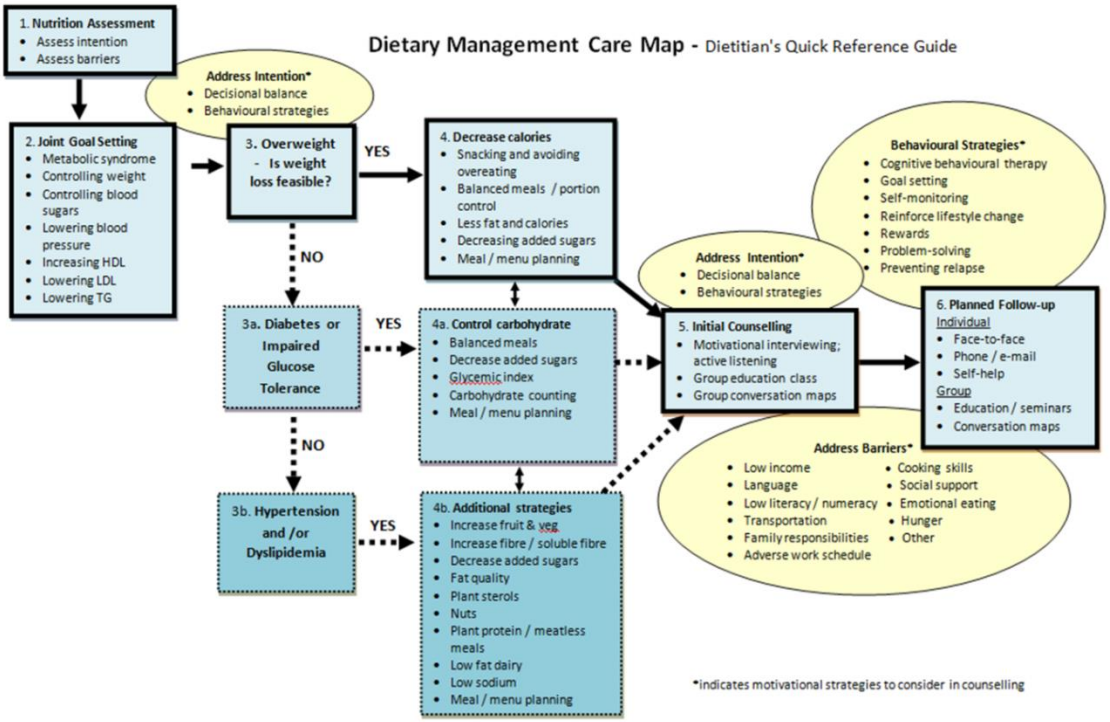
Woollard, J., Burke, V., Beilin, L. J., Verheijden, M., & Bulsara, M. K. (2003). Effects of a general practice-based intervention on diet, body mass index and blood lipids in patients at cardiovascular risk. *Journal of Cardiovascular Risk, 10*, 31-40.

Yamaoka, K., & Tango, T. (2012). Effects of lifestyle modification on metabolic syndrome: A systematic review and meta-analysis. *BMC Medicine, 10*, 138.

Appendix A: Overview of CHANGE Study Timeline



Appendix B: Dietary Management Care Map for Treatment of Metabolic Syndrome (Royall et al., 2014)



Appendix C: Definitions of the 40 BCTs included in the CALO-RE taxonomy (Michie et al., 2011)

1. Provide information on consequences of behaviour in *general*	Information about the relationship between the behaviour and its possible or likely consequences *in the general case*, usually based on epidemiological data, and not personalised for the individual (contrast with technique 2)
2. Provide information on consequences of behaviour *to the individual*	Information about the *benefits and costs* of action or inaction to the individual or tailored to a relevant group based on that individual's characteristics (i.e. demographics, clinical, behavioural or psychological information). This can include any costs/benefits and not necessarily those related to health, e.g. feelings.
3. Provide information about others' approval	Involves information about what other people think about the target person's behaviour. It clarifies whether others will like, approve or disapprove of what the person is doing or will do. NB: Check that any instance does not also involve techniques 1 (Provide information on consequences of behaviour in *general*) or 2 (Provide information on consequences of behaviour *to the individual*) or 4 (Provide normative information about others' behaviour).
4. Provide normative information about others' behaviour	Involves providing information about what other people are *doing* i.e. indicates that a particular behaviour or sequence of behaviours is common or uncommon amongst the population or amongst a specified group – presentation of case studies of a few others is not normative information. NB: this concerns other people's actions and is distinct from the provision of information about others' approval (technique 3 (Provide information about others' approval)).
5. Goal setting (behaviour)	The person is encouraged to make a behavioural resolution (e.g. take more exercise next week). This is directed towards encouraging people to decide to change or maintain change. NB: This is distinguished from technique 6 (goal setting – outcome) and 7 (action planning) as it does not involve planning exactly how the behaviour will be done and either when or where the behaviour or action sequence will be performed. Where the text only states that goal setting was used without specifying the detail of action planning involved then this would be an example of this technique (not technique 7 (action planning)). If the text states that 'goal

	setting' was used if it is not clear from the report, if the goal setting was related to behaviour or to other outcomes, technique 6 should be coded. This includes sub-goals or preparatory behaviours and/or specific contexts in which the behaviour will be performed. The behaviour in this technique will be directly related to or be a necessary condition for the target behaviour (e.g. shopping for healthy eating; buying equipment for physical activity). NB: check if techniques applied to preparatory behaviours should also be coded as instances of technique 9 (Set graded tasks).
6. Goal setting (outcome)	The person is encouraged to set a general goal that can be achieved by behavioural means but is not defined in terms of behaviour (e.g. to reduce blood pressure or lose/maintain weight), as opposed to a goal based on changing behaviour as such. The goal may be an expected consequence of one or more behaviours, but is not a behaviour per se (see also techniques 5 (Goal setting – behaviour) and 7 (Action planning)). This technique may co-occur with technique 5 if goals for both behaviour and other outcomes are set.
7. Action planning	Involves detailed planning of what the person will do including, as a minimum, when, in which situation and/or where to act. 'When' may describe frequency (such as how many times a day/week or duration (e.g. for how long). The exact content of action plans may or may not be described, in this case code as this technique if it is stated that the behaviour is planned contingent to a specific situation or set of situations even if exact details are not present. NB: The terms 'goal setting' or 'action plan' are not enough to ensure inclusion of this technique unless it is clear that plans involve linking behavioural responses to specific situational cues, when only described as 'goal setting' or 'action plan' without the above detail it should be regarded as applications of techniques 5 and 6.
8. Barrier identification/problem solving	This presumes having formed an initial plan to change behaviour. The person is prompted to think about potential barriers *and* identify the ways of overcoming them. Barriers may include competing goals in specified situations. This may be described as 'problem solving'. If it is problem solving in relation to the performance of a behaviour, then it counts as an instance of this technique. Examples of barriers

	may include behavioural, cognitive, emotional, environmental, social and/or physical barriers. NB: Closely related to techniques 7 (action planning) and 9 (set graded task), but involves a focus on specific obstacles to performance. It contrasts with technique 35 (relapse prevention/coping planning), which is about maintaining behaviour that has already been changed.
9. Set graded tasks	Breaking down the target behaviour into smaller easier to achieve tasks and enabling the person to build on small successes to achieve target behaviour. This may include increments towards target behaviour or incremental increases from baseline behaviour. NB: The key difference to technique 7 (Action planning) lies in planning to perform a sequence of preparatory actions (e.g. remembering to take gym kit to work), task components or target behaviours which are in a logical sequence or *increase in difficulty over time* – as opposed to planning 'if-then' *contingencies* when/where to perform behaviours. General references to *increasing* physical activity as intervention goal are not instances of this technique.
10. Prompt review of behavioural goals	Involves a review or analysis of the extent to which previously set *behavioural* goals (e.g. take more exercise next week) were achieved. In most cases, this will follow previous goal setting (see technique 5, 'goal setting-behaviour') and an attempt to act on those goals, followed by a revision or readjustment of goals, and/or means to attain them. NB: Check if any instance also involves techniques 6 (goal setting – behaviour), 8 (barrier identification/problem solving), 9 (set graded tasks) or 11 (prompt review of outcome goals).
11. Prompt review of outcome goals	Involves a review or analysis of the extent to which previously set *outcome* goals (e.g. to reduce blood pressure or lose/maintain weight) were achieved. In most cases, this will follow previous goal setting (see technique 6, goal setting-outcome') and an attempt to act on those goals, followed by a revision of goals, and/or means to attain them. NB: Check that any instance does not also involve techniques 5 (goal setting – outcome), 8 (barrier identification/problem solving), 9 (set graded tasks) or 10 (prompt review of behavioural goals).

12. Prompt rewards contingent on effort or progress towards behaviour	Involves the person using praise or rewards for attempts at achieving a behavioural goal. This might include efforts made towards achieving the behaviour or progress made in preparatory steps towards the behaviour, but not merely participation in intervention. This can include self-reward. NB: This technique is not reinforcement for performing the target behaviour itself, which is an instance of technique 13 (provide rewards contingent on successful behaviour).
13. Provide rewards contingent on successful behaviour	Reinforcing successful performance of the specific target behaviour. This can include praise and encouragement as well as material rewards but the reward/incentive must be explicitly linked to the achievement of the specific target behaviour i.e. the person receives the reward if they perform the specified behaviour but not if they do not perform the behaviour. This can include self-reward. Provisions of rewards for completing intervention components or materials are not instances of this technique. References to provision of incentives for being more physically active are not instances of this technique unless information about contingency to the performance of the target behaviour is provided. NB: Check the distinction between this and techniques 7 (action planning) and 17 (prompt self-monitoring of behavioural outcome) and 19 (provide feedback on performance).
14. Shaping	Contingent rewards are first provided for any approximation to the target behaviour e.g. for any increase in physical activity. Then, later, only a more demanding performance, e.g. brisk walking for 10 min on 3 days a week would be rewarded. Thus, this is graded use of contingent rewards over time.
15. Prompting generalisation of a target behaviour	Once behaviour is performed in a particular situation, the person is encouraged or helped to try it in another situation. The idea is to ensure that the behaviour is not tied to one situation but becomes a more integrated part of the person's life that can be performed at a variety of different times and in a variety of contexts.
16. Prompt self-monitoring of behaviour	The person is asked to keep a record of specified behaviour(s) as a method for changing behaviour. This should be an explicitly stated intervention component, as opposed to occurring as part of completing measures for research purposes. This could e.g. take the form of a diary or

	completing a questionnaire about their behaviour, in terms of type, frequency, duration and/or intensity. Check the distinction between this and techniques 17 (prompt self-monitoring of behavioural outcome).
17. Prompt self-monitoring of behavioural outcome	The person is asked to keep a record of specified measures expected to be influenced by the behaviour change, e.g. blood pressure, blood glucose, weight loss, physical fitness. NB: It must be reported as part of the intervention, rather than only as an outcome measure. Check the distinction between this and techniques 16 (Prompt self-monitoring of behaviour).
18. Prompting focus on past success	Involves instructing the person to think about or list previous successes in performing the behaviour (or parts of it). NB: This is not just encouragement but a clear focus on the person's past behaviour. It is also not feedback because it refers to behaviour preceded the intervention.
19. Provide feedback on performance	This involves providing the participant with data about their own recorded behaviour (e.g. following technique 16 (prompt self-monitoring of behaviour)) or commenting on a person's behavioural performance (e.g. identifying a discrepancy with between behavioural performance and a set goal – see techniques 5 (Goal setting – behaviour) and 7 (action planning) – or a discrepancy between one's own performance in relation to others' – note this could also involve technique 28 (Facilitate social comparison).
20. Provide information on *where and when* to perform the behaviour	Involves telling the person about when and where they might be able to perform the behaviour this e.g. tips on places and times participants can access local exercise classes. This can be in either verbal or written form. NB: Check whether there are also instances of technique 21 (Provide instruction on how to perform the behaviour).
21. Provide instruction on how to perform the behaviour	Involves *telling* the person *how* to perform behaviour or preparatory behaviours, either verbally or in written form. Examples of instructions include; how to use gym equipment (without getting on and showing the participant), instruction on suitable clothing, and tips on how to take action. *Showing* a person how to perform a behaviour without verbal instruction would be an instance of technique 22 only. NB: Check whether there are also instances of techniques 5, 7, 8, 9 and 22. Instructions to follow a specific diet or programme of exercise without instructions how to perform

	the behaviours are not included in this definition. Cooking and exercise classes as well as personal trainers and recipes should always be coded as this technique, but may also be coded as 22 (model/demonstrate the behaviour).
22. Model/Demonstrate the behaviour	Involves *showing* the person how to perform a behaviour e.g. through physical or visual demonstrations of behavioural performance, in person or remotely. NB: This is distinct from just providing instruction (technique 21) because in 'demonstration' the person is able to *observe* the behaviour being enacted. This technique and techniques 21 (Provide instruction on how to perform the behaviour) and may be used separately or together. Instructing parents or peers to perform the target behaviour is not an instance of this technique as fidelity would be uncertain.
23. Teach to use prompts/cues	The person is taught to identify environmental prompts which can be used to remind them to perform the behaviour (or to perform an alternative, incompatible behaviour in the case of behaviours to be reduced). Cues could include times of day, particular contexts or technologies such as mobile phone alerts which prompt them to perform the target behaviour. NB: This technique could be used independently or in conjunction with techniques 5 (goal setting - behaviour) and 7 (action planning; see also 24 (environmental restructuring)).
24. Environmental restructuring	*The person* is prompted to alter the environment in ways so that it is more *supportive* of the target behaviour e.g. altering cues or reinforcers. For example, they might be asked to lock up or throw away or their high calorie snacks or take their running shoes to work. Interventions in which the interveners directly modify environmental variables (e.g. the way food is displayed in shops, provision of sports facilities) are not covered by this taxonomy and should be coded independently.
25. Agree behavioural contract	Must involve written agreement on the performance of an explicitly specified behaviour so that there is a written record of the person's resolution witnessed by another.
26. Prompt practice	Prompt the person to rehearse and repeat the behaviour or preparatory behaviours numerous times. Note this will also include parts of the behaviour e.g. refusal skills in relation to unhealthy snacks. This could be described as 'building habits or routines' but is still practice so long as the person is

	prompted to try the behaviour (or parts of it) during the intervention or practice between intervention sessions, e.g. as 'homework'.
27. Use of follow-up prompts	Intervention components are gradually reduced in intensity, duration and frequency over time, e.g. letters or telephone calls instead of face to face and/or provided at longer time intervals.
28. Facilitate social comparison	Involves explicitly drawing attention to others' performance to elicit comparisons. NB: The fact the intervention takes place in a group setting, or have been placed in groups on the basis of shared characteristics, does not necessarily mean social comparison is actually taking place. Social support may also be encouraged in such settings and this would then involve technique 29 (plan social support/social change). Group classes may also involve instruction (technique 21 (provide instruction on how to perform the behaviour)) demonstration (technique 22 (model/demonstrate the behaviour)) and practice (technique 26 (prompt practice)).
29. Plan social support/social change	Involves prompting the person to plan how to elicit social support from other people to help him/her achieve their target behaviour/outcome. This will include support during interventions e.g. setting up a 'buddy' system or other forms of support and following the intervention including support provided by the individuals delivering the intervention, partner, friends and family.
30. Prompt identification as role model/position advocate	Involves focusing on how the person may be an example to others and affect their behaviour, e.g. being a good example to children. Also includes providing opportunities for participants to persuade others of the importance of adopting/ changing the behaviour, for example, giving a talk or running a peer-led session.
31. Prompt anticipated regret	Involves inducing expectations of future regret about the performance or nonperformance of a behaviour. This includes focusing on how the person will *feel* in the future and specifically whether they will feel regret or feel sorry that they did or did not take a different course of action. Do not also code instances of this technique as the more generic providing information on consequences (techniques 1

	(provide information on consequences of behaviour in *general* and 2 (provide information on consequences of behaviour *to the individual*)).
32. Fear arousal	Involves presentation of risk and/or mortality information relevant to the behaviour as emotive images designed to evoke a fearful response (e.g. 'smoking kills!' or images of the grim reaper). Do not also code instances of this technique as the more generic providing information on consequences (techniques 1 (provide information on consequences of behaviour in *general*) and 2 (provide information on consequences of behaviour *to the individual*)).
33. Prompt self talk	Encourage the person to use talk to themselves (aloud or silently) before and during planned behaviours to encourage, support and maintain action.
34. Prompt use of imagery	Teach the person to imagine successfully performing the behaviour or to imagine finding it easy to perform the behaviour, including component or easy versions of the behaviour. Distinct from recalling instances of previous success without imagery (technique 18 (prompting focus on past success)).
35. Relapse prevention/coping planning	This relates to planning how to maintain behaviour that has been changed. The person is prompted to identify in advance situations in which the changed behaviour may not be maintained and develop strategies to avoid or manage those situations. Contrast with techniques 7 (action planning) and 8 (barrier identification/problem solving) which are about initiating behaviour change.
36. Stress management/emotional control training	This is a set of specific techniques (e.g. progressive relaxation) which do not target the behaviour directly but seek to reduce anxiety and stress to facilitate the performance of the behaviour. It might also include techniques designed to reduce negative emotions or control mood or feelings that may interfere with performance of the behaviour, and/or to increase positive emotions that might help with the performance of the behaviour. NB: Check whether there are any instances of technique 8 (barrier identification/ problem solving), which includes identifying emotional barriers to performance, in contrast to the current technique, which addresses stress and emotions, whether they have been identified as barriers or not.

37. Motivational interviewing	This is a clinical method including a specific set of techniques involving prompting the person to engage in change talk in order to minimise resistance and resolve ambivalence to change (includes motivational counselling). NB: Only rate this technique if explicitly referred to by name, not if one identifies specific elements of it, this may happen if you have prior experience with this technique.
38. Time management	This includes any technique designed to teach a person how to manage their time in order to make time for the behaviour. These techniques are not directed towards performance of target behaviour but rather seek to facilitate it by freeing up times when it could be performed. NB: Only rate this technique if explicitly referred to by name, not if one identifies specific elements of it, this may happen if you have prior experience with this technique.
39. General communication skills training	This includes any technique directed at general communication skills but not directed towards a particular behaviour change. Often this may include role play and group work focusing on listening skills or assertive skills. NB: Practicing a particular behaviour-specific interpersonal negotiation e.g. refusal skills in relation to cigarettes or alcohol would not be an instance of this technique.
40. Stimulate anticipation of future rewards	Create anticipation of future rewards without necessarily reinforcing behaviour throughout the active period of the intervention. Code this technique when participants are told at the onset that they will be rewarded based on behavioural achievement.

Appendix D: Nutrition Intervention Checklist (Behaviour Change Techniques & Food Behaviour Goals)

Week#: ___ OR **Month#:** ___

If no visits in this time period, record reason: _____

___ - ___ - ___
Site # Protocol # Enrollment #

Nutrition Intervention Checklist

Encounter	1	2	3	4	5
Date					
Setting	☐ Individual ☐ Group	☐ Individual ☐ Group	☐ Individual ☐ Group	☐ Individual ☐ Group	☐ Individual ☐ Group
Partner/family/ friend(s)	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No
Delivery method (Check all that apply)	☐ Face-to-Face ☐ Phone ☐ Web/Email	☐ Face-to-Face ☐ Phone ☐ Web/Email	☐ Face-to-Face ☐ Phone ☐ Web/Email	☐ Face-to-Face ☐ Phone ☐ Web/Email	☐ Face-to-Face ☐ Phone ☐ Web/Email
Contact Time (mins)	___	___	___	___	___

Behavioural change strategies used in counseling (Check all that apply)	☐ Consequences of behaviour	☐ Graded tasks	☐ Action planning
	☐ Problem solving	☐ Rewards	☐ Review of goals
	☐ Feedback on performance	☐ Self monitoring	☐ Cues/prompts
	☐ Environmental restructuring	☐ Focus on past success	☐ Relapse prevention / coping
	☐ Behavioural contract	☐ Social support	☐ Other (specify)
	☐ Goal setting	☐ Motivational interviewing	_____
Skill Building Activities Recommended (Describe)			

Food Behaviour Goal	Stage (Check one)	Resources Used		
None	☐ None			
Decrease intake added sugars	☐ Set ☐ Being Worked On ☐ Attained	1)	2)	3)
Balanced meals	☐ Set ☐ Being Worked On ☐ Attained	1)	2)	3)
Eating breakfast	☐ Set ☐ Being Worked On ☐ Attained	1)	2)	3)
Carbohydrate counting	☐ Set ☐ Being Worked On ☐ Attained	1)	2)	3)
Healthier choices when eating out	☐ Set ☐ Being Worked On ☐ Attained	1)	2)	3)
Decrease calories	☐ Set ☐ Being Worked On ☐ Attained	1)	2)	3)
Choosing healthier fats	☐ Set ☐ Being Worked On ☐ Attained	1)	2)	3)
Decrease total fat	☐ Set ☐ Being Worked On ☐ Attained	1)	2)	3)
Increase fibre	☐ Set ☐ Being Worked On ☐ Attained	1)	2)	3)
Decrease glycemic index	☐ Set ☐ Being Worked On ☐ Attained	1)	2)	3)
Increase nuts	☐ Set ☐ Being Worked On ☐ Attained	1)	2)	3)
Increase plant protein	☐ Set ☐ Being Worked On ☐ Attained	1)	2)	3)
Increase plant sterols	☐ Set ☐ Being Worked On ☐ Attained	1)	2)	3)
Healthier snacks	☐ Set ☐ Being Worked On ☐ Attained	1)	2)	3)
Decrease sodium	☐ Set ☐ Being Worked On ☐ Attained	1)	2)	3)
Increase fruits/vegetables	☐ Set ☐ Being Worked On ☐ Attained	1)	2)	3)
Other (Please specify):	☐ Set ☐ Being Worked On ☐ Attained	1)	2)	3)

Appendix E: Healthy Eating Index and Mediterranean Diet Questions

Client ID #: _____ Gender: Male____ or Female____ Age: ≤50 years ____ or >51 years____	Date:	Dietitian:

Healthy Eating Index and Mediterranean Diet Questions (rev July 2013)

Average Daily Servings (unless indicated as weekly svg), where 1 serving is a Food Guide Serving		
Food item	**Food Guide Serving**	**Comments** (e.g. prepared with added, fat, sugar, salt?)
Total Vegetables and Fruit	*[whole svgs/day]*	
• **Whole Fruit (not juice)**	*[½ or whole svgs/day]*	
• **Fruit juice**	*[½ or whole svgs/day]*	
• **Vegetables**	*[whole svgs/day]*	
• **Dark Green/Orange Vegetable**	*[½ or whole svgs/day]*	
Total Grain products	*[whole svgs/day]*	
• **Whole Grains**	*[whole svgs/day]*	
Milk and Alternatives	*[½ or whole svgs/day]*	
Meat and Alternatives	*[½ or whole svgs/day]*	
• **Red or Processed Meat**	*[svgs/day]*	
• **Poultry more than red meats?**	**YES** _____ **NO** _____	
• **Legumes** *(fill in one option)*	_____< *once/month* _____ *# svgs/**month*** _____ *# svgs/**week***	
• **Fish / Shellfish** *(fill in one option)*	_____< *once/month* _____ *# svgs/**month*** _____ *# svgs/**week***	
• **Nuts (incl peanuts)***(fill*	_____< *once/month* _____ *# svgs/**month***	

in one option)	_____ # *svgs/**week***	
Fats - Butter or cream	*[Tbsp/day]*	
• **Olive oil as main added fat?**	**YES** _____ **NO** _____	
• **Olive oil**	*[Tbsp/day]*	
• **Margarine and Vegetable oils (other than olive oil)**	*[Tbsp/day]*	

Average Daily <u>or</u> Weekly Intake as Actual Food Description or Amount		
Other food	**Average daily intake (size or amount)**	**Average weekly intake (size or amount)**
Alcohol (excluding wine)		
Wine		
Baked goods (cakes, cookies, muffins, granola bars)		
Ice cream, other desserts		
Chocolate, candies		
Salty snacks (french fries, potato chips, nachos)		
Sweetened drinks (pop, sports drinks, hot or cold chocolate or specialty drinks)		

Appendix F: Additional Tables, Figures and Analyses

Table A1 One-year dietary changes in review of intervention studies of relevant areas.

Author; Country/ Region	Focus	Sample size	Study design/ Intervention method	Mean age	Dietary assessment	One-year dietary changes (significant results only)
Absetz et al., 2007; Finland	T2DM prevention	352 (265 F, 87 M)	One group pre and post (but use DPS as reference group for comparison) 6 group counseling sessions; 5 sessions were performed during the first 8 weeks with 2-week intervals in between sessions, and final session was done at 8 months.	58 (F) 59 (M)	3-day food diary for assessing three dietary goals: <30% energy intake from total fat; <10% energy intake from saturated fat; fiber ≥ 15g/1000kcal	***Nutrient level:*** More % participants in GOAL study achieved saturated fat and fiber intake goals at 1 year, compared to DPS study (34% vs. 26%, 52% vs. 25%, respectively). Yet more % participants who met lifestyle objectives at baseline achieved total fat, saturated fat and fiber intake goals at 1 year, compared to those who did not meet lifestyle objectives at baseline (61% vs. 44% for total fat, 55% vs. 29% for saturated fat, 73% vs. 47% for fiber).
Bo et al., 2007; Italy	Metabolic syndrome management	169 INT 166 CON	RCT All participants received general information emphasizing healthy lifestyle. Then intervention group received individualized recommendations through 5 sessions, each lasting	55.7	Semi-quantitative food frequency questionnaire	***Nutrient level:*** -2.64% energy from total fat and -1.97% energy from saturated fat intake in intervention group at 1 year. +0.99% energy from PUFA, +2.14% energy from CHO, and +1.7g/day fiber intake in intervention group at 1 year. No significant changes were found in control

Author; Country/ Region	Focus	Sample size	Study design/ Intervention method	Mean age	Dietary assessment	One-year dietary changes (significant results only)
			for at least 60 mins: one individual face-to-face counselling session and four group sessions from trained professionals during the study year. Control group did not receive any further intervention.			group.
Cade et al., 2009; England	T2DM management	162 INT 155 CON	RCT Intervention group received 7 group sessions, each lasting for 2 hours; frequency is once a week. First six sessions were about coping with chronic health issues, improved eating, relaxation and exercise patterns; one extra session was specific to management of diabetes. Control group received "standard care" which is an individual appointment with a dietitian for 15-30 mins.	66	Repeated 3-day food diaries and questionnaire	***Nutrient level:*** No significant difference between groups.

Author; Country/ Region	Focus	Sample size	Study design/ Intervention method	Mean age	Dietary assessment	One-year dietary changes (significant results only)
Huang et al., 2010; Taiwan	T2DM management	79 INT 75 CON	RCT Both intervention group and control group received usual care. In addition, intervention group received individual face-to-face counselling with dietitians, emphasizing portion control, every 3 months, each lasting for 30-60 mins.	56	24-hour recall	***Nutrient level:*** Intervention group -229kcal/day of energy intake, -31g of daily CHO intake, -11g of daily protein intake, -7.7g of daily fat intake, and -0.98% energy from saturated fat at 1 year, while control group +56kcal/day of energy intake, +7g of daily CHO intake, +2.9g daily protein intake, +3.84g daily fat intake and +0.6% energy from saturated fat at 1 year.
Korhonen et al., 2003; Finland	Blood pressure management	360 INT 355 CON	Controlled clinical trial Intervention group received individual face-to-face counselling with trained nurses at 1,3,6, and 9 months, focusing on reducing fat intake, saturated fat intake and Na intake while maintaining adequate K intake, and one group session with study physician at 6 months during first year. Control group received usual care.	54.4 (INT) 54.2 (CON)	4-day food records	***Nutrient level:*** Intervention group had +1.4% more energy from CHO, +0.7g/1000 kcal of fiber, and +3mmol/1000 kcal K intake at 1 year, compared with control group. Intervention group had -1.8% energy from fat, -1.2% energy from SFA, -23mg cholesterol, and -8mmol Na intake at 1 year, compared with control group.

Author; Country/ Region	Focus	Sample size	Study design/ Intervention method	Mean age	Dietary assessment	One-year dietary changes (significant results only)
Mensink et al., 2003; Netherlands	Diet and physical activity intervention on glucose tolerance	40 INT 48 CON	RCT Intervention group received individual face-to-face counselling with a skilled dietitian every 3 months focusing on following a healthy diet recommended by Dutch dietary guideline & were encouraged to attend group exercise class for at least 1hr/week. Control group received oral and written information about healthy diet, weight loss and physical activity.	55.6 (INT) 57.8 (CON)	3-day food record	***Nutrient level:*** Intervention group +5.1% energy from CHO and +0.7g/MJ fiber intake, +1.8% energy from protein, -5.5% energy from fat and -3.1% energy from saturated fat at 1 year, compared to nonsignificant changes in control group.
Sakane et al., 2011; Japan	T2DM prevention	146 INT 150 CON	RCT Intervention group received four group sessions with study nurse during first 6 months, each lasting for 2-3 hours, and then biannual individual face-to-face sessions, lasting 20-40 mins	51	Semi-quantitative food frequency questionnaire	***Nutrient level:*** Both groups ↓ energy intake at 1 year (-200 kcal in INT and -160kcal in CON); difference was nonsignificant. Intervention group -1% energy intake from fat at 1 year, yet the change between groups was nonsignificant.

Author; Country/ Region	Focus	Sample size	Study design/ Intervention method	Mean age	Dietary assessment	One-year dietary changes (significant results only)
			during first year. The intervention emphasized on weight loss. Control group received one group session on healthy lifestyle and prevention of diabetes at baseline.			
ter Bogt et al., 2011; Netherlands	Weight gain prevention	225 INT 232 CON	RCT Intervention group received 4 individual face-to-face counselling sessions at 1, 2, 3, and 8 months, plus one feedback session by telephone at 5 months. The focus of intervention is to prevent weight gain and to lose weight. Control group received usual care.	56	Food frequency questionnaire	***Nutrient level:*** Both groups ↓ energy intake (-179kcal in NP and -175kcal in GP-UC) and ↓ saturated fat intake, ↑protein and CHO intake. No significant differences between groups.
Verheijden et al., 2004; Netherlands	CVD prevention	71 INT 70 CON	Clinical controlled trial Intervention group received a maximum of 3 consultations with trained family physician, each lasting for 10 mins. If patients' stage of change	60	Food frequency questionnaire	***Nutrient level:*** Participants who had not moved from pre-action to post-preparation in intervention group had more ↓ total fat intake compared to those in control group.

Author; Country/ Region	Focus	Sample size	Study design/ Intervention method	Mean age	Dietary assessment	One-year dietary changes (significant results only)
			reached the preparation or the action stage they were referred to a dietitian and then had a series of 3 individual consultations, with first one lasting 30-40 mins and the subsequent ones lasting 20-25 mins. Intervention mainly focused on reducing fat intake and followed Dutch national dietary guideline. Control group received usual care.			
Woollard et al., 2003; Australia	CHD prevention	68 CON 69 INT-T 74 INT-I	RCT Low level intervention group received one individual face-to-face counselling and then monthly consultations, each lasting 10-15 mins, for a year. High level intervention group received monthly individual face-to-face counselling sessions, each lasting for 1 hour for a year.	59.5 (INT-I) 61.0 (INT-T) 60.3 (CON)	Deakin food frequency questionnaire	***Nutrient level:*** Both intervention groups↓ total fat and PUFA intake at 12 months, compared to nonsignificant changes in control.

Author; Country/ Region	Focus	Sample size	Study design/ Intervention method	Mean age	Dietary assessment	One-year dietary changes (significant results only)
			Control group received Heart Foundation health promotion literature and with usual care.			
Eakin et al., 2009; Australia	CVD management	228 INT 206 CON	Cluster RCT Intervention group received 18 telephone counselling over 12 months; frequency changed from weekly to bi-weekly to monthly. The focus was on fat and saturated fat intakes, vegetables & fruits, and fiber, following the Australian national guidelines. Control group received usual care with brochures on health advices.	58.2	Food frequency questionnaire; Australian National Nutrition Survey	***Nutrient level:*** Intervention group -2% energy from total fat and -1.25% to -1.57% energy from saturated fat intake, +1g/day to +1.8g/day of fiber intake at 4 month and 12 month. Control group ↓ total fat and saturated fat intake only at 12 month. ***Behaviour level:*** Intervention group ↑ 1 serving of daily vegetable intake and 0.5 serving of daily fruit intake at 4 month and 12 month. Control group ↑0.76 serving of vegetable intake only at 4 month; ↑ 0.2 serving of daily fruit intake at 4 month and 12 month.
Koelewijn-van Loon et al., 2009; Netherlands	CVD prevention	304 INT 285 CON	Cluster RCT Intervention group received 2 individual face-to-face meetings (15-20mins) with a practice nurse and had 10-min telephone consultation for follow-up.	57	The Dutch Fat List for saturated fat 10-item food frequency questionnaire for fruit and vegetable intake	***Behaviour level:*** Intervention group had more ↓ fat score at 1 year compared to control group (-2.2 vs. -1.8) More % participants in intervention group met the national recommended level of vegetable intake at 1 year, compared to

Author; Country/ Region	Focus	Sample size	Study design/ Intervention method	Mean age	Dietary assessment	One-year dietary changes (significant results only)
			Control group received usual care.			control.
Clark et al., 2004; UK	T2DM management	100 in total	RCT Intervention group received one 30min individual face-to-face counselling and then had follow-up telephone calls at 1 week, 3 weeks, and 7 weeks, each lasting for 10mins. At 12 weeks and 24 weeks, intervention group had individual meeting with interventionist again to review the progress. Control group received usual care.	59.5	Food Habits Questionnaire; Block fat screener	***Behaviour level:*** Both groups improved in "substituting low-fat foods" at 3 months and maintained improvement at 12 months. Intervention group had greater improvement than control. Intervention group ↓ fat eating at 3 months and 12 months.
Garcia-Huidobro et al., 2011; Chile	T2DM management	83 INT 76 CON-1 84 CON-2	Controlled clinical trial Intervention group received two family meetings or home visits with intervention providers, one by him/herself and one with family members, and received a recipe book during meeting.	55	Self-reported consumption of bread, use of sugar, and fruit or vegetable intake	***Behaviour level:*** No significant differences among groups.

Author; Country/ Region	Focus	Sample size	Study design/ Intervention method	Mean age	Dietary assessment	One-year dietary changes (significant results only)
			Patients and relatives were also encouraged to attend multifamily group sessions. Control group received usual care.			
Jackson et al., 2007; UK	Weight management	89 (27 M, 62 F)	One group pre and post Individual face-to-face counselling with specialist health visitor. First appointment took 1 hour and then each subsequent session took 10-30mins, happened at two weekly intervals for 12 months. The focus of intervention was weight loss; participants were given tips on portion control, vegetable & fruit intake and water consumption.	58.3	Self-reported weekly cake, dessert and snack intake and weekly fruit and vegetable intake	***Behaviour level:*** Average increase of 5 portions/week of fruit and vegetable intake at week 13, 27, and 52. ↓ 5 portions/week of cake, dessert and snack intake only at week 13.
Sacerdote et al., 2006; Italy	promoting healthy diet (obesity prevention and	1592 INT 1587 CON	RCT Both groups visited GP three times during the one year. Intervention group received	44.5 (INT) 44.1 (CON)	40-items food frequency questionnaire	***Behaviour level:*** Intervention group had more ↑ fruit and vegetable intake at 1 year, compared to control group (+2.9 servings vs. +1.6 servings). Intervention group also had higher

Author; Country/ Region	Focus	Sample size	Study design/ Intervention method	Mean age	Dietary assessment	One-year dietary changes (significant results only)
	hypertension prevention)		15-min individual face-to-face counselling with GP during first visit. The intervention focused on diet high in fruits, vegetables, fish, and olive oil and low in red meat, snack, and sweets.			proportion of participants consuming olive oil compared to control group.
Wood et al., 2008; Denmark, Italy, Poland, Spain, Netherlands, & UK	CVD prevention	1189 INT 1128 CON	RCT Intervention group received weekly group workshops, delivered by study nurse, with their family members. Control group received usual care.	62 (INT) 62.8 (CON)	Food-habit questionnaire	***Behaviour level:*** More % participants in intervention group achieved fruit and vegetable intake goals, compared to control group (50% vs. 35%).

Table A2.1 Points to calculate Canadian HEI based on number of Food Guide Servings (Adequacy) and % of Energy or Mg Sodium (Moderation), for males aged 19-50.

	Point range	Number of Food Guide Servings										
		0	**0.5**	**1**	**1.5**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Adequacy												
Total Vegetables and Fruit	0 to 10	0		1.25		2.5	3.75	5	6.25	7.5	8.75	10
Whole Fruit	0 to 5	0	1.25	2.5	3.75	5						
Dark Green & Orange Vegetables	0 to 5	0	1.25	2.5	3.75	5						
Total Grains	0 to 5	0		0.625		1.25	1.875	2.5	3.13	3.75	4.375	5
Whole Grains	0 to 5	0		1.25		2.5	3.75	5				
Milk & Alternatives	0 to 10	0	2.5	5	7.5	10						
Meat & Alternatives	0 to 10	0	1.67	3.33	5	6.67	10					
Unsaturated Fats (15ml = 1 svg)	0 to 10	0	1.67	3.33	5	6.67	10					
Moderation												
Saturated Fats (% of energy)		**≥15%**	**14%**	**13%**	**12%**	**11%**	**10%**	**8 or 9%**	**7%**			
	0 to 10	0	1.6	3.2	4.8	6.4	8	9	10			
Sodium (mg)		**4600**	**4300**	**4000**	**3700**	**3400**	**3100**	**2800**	**2300**	**1500-2300**	**1500**	
	0 to 10	0	1.04	2.09	3.13	4.17	5.21	6.26	8	9	10	
Other Foods (% of total energy)		**≥40%**	**35%**	**30%**	**25%**	**20%**	**15%**	**10%**	**5%**			
	0 to 20	0	2.86	5.71	8.57	11.42	14.29	17.14	20			

Table A2.2 Points to calculate Canadian HEI based on number of Food Guide Servings (Adequacy) and % of Energy or Mg Sodium (Moderation), for females aged 19-50.

	Point range	Number of Food Guide Servings									
		0	**0.5**	**1**	**1.5**	**2**	**3**	**4**	**5**	**6**	**7**
Adequacy											
Total Vegetables and Fruit	0 to 10	0		1.4		2.8	4.2	5.6	7	8.4	10
Whole Fruit	0 to 5	0	1.67	3.34	5						
Dark Green & Orange Vegetables	0 to 5	0	1.67	3.34	5						
Total Grains	0 to 5	0		0.83		1.66	2.5	3.32	4.15	5	
Whole Grains	0 to 5	0		1.67		3.34	5				
Milk & Alternatives	0 to 10	0	2.5	5	7.5	10					
Meat & Alternatives	0 to 10	0	2.5	5	7.5	10					
Unsaturated Fats (15ml = 1 svg)	0 to 10	0	2.5	5	7.5	10					
Moderation											
Saturated Fats (% of energy)		**≥15%**	**14%**	**13%**	**12%**	**11%**	**10%**	**8 or 9%**	**7%**		
	0 to 10	0	1.6	3.2	4.8	6.4	8	9	10		
Sodium (mg)		**4600**	**4300**	**4000**	**3700**	**3400**	**3100**	**2800**	**2300**	**1500-2300**	**1500**
	0 to 10	0	1.04	2.09	3.13	4.17	5.21	6.26	8	9	10
Other Foods (% of total energy)		**≥40%**	**35%**	**30%**	**25%**	**20%**	**15%**	**10%**	**5%**		
	0 to 20	0	2.86	5.71	8.57	11.42	14.29	17.14	20		

Table A2.3 Points to calculate Canadian HEI based on number of Food Guide Servings (Adequacy) and % of Energy or Mg Sodium (Moderation), for males aged 51 and older.

	Point range	Number of Food Guide Servings											
		0	**0.5**	**1**	**1.5**	**2**	**2.5**	**3**	**3.5**	**4**	**5**	**6**	**7**
Adequacy													
Total Vegetables and Fruit	0 to 10	0		1.4		2.8		4.2		5.6	7	8.4	10
Whole Fruit	0 to 5	0	1.67	3.34	5								
Dark Green & Orange Vegetables	0 to 5	0	1.67	3.34	5								
Total Grains	0 to 5	0		0.71		1.4		2.13		2.8	3.55	4.26	5
Whole Grains	0 to 5	0	0.7	1.4	2.1	2.8	3.5	4.2	5				
Milk & Alternatives	0 to 10	0	1.67	3.33	5	6.67	8.3	10					
Meat & Alternatives	0 to 10	0	1.67	3.33	5	6.67	8.3	10					
Unsaturated Fats (15ml = 1 svg)	0 to 10	0	1.67	3.33	5	6.67	8.3	10					
Moderation													
Saturated Fats (% of energy)		**≥15%**	**14%**	**13%**	**12%**	**11%**	**10%**	**8 or 9%**	**7%**				
	0 to 10	0	1.6	3.2	4.8	6.4	8	9	10				
Sodium (mg)		**4600**	**4300**	**4000**	**3700**	**3400**	**3100**	**2800**	**2300**	**1500-2300**	**1500**		
	0 to 10	0	1.04	2.09	3.13	4.17	5.21	6.26	8	9	10		
Other Foods (% of total energy)		**≥40%**	**35%**	**30%**	**25%**	**20%**	**15%**	**10%**	**5%**				
	0 to 20	0	2.86	5.71	8.57	11.42	14.29	17.14	20				

Table A2.4 Points to calculate Canadian HEI based on number of Food Guide Servings (Adequacy) and % of Energy or Mg Sodium (Moderation), for males aged 51 and older.

	Point range	Number of Food Guide Servings									
		0	**0.5**	**1**	**1.5**	**2**	**3**	**4**	**5**	**6**	**7**
Adequacy											
Total Vegetables and Fruit	0 to 10	0		1.4		2.8	4.2	5.6	7	8.4	10
Whole Fruit	0 to 5	0	1.67	3.34	5						
Dark Green & Orange Vegetables	0 to 5	0	1.67	3.34	5						
Total Grains	0 to 5	0		0.83		1.66	2.5	3.32	4.15	5	
Whole Grains	0 to 5	0		1.67		3.34	5				
Milk & Alternatives	0 to 10	0	1.67	3.33	5	6.67	10				
Meat & Alternatives	0 to 10	0	2.5	5	7.5	10					
Unsaturated Fats (15ml = 1 svg)	0 to 10	0	2.5	5	7.5	10					
Moderation											
Saturated Fats (% of energy)		**≥15%**	**14%**	**13%**	**12%**	**11%**	**10%**	**8 or 9%**	**7%**		
	0 to 10	0	1.6	3.2	4.8	6.4	8	9	10		
Sodium (mg)		**4600**	**4300**	**4000**	**3700**	**3400**	**3100**	**2800**	**2300**	**1500-2300**	**1500**
	0 to 10	0	1.04	2.09	3.13	4.17	5.21	6.26	8	9	10
Other Foods (% of total energy)		**≥40%**	**35%**	**30%**	**25%**	**20%**	**15%**	**10%**	**5%**		
	0 to 20	0	2.86	5.71	8.57	11.42	14.29	17.14	20		

Table A3 Normality tests of HEI-C components and MDS total score using skewness, kurtosis, Kolomogorov-Smirnov and Shapiro-Wilk tests.

Component		Skewness	SE	z-value	Kurtosis	SE	z-value	KS (p)	SW (p)
Total Vegetables and Fruit (HEI-C)	Baseline	-0.381	0.169	-2.25	-0.697	0.336	-2.07	0.127 (<0.001)	0.932 (<0.001)
	3 months	-0.727	0.169	-4.30	-0.583	0.336	-1.74	0.245 (<0.001)	0.842 (<0.001)
	12 months	-1.153	0.169	-6.82	0.748	0.336	2.23	0.208 (<0.001)	0.831 (<0.001)
	0-3 months Change	0.248	0.169	1.47	0.313	0.336	0.93	0.154 (<0.001)	0.968 (<0.001)
	3-12 months Change	-0.335	0.169	-1.98	0.702	0.336	2.09	0.184 (<0.001)	0.962 (<0.001)
	0-12 months Change	-0.290	0.169	-1.72	0.368	0.336	1.10	0.154 (<0.001)	0.972 (<0.001)
Whole Fruit (HEI-C)	Baseline	-0.965	0.169	-5.71	-0.596	0.336	-1.77	0.341 (<0.001)	0.723 (<0.001)
	3 months	-2.016	0.169	-11.9	3.229	0.336	9.61	0.429 (<0.001)	0.577 (<0.001)
	12 months	-1.830	0.169	-10.8	2.077	0.336	6.18	0.443 (<0.001)	0.571 (<0.001)
	0-3 months Change	0.571	0.169	3.38	0.756	0.336	2.25	0.304 (<0.001)	0.858 (<0.001)
	3-12 months Change	-0.591	0.169	-3.50	2.554	0.336	7.60	0.348 (<0.001)	0.789 (<0.001)
	0-12 months Change	0.178	0.169	1.05	1.032	0.336	3.07	0.287 (<0.001)	0.848 (<0.001)
Dark Green and Orange Vegetables (HEI-C)	Baseline	-0.162	0.169	-0.96	-1.561	0.336	-4.65	0.213 (<0.001)	0.818 (<0.001)
	3 months	-0.953	0.169	-5.64	-0.335	0.336	-1.00	0.321 (<0.001)	0.761 (<0.001)
	12 months	-0.923	0.169	-5.46	-0.497	0.336	-1.48	0.324 (<0.001)	0.757 (<0.001)
	0-3 months Change	0.114	0.169	0.68	-0.188	0.336	-0.56	0.233 (<0.001)	0.917 (<0.001)
	3-12 months Change	-0.378	0.169	-2.24	0.637	0.336	1.90	0.271 (<0.001)	0.899 (<0.001)
	0-12 months Change	-0.050	0.169	-0.30	-0.189	0.336	-0.56	0.196 (<0.001)	0.928 (<0.001)
Total Grains (HEI-C)	Baseline	-0.332	0.169	-1.96	-0.734	0.336	-2.18	0.135 (<0.001)	0.933 (<0.001)
	3 months	-0.119	0.169	-0.70	-0.693	0.336	-2.06	0.094 (<0.001)	0.958 (<0.001)
	12 months	-0.069	0.169	-0.41	-1.018	0.336	-3.03	0.133 (<0.001)	0.949 (<0.001)
	0-3 months Change	-0.090	0.169	-0.53	0.116	0.336	0.34	0.124 (<0.001)	0.986 (0.042)

Component		Skewness	SE	z-value	Kurtosis	SE	z-value	KS (p)	SW (p)
	3-12 months Change	0.002	0.169	0.01	-0.147	0.336	-0.44	0.123 (<0.001)	0.982 (.011)
	0-12 months Change	-0.033	0.169	-0.20	0.066	0.336	0.20	0.107 (<0.001)	0.988 (.079)
Whole Grains (HEI-C)	Baseline	-0.157	0.169	-0.93	-1.445	0.336	-4.30	0.169 (<0.001)	0.858 (<0.001)
	3 months	-0.543	0.169	-3.21	-0.875	0.336	-2.60	0.190 (<0.001)	0.870 (<0.001)
	12 months	-0.508	0.169	-3.01	-0.937	0.336	-2.79	0.206 (<0.001)	0.866 (<0.001)
	0-3 months Change	0.144	0.169	0.85	-0.183	0.336	-0.54	0.173 (<0.001)	0.961 (<0.001)
	3-12 months Change	-0.074	0.169	-0.44	0.743	0.336	2.21	0.206 (<0.001)	0.949 (<0.001)
	0-12 months Change	0.159	0.169	0.94	-0.078	0.336	-0.23	0.183 (<0.001)	0.959 (<0.001)
Milk and Alternatives (HEI-C)	Baseline	0.344	0.169	2.04	-1.007	0.336	-3.00	0.184 (<0.001)	0.913 (<0.001)
	3 months	0.018	0.169	0.11	-1.097	0.336	-3.26	0.144 (<0.001)	0.921 (<0.001)
	12 months	0.116	0.169	0.69	-0.809	0.336	-2.41	0.118 (<0.001)	0.941 (<0.001)
	0-3 months Change	0.211	0.169	1.25	0.027	0.336	0.08	0.173 (<0.001)	0.971 (<0.001)
	3-12 months Change	-0.300	0.169	-1.78	0.595	0.336	1.77	0.128 (<0.001)	0.967 (<0.001)
	0-12 months Change	-0.055	0.169	-0.33	-0.003	0.336	-0.01	0.134 (<0.001)	0.978 (0.002)
Meat and Alternatives (HEI-C)	Baseline	-0.986	0.169	-5.83	0.012	0.336	0.04	0.303 (<0.001)	0.795 (<0.001)
	3 months	-1.621	0.169	-9.59	2.186	0.336	6.51	0.338 (<0.001)	0.711 (<0.001)
	12 months	-1.768	0.169	-10.5	2.760	0.336	8.21	0.399 (<0.001)	0.650 (<0.001)
	0-3 months Change	-0.321	0.169	-1.90	1.824	0.336	5.43	0.238 (<0.001)	0.916 (<0.001)
	3-12 months Change	0.285	0.169	1.69	2.134	0.336	6.35	0.250 (<0.001)	0.899 (<0.001)
	0-12 months Change	0.048	0.169	0.28	1.367	0.336	4.07	0.234 (<0.001)	0.927 (<0.001)
Unsaturated Fats (HEI-C)	Baseline	0.781	0.169	4.62	-0.538	0.336	-1.60	0.175 (<0.001)	0.849 (<0.001)
	3 months	0.899	0.169	5.32	-0.020	0.336	-0.06	0.157 (<0.001)	0.861 (<0.001)
	12 months	0.955	0.169	5.65	-0.010	0.336	-0.03	0.196 (<0.001)	0.841 (<0.001)
	0-3 months Change	0.071	0.169	0.42	0.905	0.336	2.69	0.165 (<0.001)	0.959 (<0.001)

Component		Skewness	SE	z-value	Kurtosis	SE	z-value	KS (p)	SW (p)
	3-12 months Change	0.035	0.169	0.21	0.797	0.336	2.37	0.166 (<0.001)	0.960 (<0.001)
	0-12 months Change	0.218	0.169	1.29	0.308	0.336	0.62	0.162 (<0.001)	0.962 (<0.001)
Saturated Fats (HEI-C)	Baseline	-0.405	0.169	-2.40	-1.226	0.336	-3.65	0.139 (<0.001)	0.892 (<0.001)
	3 months	-1.115	0.169	-6.60	0.176	0.336	0.52	0.249 (<0.001)	0.822 (<0.001)
	12 months	-1.192	0.169	-7.05	0.358	0.336	1.07	0.243 (<0.001)	0.796 (<0.001)
	0-3 months Change	-0.161	0.169	-0.95	-0.181	0.336	-0.54	0.071 (0.012)	0.983 (0.012)
	3-12 months Change	0.078	0.169	0.46	0.251	0.336	0.75	0.145 (<0.001)	0.972 (<0.001)
	0-12 months Change	0.179	0.169	1.06	-0.346	0.336	-1.03	0.118 (<0.001)	0.978 (0.003)
Sodium (HEI-C)	Baseline	-0.881	0.169	-5.21	-0.414	0.336	-1.23	0.235 (<0.001)	0.847 (<0.001)
	3 months	-1.485	0.169	-8.79	1.685	0.336	5.01	0.340 (<0.001)	0.784 (<0.001)
	12 months	-1.636	0.169	-9.68	2.144	0.336	6.38	0.336 (<0.001)	0.761 (<0.001)
	0-3 months Change	0.619	0.169	3.66	0.913	0.336	2.72	0.163 (<0.001)	0.923 (<0.001)
	3-12 months Change	-0.384	0.169	-2.27	1.860	0.336	5.54	0.172 (<0.001)	0.937 (<0.001)
	0-12 months Change	0.503	0.169	2.98	0.499	0.336	1.49	0.144 (<0.001)	0.948 (<0.001)
Other Foods (HEI-C)	Baseline	-0.261	0.169	-1.54	-1.088	0.336	-3.24	0.133 (<0.001)	0.925 (<0.001)
	3 months	-0.813	0.169	-4.81	-0.194	0.336	-0.58	0.203 (<0.001)	0.874 (<0.001)
	12 months	-0.973	0.169	-5.76	0.149	0.336	0.44	0.194 (<0.001)	0.859 (<0.001)
	0-3 months Change	0.208	0.169	1.23	0.281	0.336	0.84	0.156 (<0.001)	0.965 (<0.001)
	3-12 months Change	-0.139	0.169	-0.82	0.898	0.336	2.67	0.158 (<0.001)	0.962 (<0.001)
	0-12 months Change	0.291	0.169	1.72	0.558	0.336	1.66	0.148 (<0.001)	0.957 (<0.001)
HEI-C total score	Baseline	-0.199	0.169	-1.18	-0.372	0.336	-1.11	0.041 (0.200)	0.990 (0.138)
	3 months	-0.475	0.169	-2.81	-0.154	0.336	-0.46	0.066 (0.027)	0.977 (0.002)
	12 months	-0.681	0.169	-4.03	0.142	0.336	0.42	0.085 (0.001)	0.963 (<0.001)
	0-3 months Change	0.383	0.169	2.27	0.143	0.336	0.43	0.061 (0.055)	0.987 (0.047)

Component		Skewness	SE	z-value	Kurtosis	SE	z-value	KS (p)	SW (p)
	3-12 months Change	-0.256	0.169	-1.51	0.117	0.336	0.35	0.042 (0.200)	0.993 (0.407)
	0-12 months Change	0.209	0.169	1.24	0.296	0.336	0.88	0.037 (0.200)	0.995 (0.760)
MDS total score	Baseline	0.273	0.202	1.35	-0.290	0.401	0.72	0.158 (<0.001)	0.957 (<0.001)
	3 months	0.146	0.202	0.72	-0.120	0.401	0.30	0.110 (<0.001)	0.972 (0.005)
	12 months	0.153	0.202	0.76	0.173	0.401	0.43	0.118 (<0.001)	0.971 (0.003)
	0-3 months Change	0.282	0.202	1.40	0.359	0.401	0.90	0.139 (<0.001)	0.970 (0.003)
	3-12 months Change	0.028	0.202	0.14	-0.008	0.401	0.02	0.130 (<0.001)	0.969 (0.002)
	0-12 months Change	0.136	0.202	0.67	-0.075	0.401	0.19	0.135 (<0.001)	0.973 (0.006)

Table A4 Additional baseline demographics of participants, displayed as no. (%).

Baseline demographics	Participants with 12 months HEI-C assessment (N=209)	Participants without 12 months HEI-C assessment (N=84)	Whole sample (N=293)	p-value*
Working status:				
Employed	118 (56.5%)	54 (64.3%)	172 (58.7%)	.606
Unemployed	10 (4.8%)	5 (6.0%)	15 (5.1%)	
Student	2 (1.0%)	0 (0%)	2 (0.7%)	
Retired	75 (35.9%)	24 (28.6%)	99 (33.8%)	
On disability	4 (1.9%)	1 (1.2%)	5 (1.7%)	
Having a spouse/partner	154 (73.7%)	56 (66.7%)	210 (71.0%)	.228
Number of children:				
0	84 (40.2%)	26 (31.0%)	110 (37.5%)	.480
1	40 (19.1%)	18 (21.4%)	58 (19.8%)	
2	55 (26.3%)	24 (28.6%)	79 (27.0%)	
3 or more	30 (14.4%)	16 (19.0%)	46 (15.7%)	
Number of other dependents:				
0	192 (91.9%)	73 (86.9%)	265 (90.4%)	.191
1 or more	17 (8.1%)	11 (13.1%)	28 (9.6%)	
Number of other non-dependents living at home:				
0	195 (93.3%)	81 (96.4%)	276 (94.2%)	.300
1 or more	14 (6.7%)	3 (3.6%)	17 (5.8%)	

*Statistical differences between participants with and without the 12-month HEI-C scores were analyzed by the Pearson's Chi-square test for categorical variables.

Table A5 Additional baseline demographics of participants based on completion of MDS data, displayed as no. (%).

Baseline Demographics	Participants with complete MDS assessment (N=144)	Participants with baseline MDS but didn't finish (N=62)	All participants (N=206)	p-value*
Working status:				
Employed	82 (56.9%)	39 (62.9%)	121 (58.7%)	.280
Unemployed	4 (2.8%)	5 (8.1%)	9 (4.4%)	
Student	1 (0.7%)	0 (0%)	1 (0.5%)	
Retired	56 (38.9%)	18 (29.0%)	74 (35.9%)	
On disability	1 (0.7%)	0 (0%)	1 (0.5%)	
Having a spouse/partner	107 (74.3%)	39 (62.9%)	146 (70.9%)	.099
Number of children:				
0	66 (45.8%)	19 (30.6%)	85 (41.3%)	.222
1	25(17.4%)	14 (22.6%)	39 (18.9%)	
2	34 (23.6%)	17 (27.4%)	51 (24.8%)	
3 or more	19 (13.2%)	12 (19.4%)	31 (15.0%)	
Number of other dependents:				
0	134 (93.1%)	55 (88.7%)	189 (91.7%)	.298
1 or more	10 (6.9%)	7 (11.3%)	17 (8.3%)	
Number of other non-dependents living at home:				
0	136 (94.4%)	59 (95.2%)	195 (94.7%)	.834
1 or more	8 (5.6%)	3 (4.8%)	11 (5.3%)	

*Statistical differences between subgroups were analyzed by the Pearson Chi-square test for categorical variables.

Table A6 Additional baseline demographics of participants separated by their HEI-C score (≤60 and >60) and PROCAM risk score (≤10% and > 10%) at baseline (N=204), displayed as no. (%).

Baseline demographics	**Low HEI, High PROCAM (N=34)**	**Low HEI, Low PROCAM (N=76)**	**High HEI, High PROCAM (N=39)**	**High HEI, Low PROCAM (N=55)**	**p-value ***
Working status:					
Employed	21 (61.8%)	46 (60.5%)	18 (46.2%)	30 (54.5%)	.692
Unemployed	3 (8.8%)	2 (2.6%)	2 (5.1%)	2 (3.6%)	
Student	0 (0%)	1 (1.3%)	0 (0%)	0 (0%)	
Retired	10 (29.4%)	26 (34.2%)	17 (43.6%)	22 (40.0%)	
On disability	0 (0%)	1 (1.3%)	2 (5.1%)	1 (1.8%)	
Having a spouse/partner	26 (76.5%)	54 (71.1%)	29 (74.4%)	42 (76.4%)	.893
Number of children:					
0	17 (50.0%)	24 (31.6%)	18 (46.2%)	21 (38.2%)	.408
1	5 (14.7%)	18 (23.7%)	7 (17.9%)	9 (16.4%)	
2	5 (14.7%)	21 (27.6%)	10 (25.6%)	19 (34.5%)	
3 or more	7 (20.6%)	13 (17.1%)	4 (10.3%)	6 (10.9%)	
Number of other dependents:					
0	34 (100%)	68 (89.5%)	37 (94.9%)	49 (89.1%)	.190
1 or more	0 (0%)	8 (10.5%)	2 (5.1%)	6 (10.9%)	
Number of other non-dependents living at home:					
0	31 (91.2%)	72 (94.7%)	36 (92.3%)	53 (96.4%)	.725
1 or more	3 (8.8%)	4 (5.3%)	3 (7.7%)	2 (3.6%)	

*Statistical differences between subgroups were analyzed by the Pearson Chi-square test for categorical variables.

Figure A1 Percentage of participants receiving advice on *Balanced meals, Regular meal pattern, Eating breakfast* and *Healthier choice when eating out* over the 12 months, combined with mean total HEI-C score, in participants with complete 12 months data (N=208).

Figure A2 Percentage of participants receiving advice on *Increase fruits/vegetables*, *Increase fibre* and *Decrease glycemic index* over the 12 months, combined with mean score on HEI-C components *Whole fruits* and *Dark green and orange vegetables*, in participants with complete 12 months data (N=208).

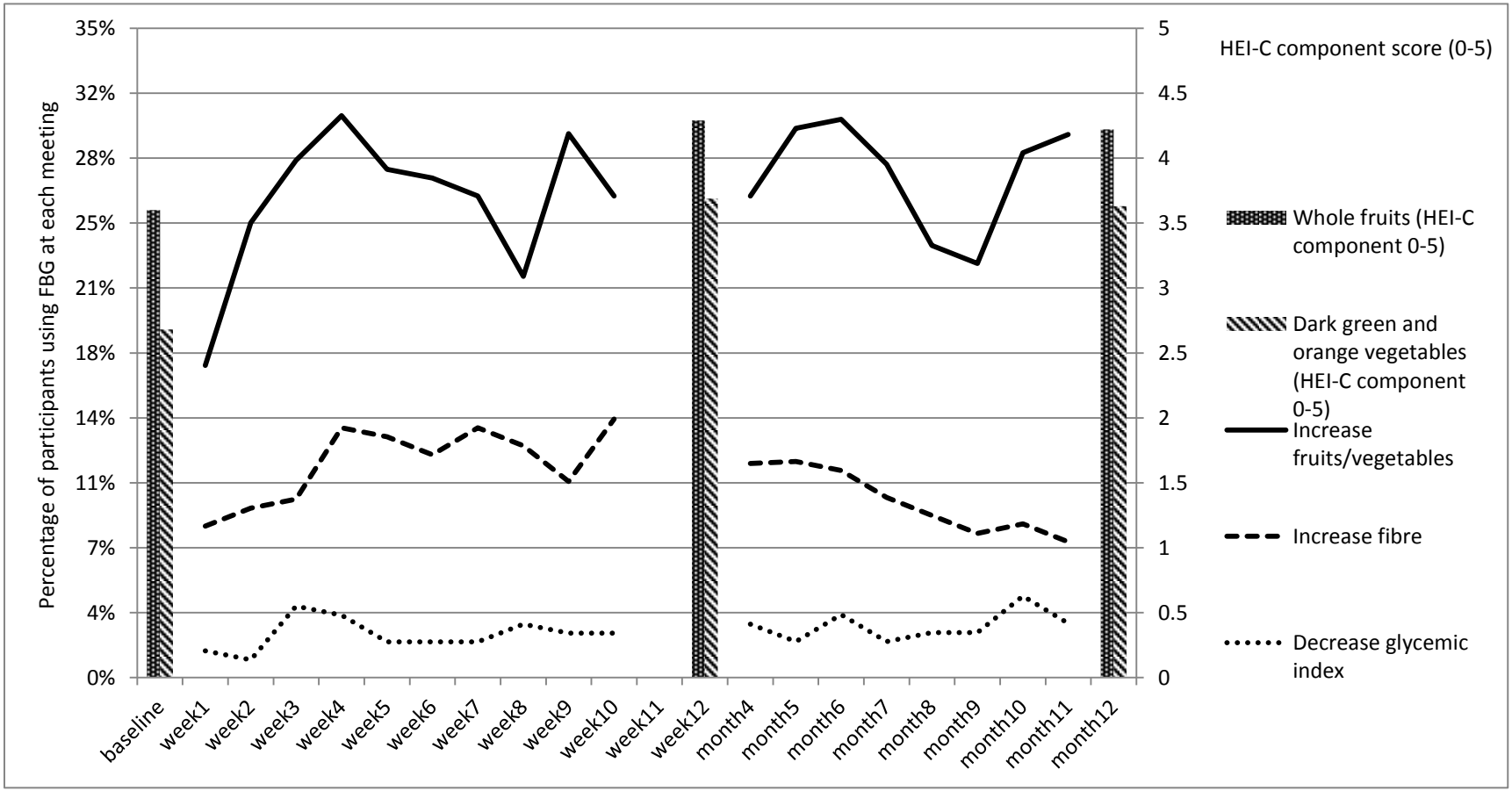


Figure A3 Percentage of participants receiving advice on *Decrease glycemic index* over the 12 months, combined with mean score on HEI-C components *Whole grains*, in participants with complete 12 months data (N=208).

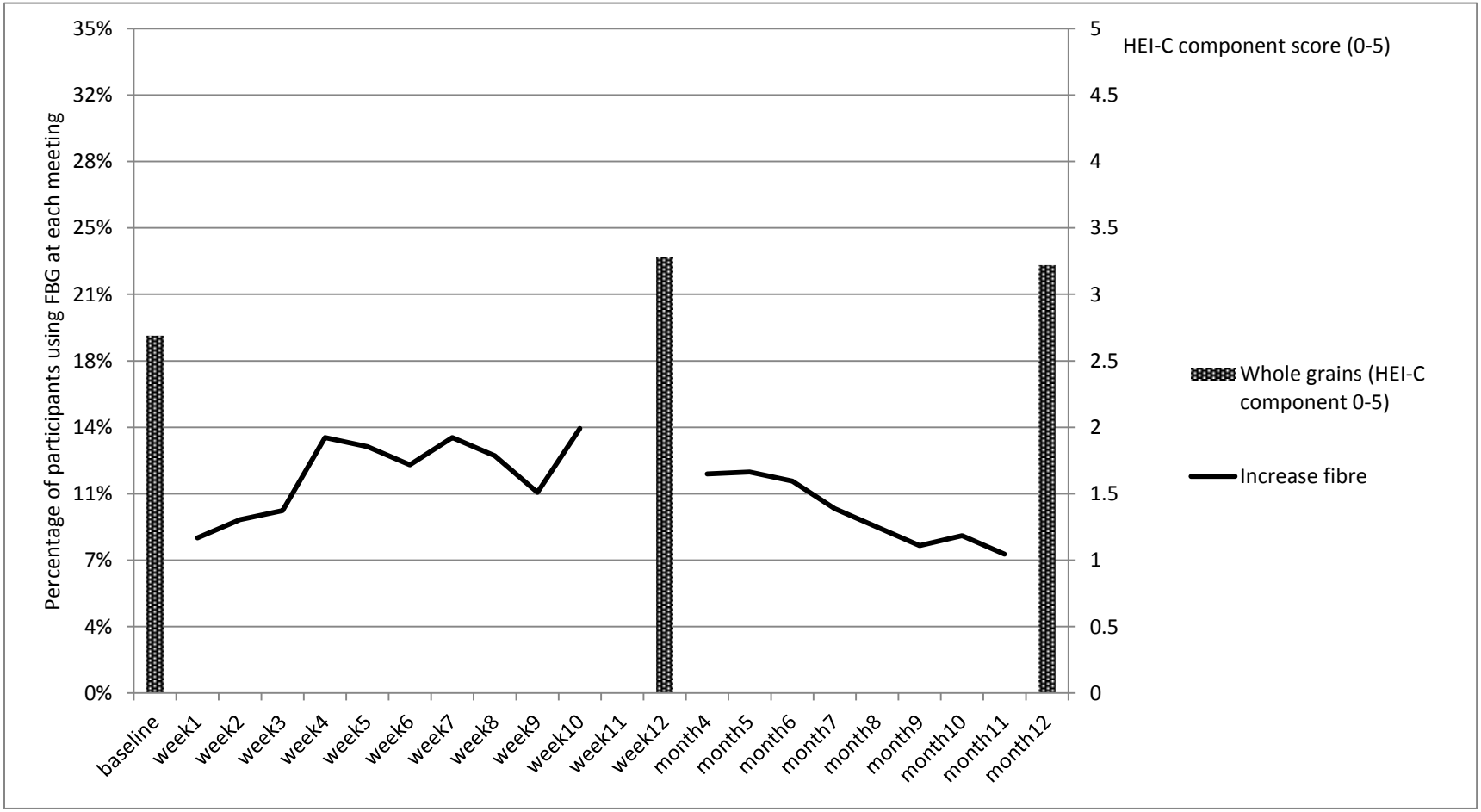


Figure A4 Percentage of participants receiving advice on *Increase fish*, *Increase nuts*, *Increase plant protein* and *Poultry more than red meat* over the 12 months, combined with mean score on HEI-C components *Meat and alternatives*, in participants with complete 12 months data (N=208).

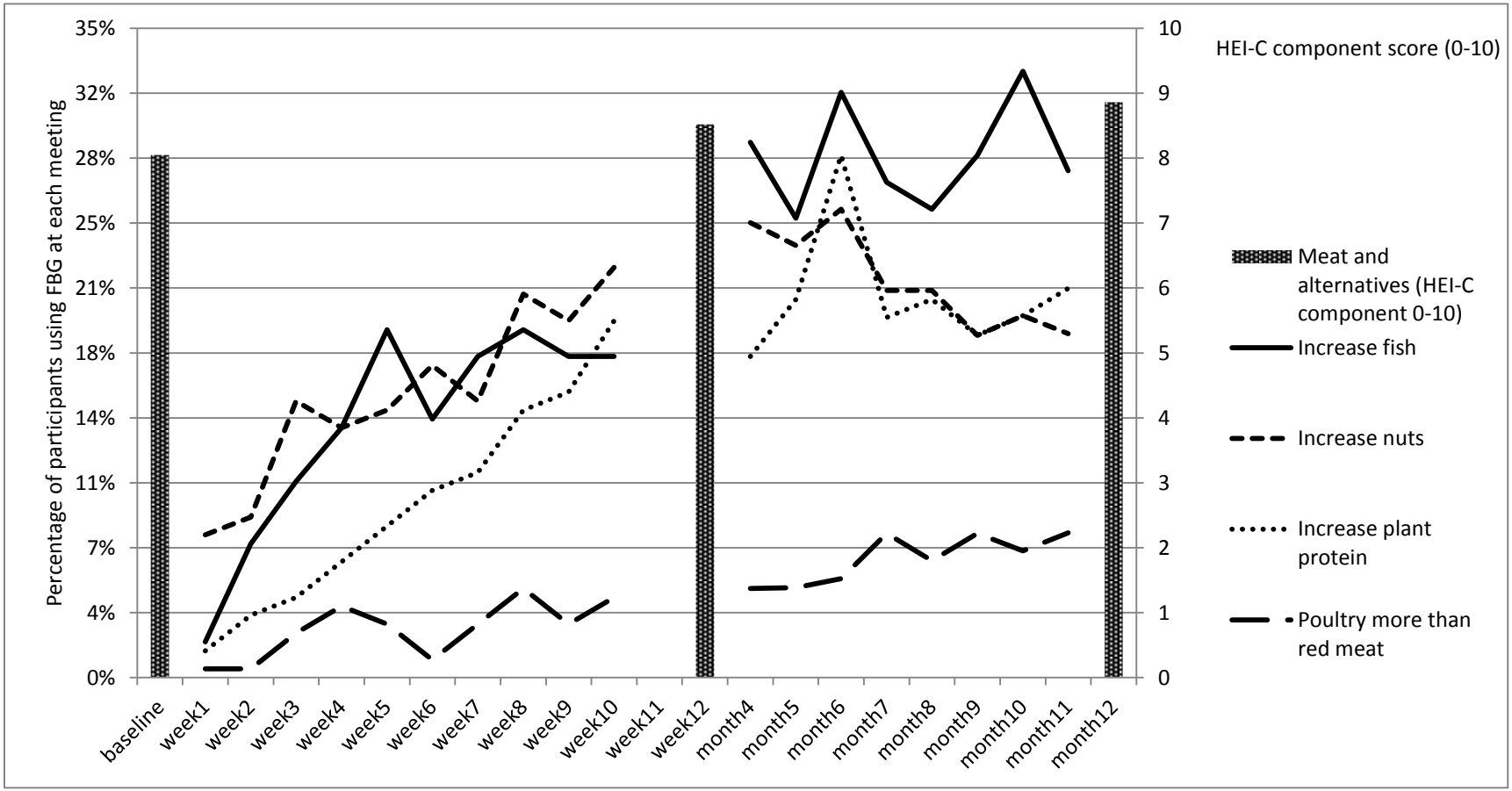


Figure A5 Percentage of participants receiving advice on *Decrease total fat*, *Choosing healthier fats*, *Healthier choice when eating out*, and *Increase olive oil* over the 12 months, combined with mean score on HEI-C components *Saturated fats* and *Unsaturated fats*, in participants with complete 12 months data (N=208).

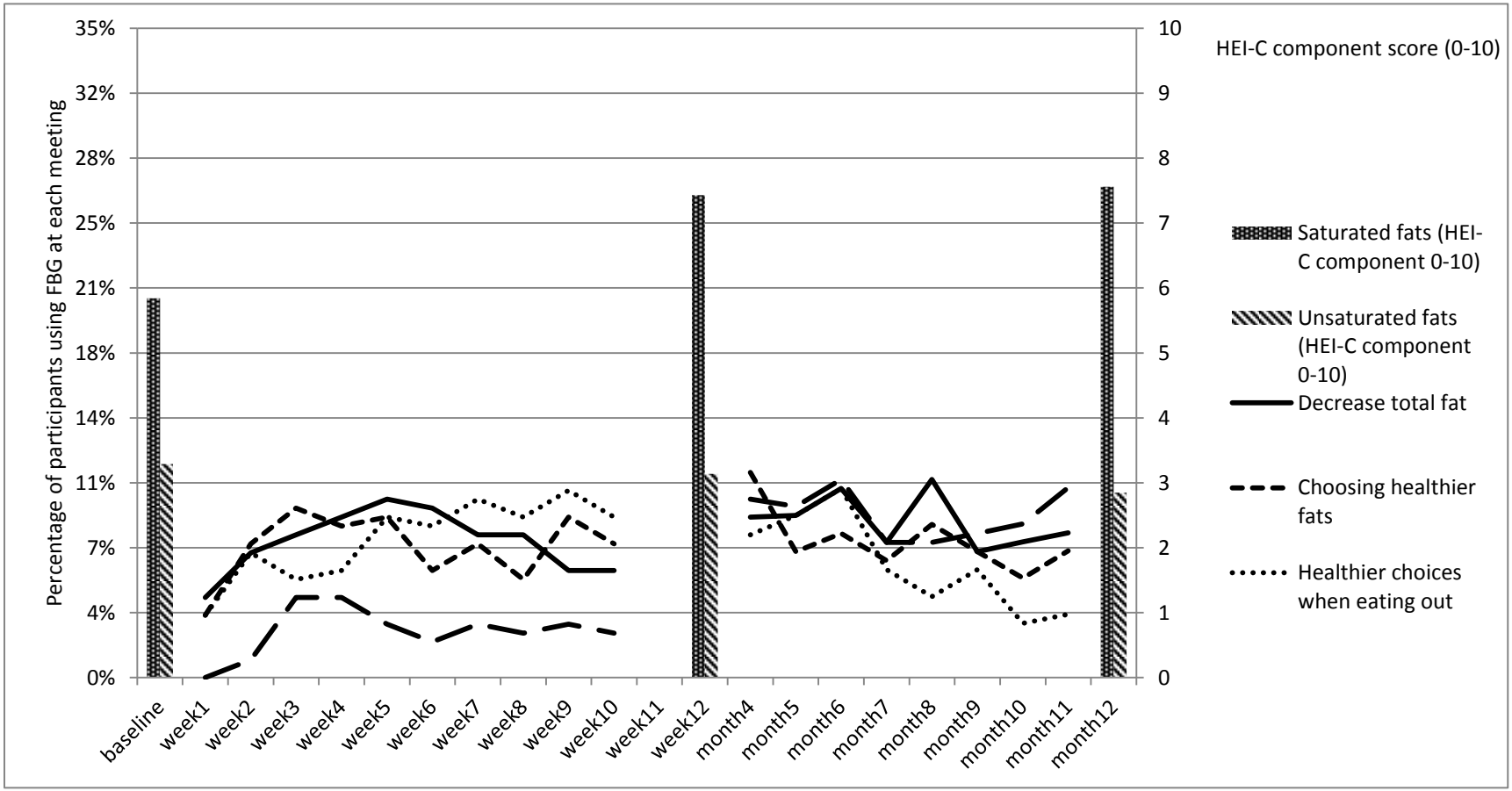


Figure A6 Percentage of participants receiving advice on *Decrease sodium* over the 12 months, combined with mean score on HEI-C component *Sodium*, in participants with complete 12 months data (N=208).

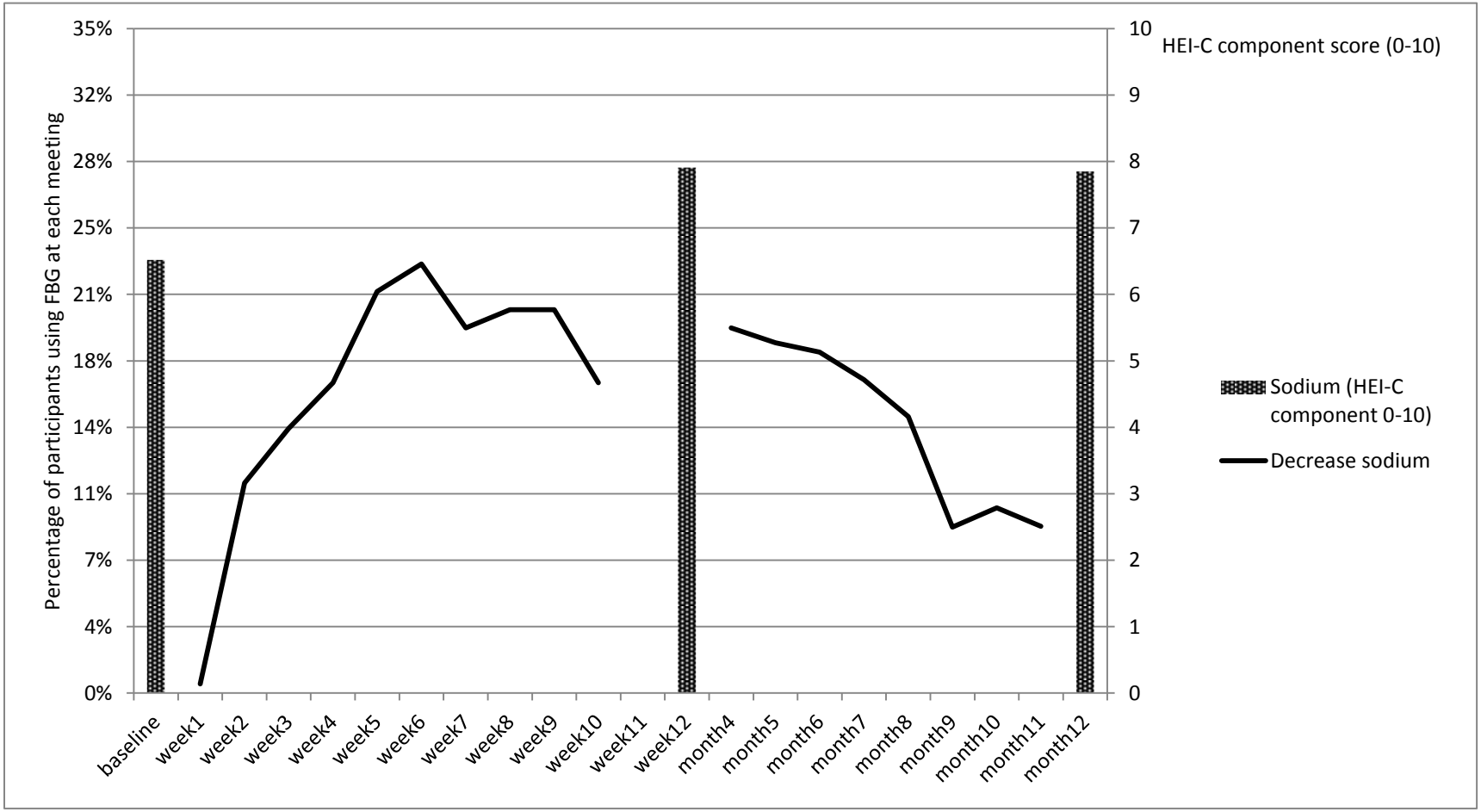


Figure A7 Percentage of participants receiving advice on *Healthier snacks* and *Decrease intake of added sugar* over the 12 months, combined with mean score on HEI-C component *Other foods*, in participants with complete 12 months data (N=208).

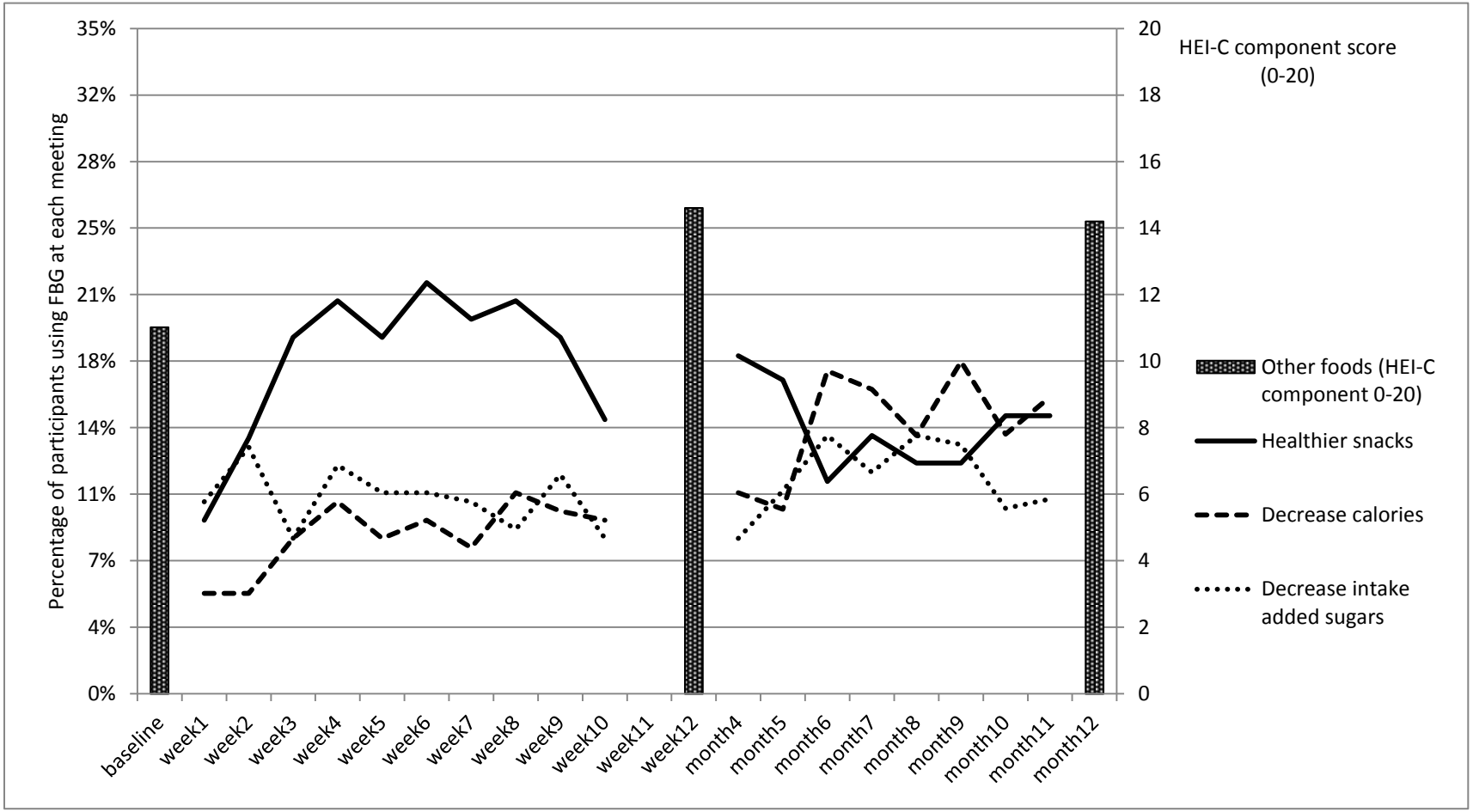


Figure A8 Percentage of participants receiving advice *Balanced meals, Regular meal pattern, Mindful eating approaches, Eating breakfast* and *Healthier choices when eating out* over the 12 months, combined with total MDS score, in participants with complete 12 months data on MDS (N=144).

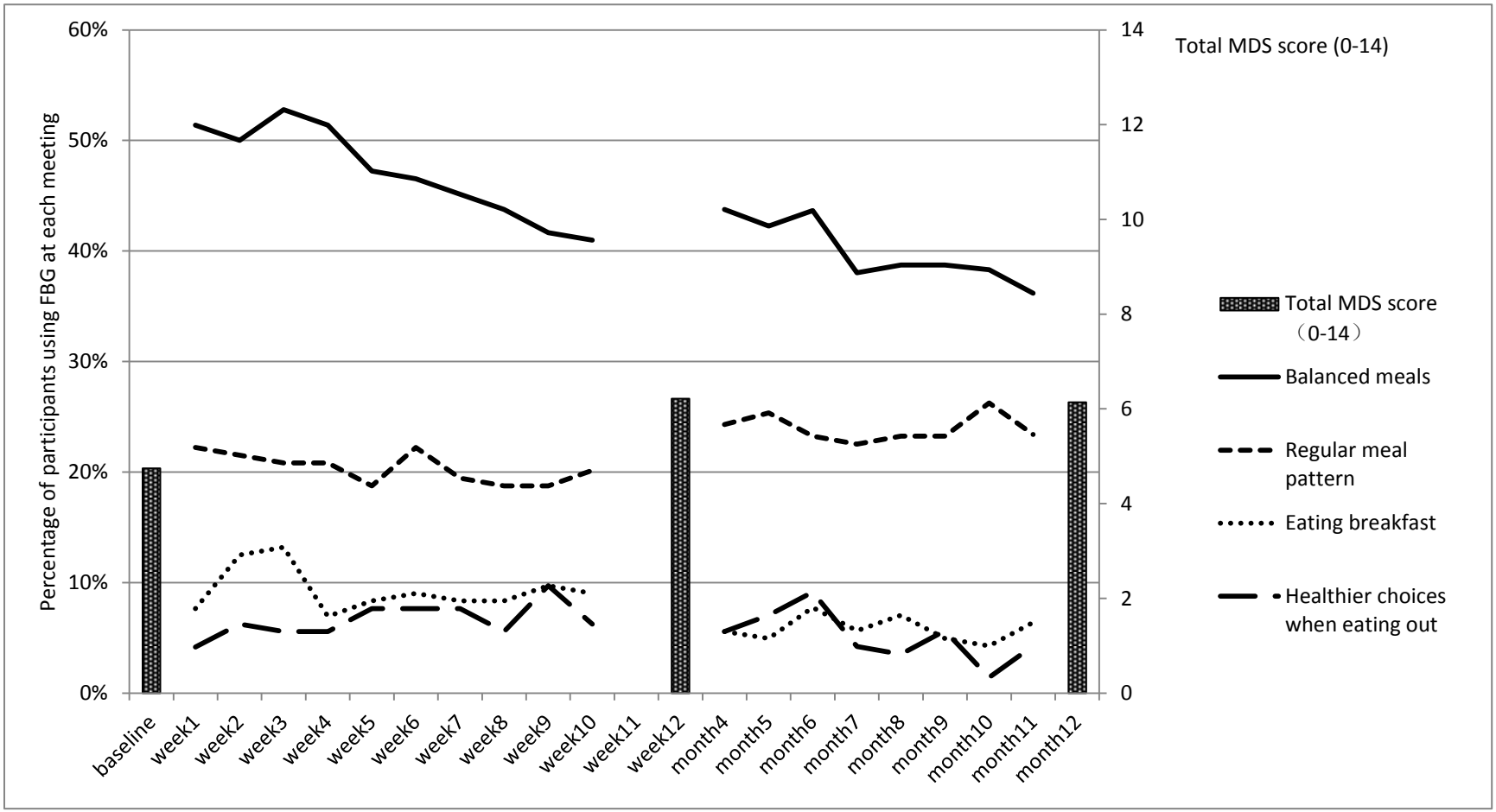


Figure A9 Percentage of participants receiving advice on *Increase fruits/vegetables*, *Increase fibre* and *Decrease glycemic index* over the 12 months, combined with percentage of participants meeting scoring criteria of 1 on Mediterranean Diet Score component *Fruits* and *Vegetables*, in participants with complete 12 months data on MDS (N=144).

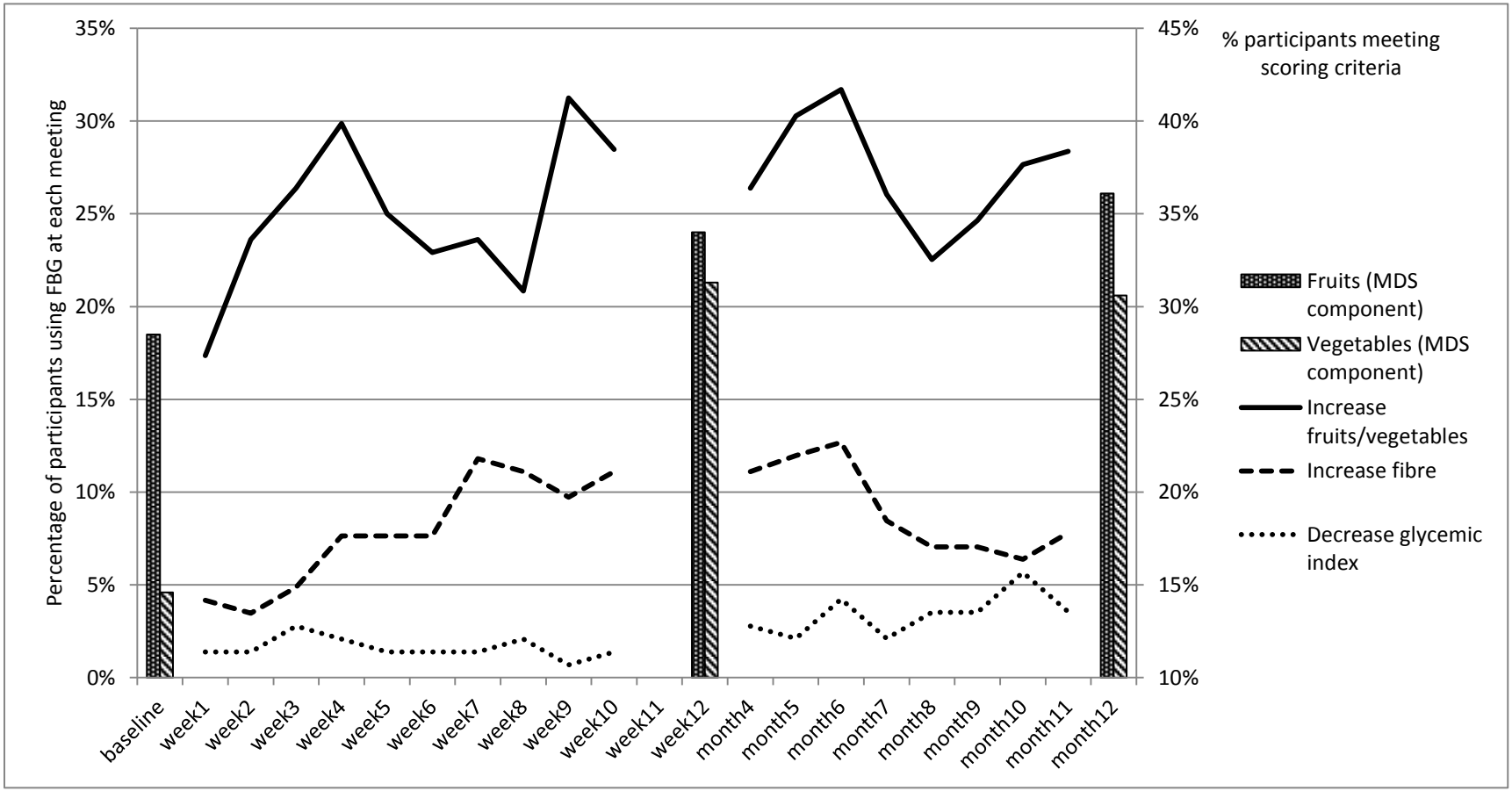


Figure A10 Percentage of participants receiving advice on *Poultry more than red meat* over the 12 months, combined with percentage of participants meeting scoring criteria of 1 on Mediterranean Diet Score component *Red or processed meats* and *Poultry more than red meat*, in participants with complete 12 months data on MDS (N=144).

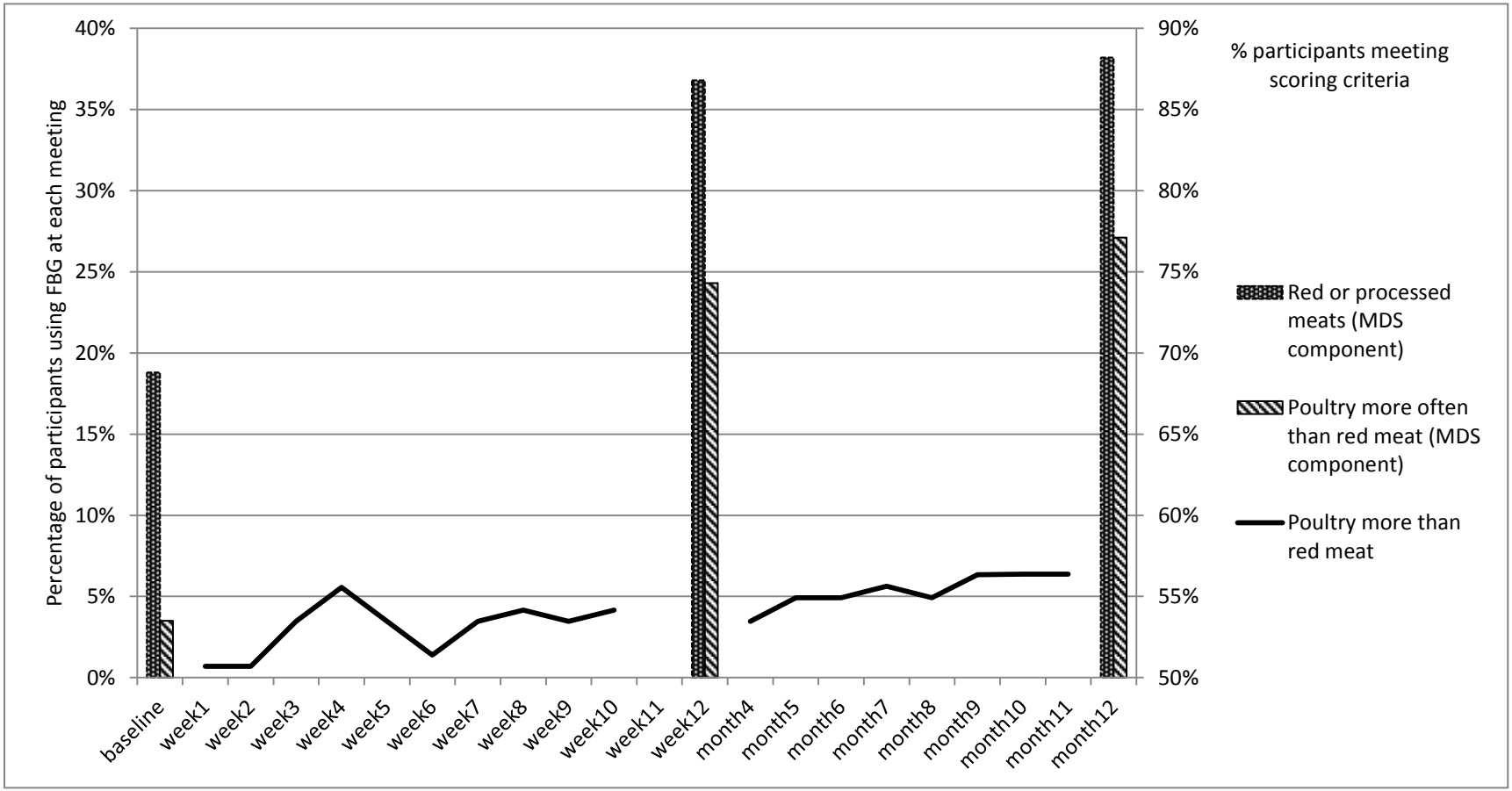


Figure A11 Percentage of participants receiving advice on *Increase nuts* and *Healthier snacks* over the 12 months, combined with percentage of participants meeting scoring criteria of 1 on Mediterranean Diet Score component *Nuts*, in participants with complete 12 months data on MDS (N=144).

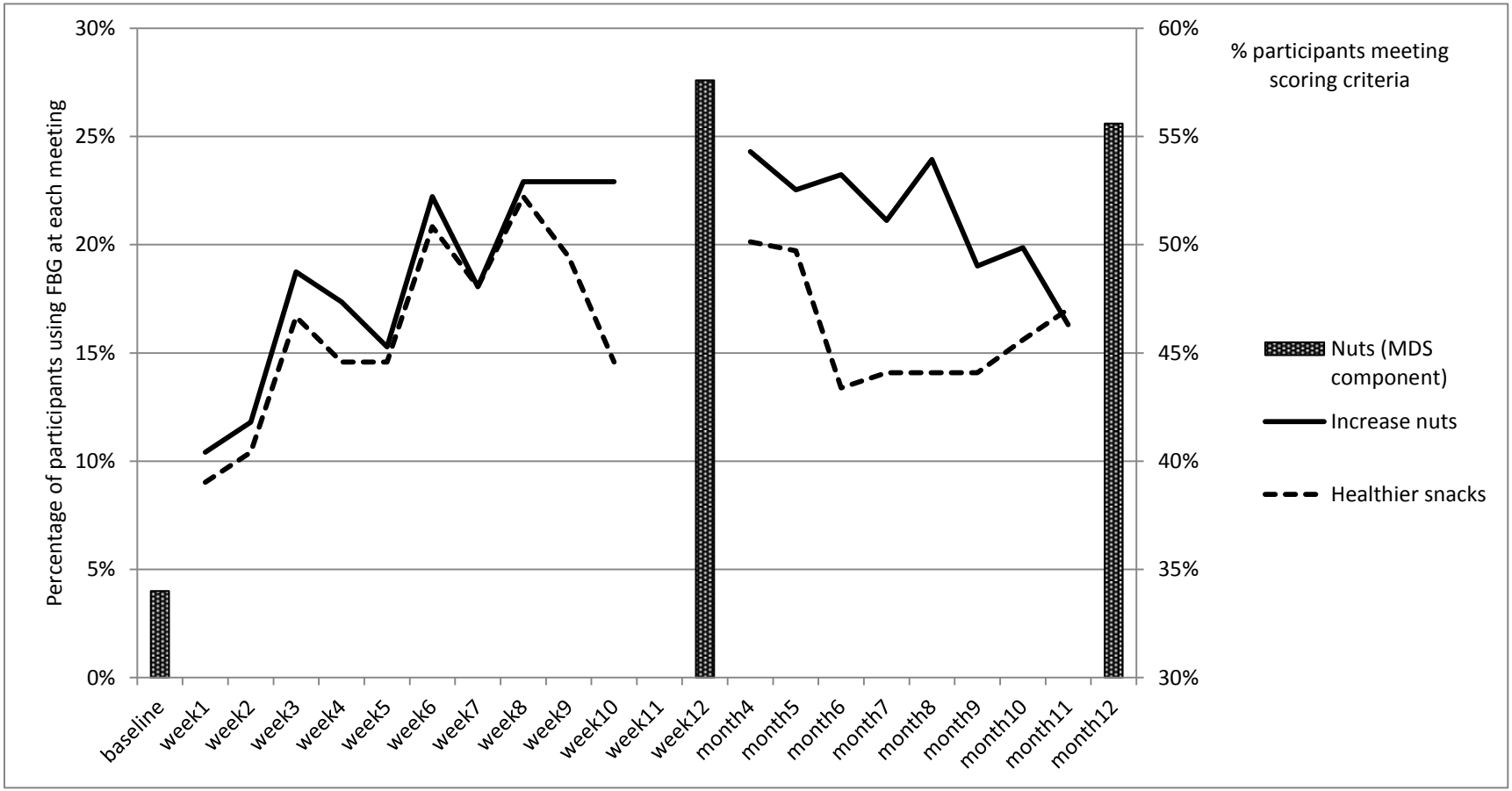


Figure A12.1 Percentage of participants receiving advice on *Decrease total fat*, *Healthier choice when eating out*, *Choosing healthier fats* and *Increase olive oil* over the 12 months, combined with percentage of participants meeting scoring criteria of 1 on Mediterranean Diet Score component *Butter or cream*, in participants with complete 12 months data on MDS (N=144).

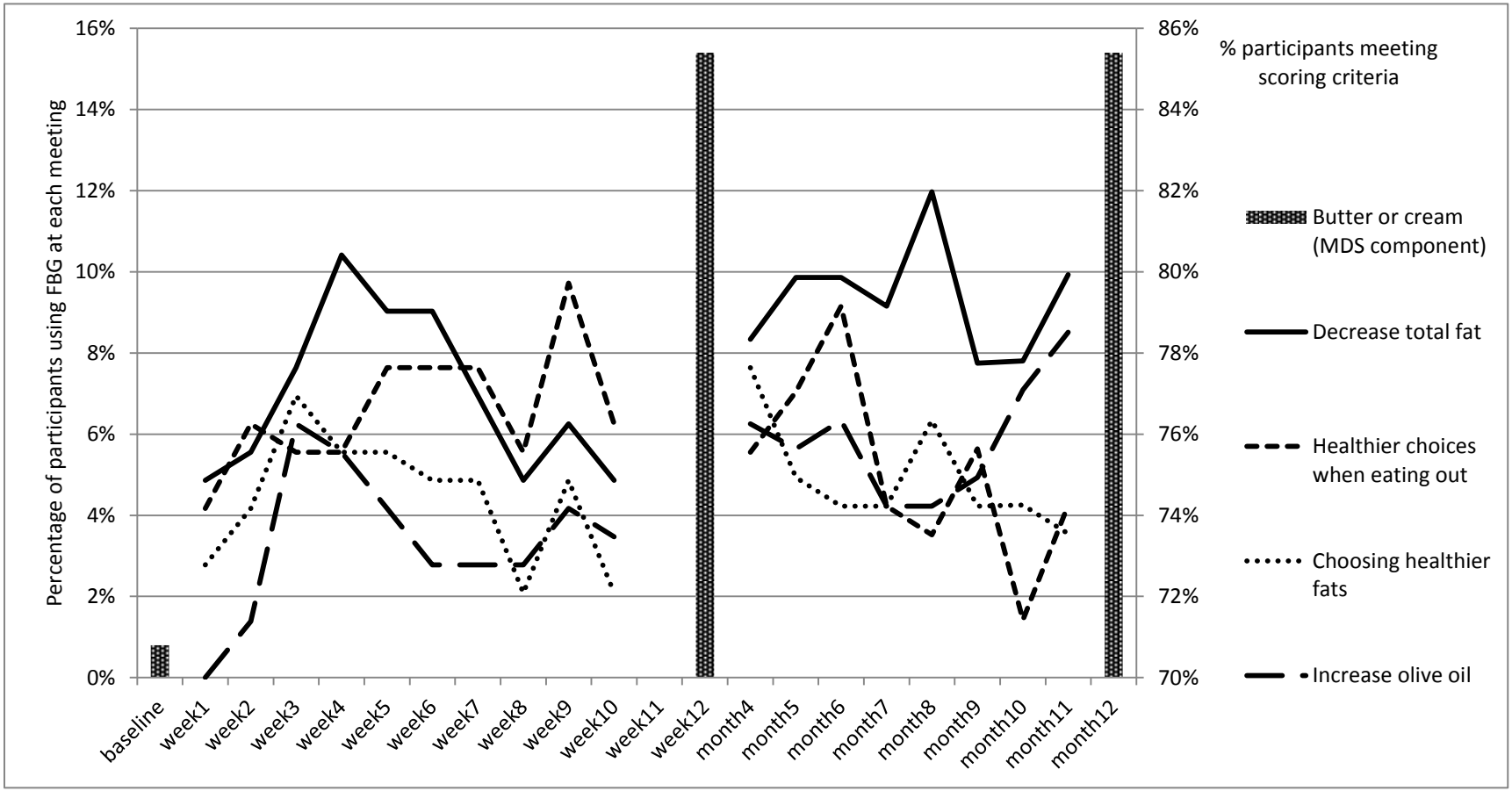


Figure A12.2 Percentage of participants receiving advice on *Decrease total fat*, *Healthier choice when eating out*, *Choosing healthier fats* and *Increase olive oil* over the 12 months, combined with percentage of participants meeting scoring criteria of 1 on Mediterranean Diet Score component *Olive oil as main fat* and *Olive oil*, in participants with complete 12 months data on MDS (N=144).

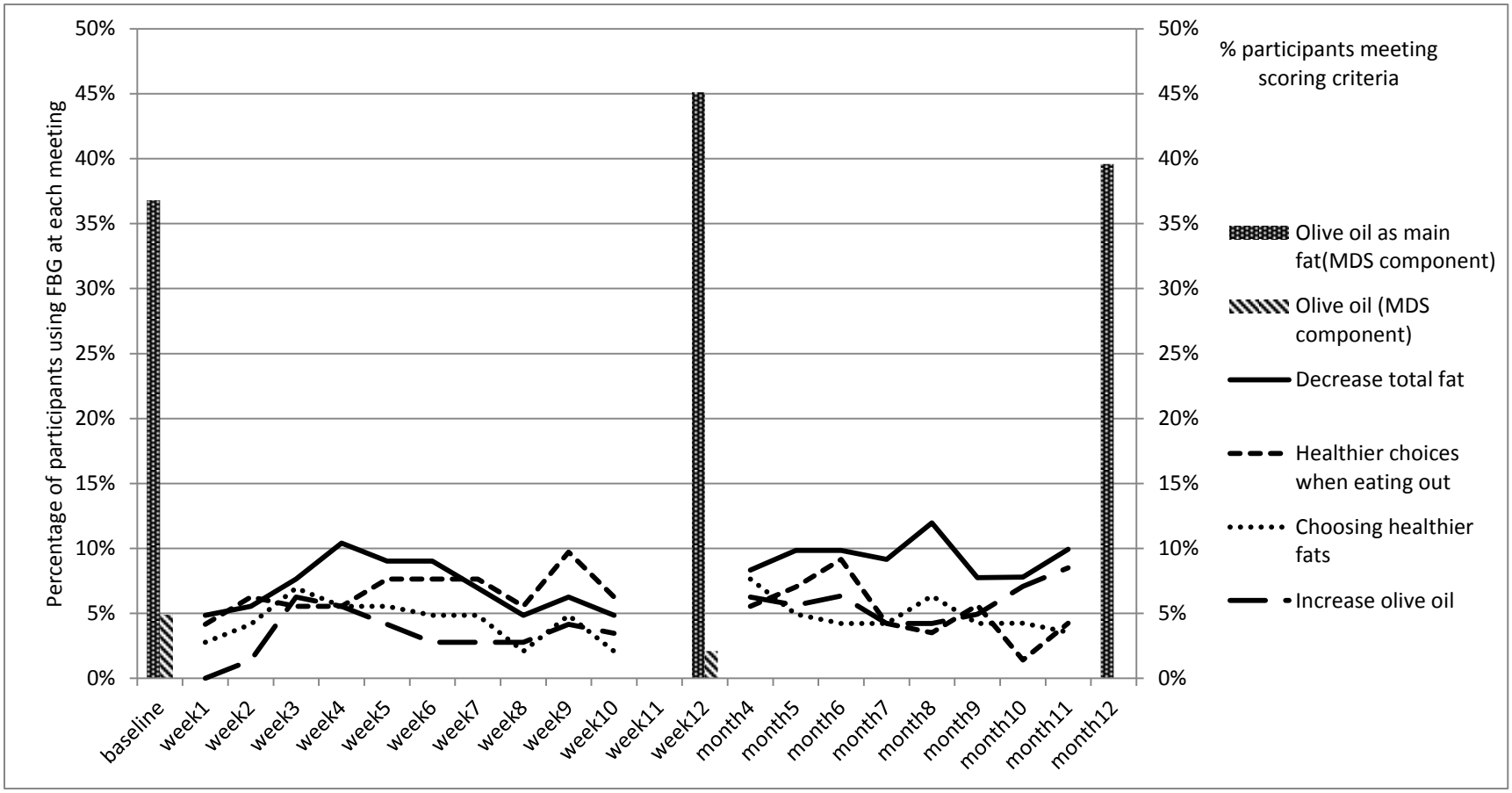


Figure A13 Percentage of participants receiving advice on *Healthier snacks*, *Decrease intake of added sugar* and *Decrease calories* over the 12 months, combined with percentage of participants meeting scoring criteria of 1 on Mediterranean Diet Score component *Commercial baked goods*, in participants with complete 12 months data on MDS (N=144).

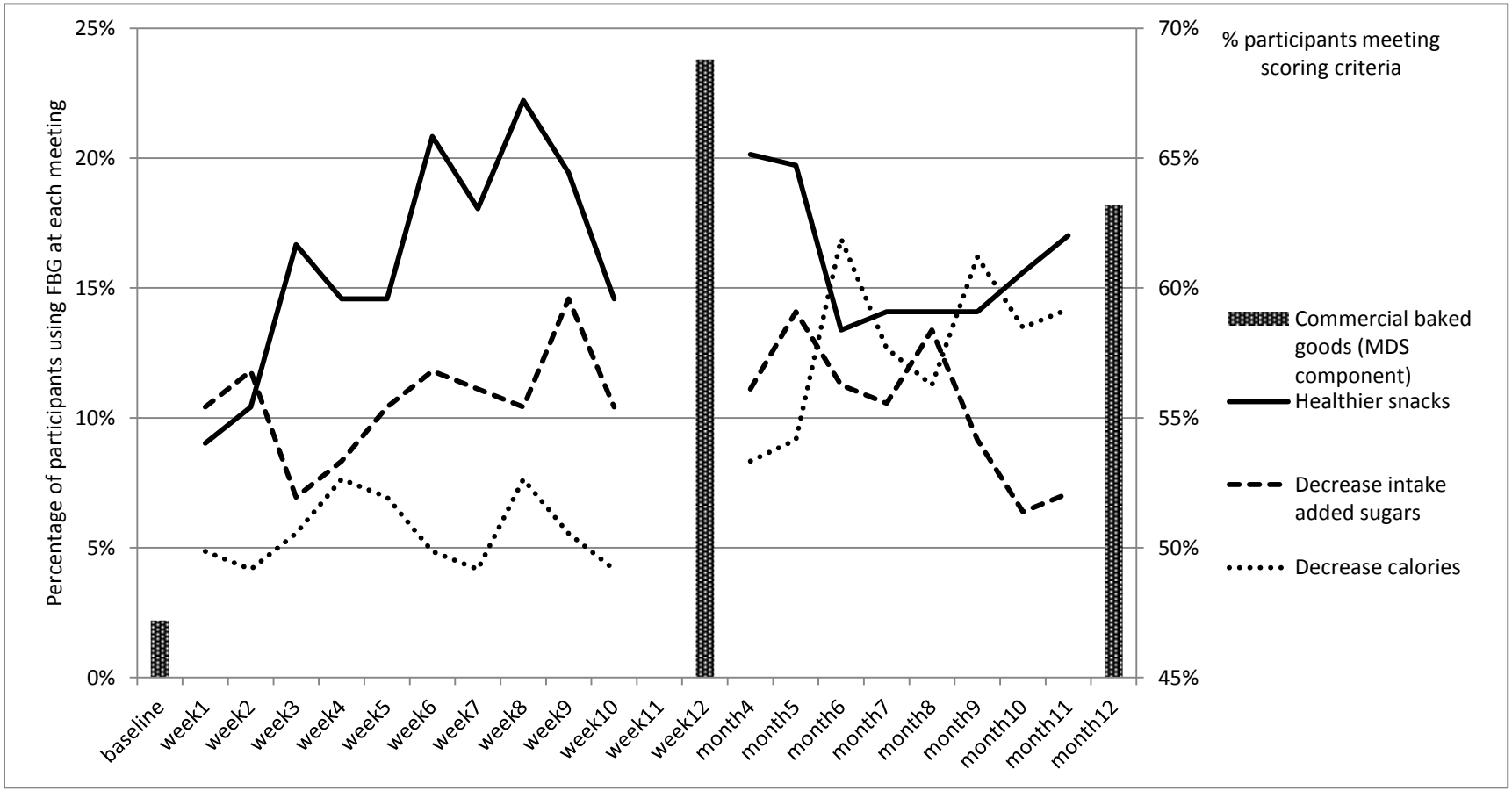


Figure A14 Percentage of participants receiving advice on *Decrease intake of added sugar* over the 12 months, combined with percentage of participants meeting scoring criteria of 1 on Mediterranean Diet Score component *Sugar-sweetened beverages*, in participants with complete 12 months data on MDS (N=144).

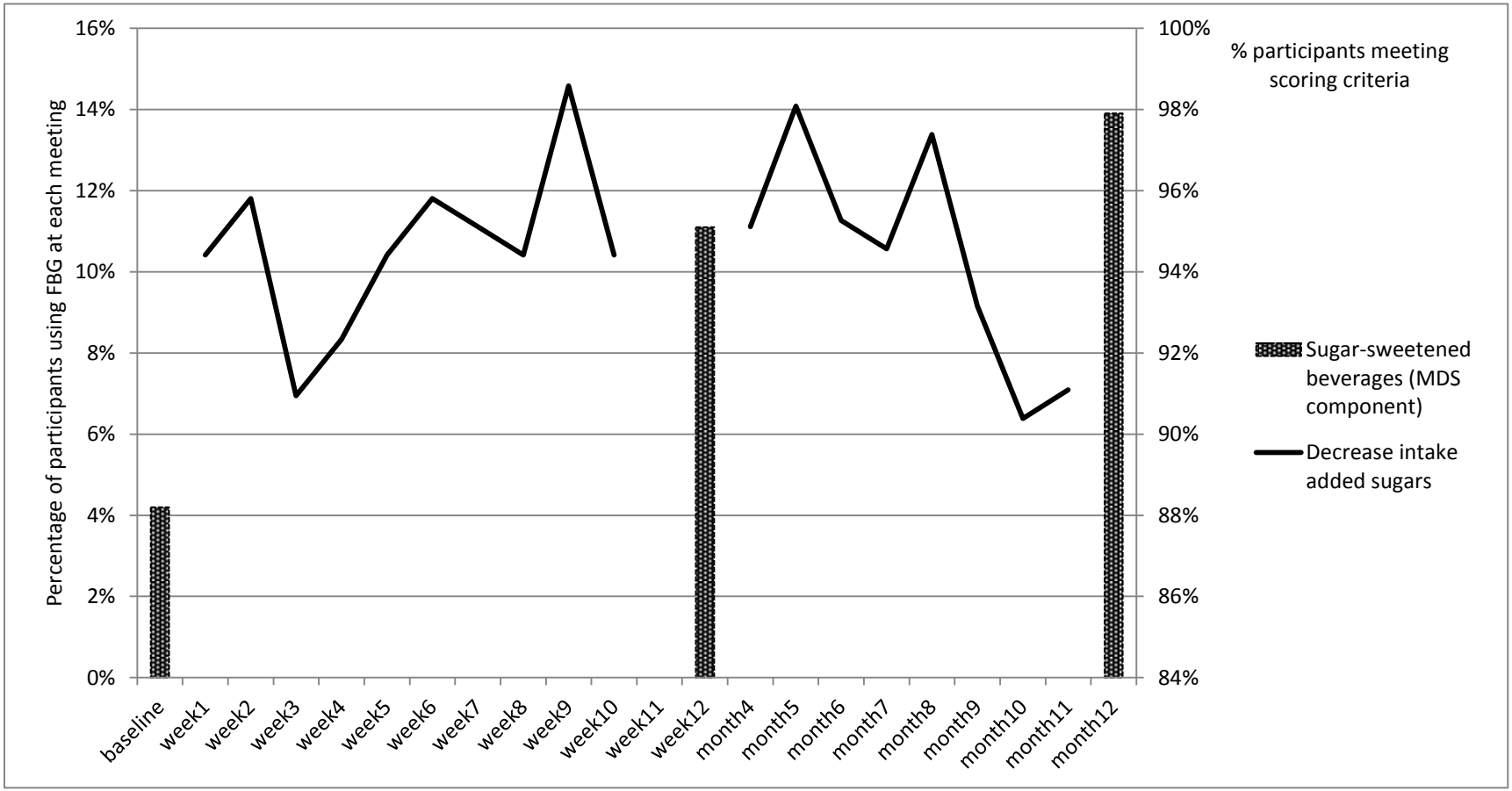


Figure A15 Percentage of participants receiving advice on *Wine if consuming alcohol* over the 12 months, combined with percentage of participants meeting scoring criteria of 1 on Mediterranean Diet Score component *Wine*, in participants with complete 12 months data on MDS (N=144).

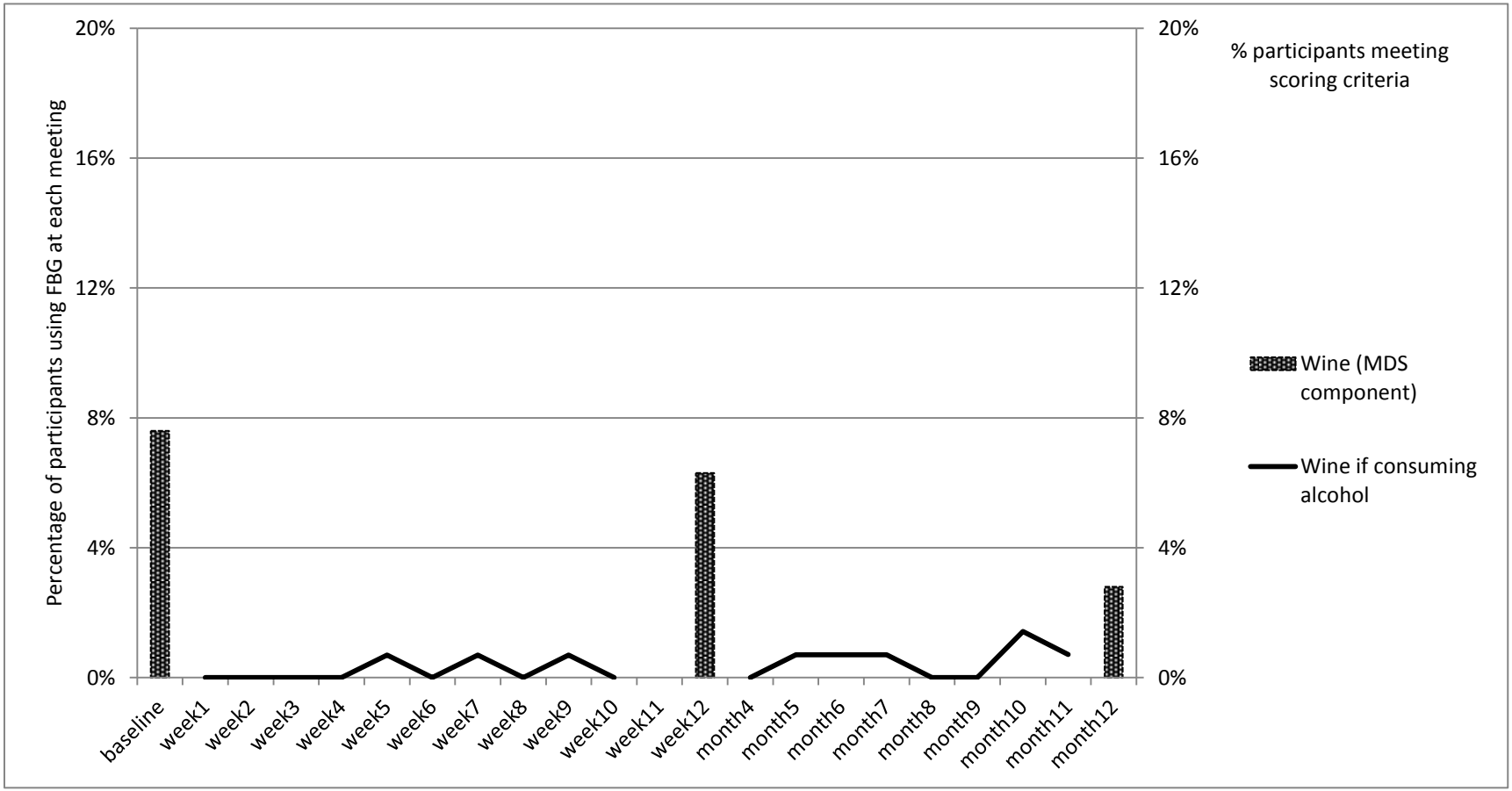
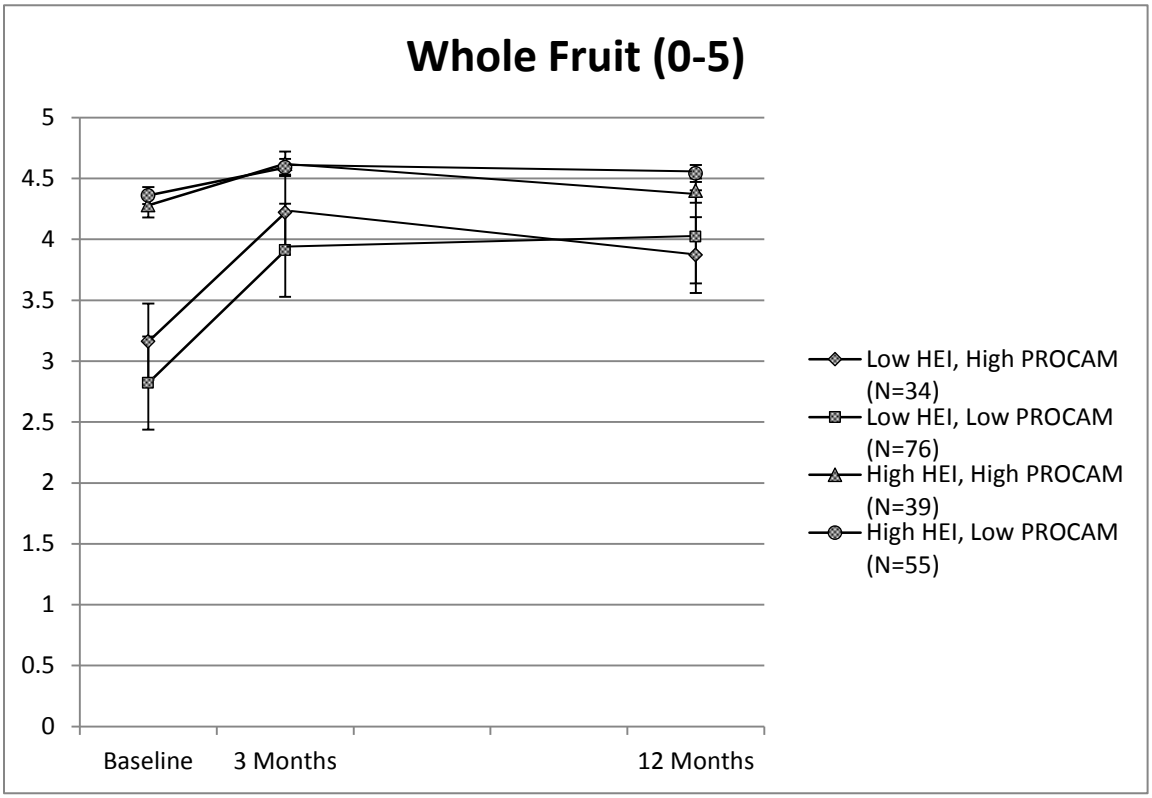
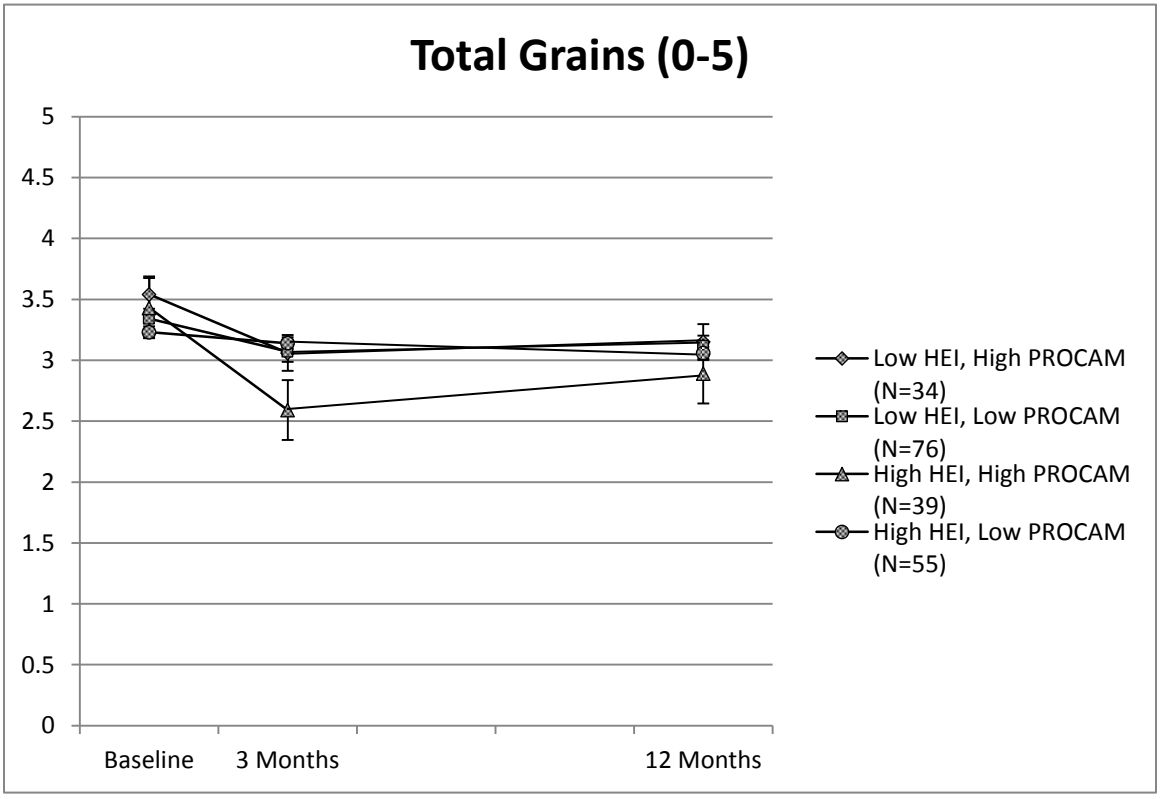


Figure A16 Trajectory graph of *Whole Fruit*, displayed by subgroups.



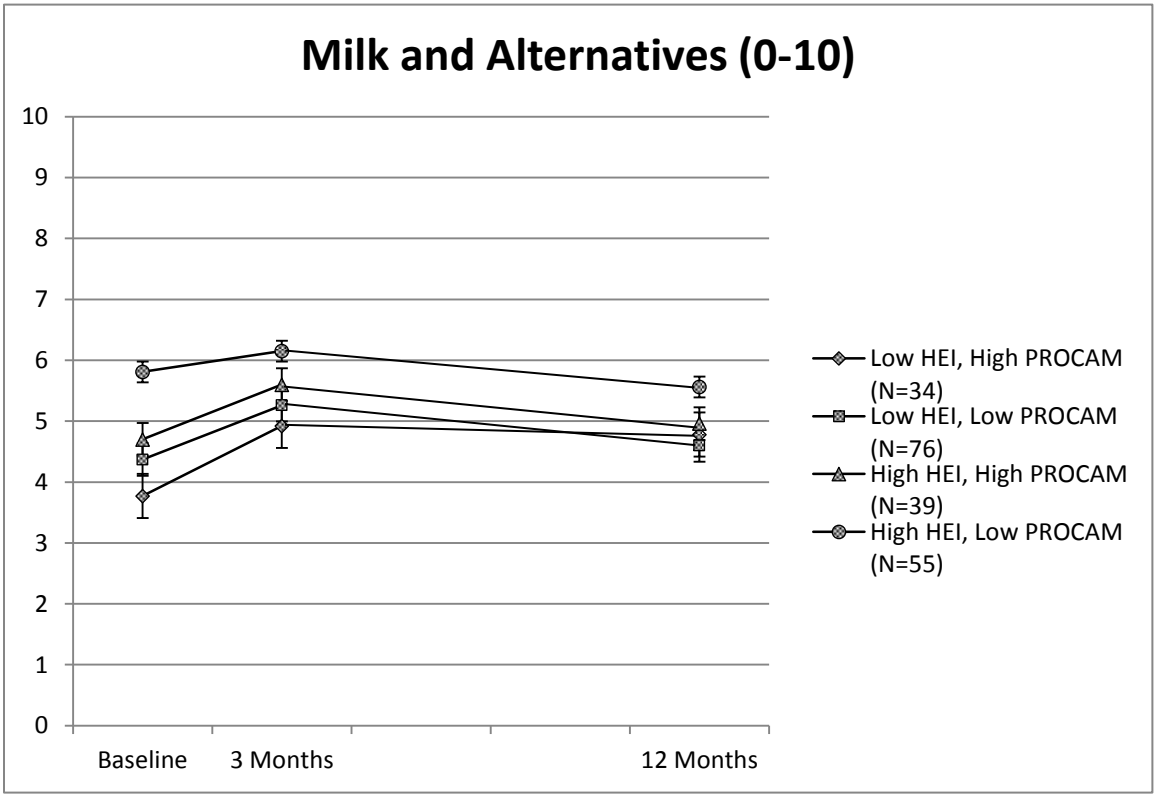
As Figure 16 shows, the Low HEI, Low PROCAM group have overall improvement of 1.20, which was equivalent to an overall increase of 0.4 to 0.5 CFG serving of whole fruit

Figure A17 Trajectory graph of *Total Grains*, displayed by subgroups.



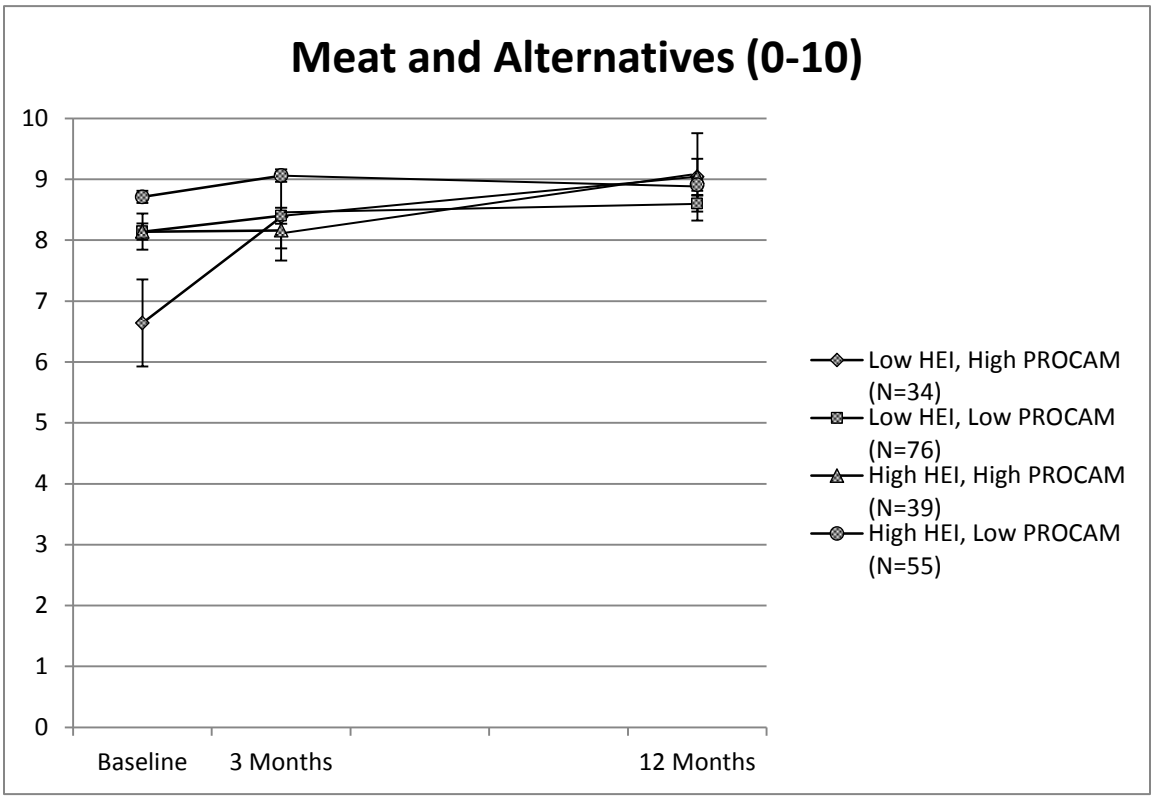
Overall, there was no significant change in total grain intake in any of the four subgroups at 12 months.

Figure A18 Trajectory graph of *Milk and Alternatives*, displayed by subgroups.



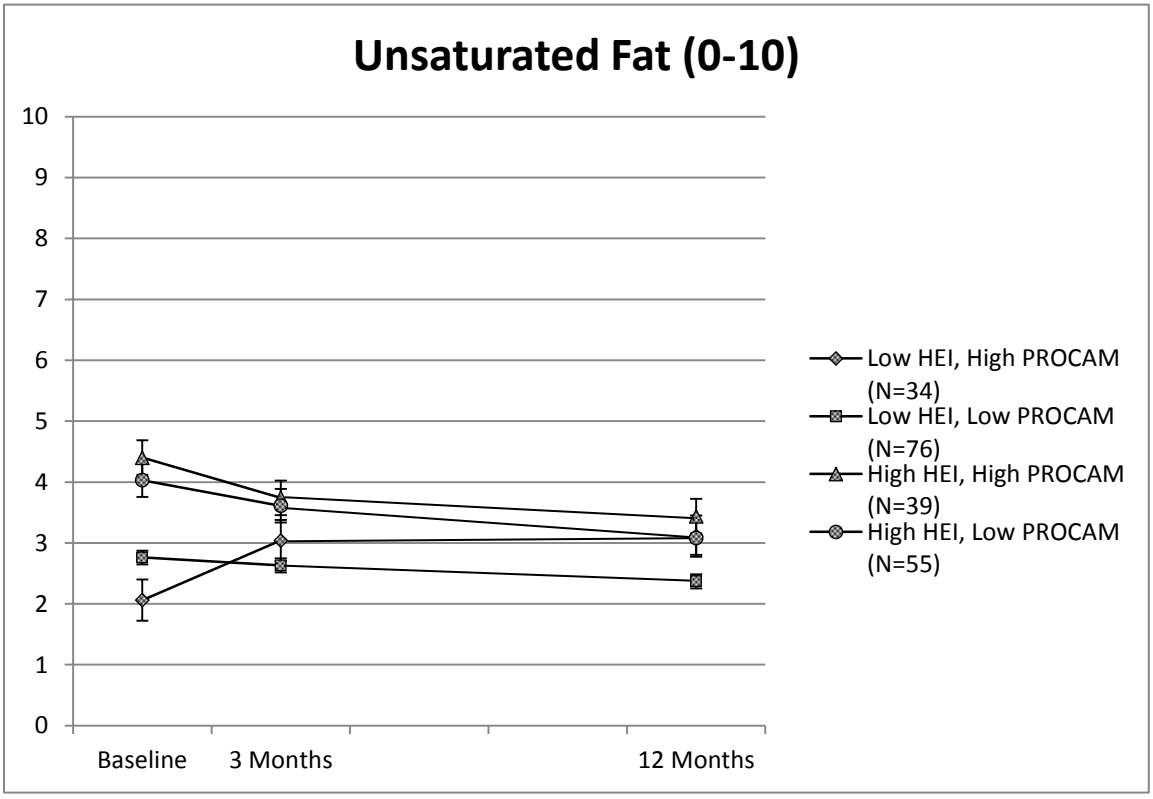
Overall, there was no significant change in the intake of milk and alternatives in any of the four subgroups at 12 months.

Figure A19 Trajectory graph of *Meat and Alternatives*, displayed by subgroups.



As Figure 19 shows, the Low HEI, High PROCAM group had overall improvement of 2.40, which was equivalent to an overall increase of 0.5 to 0.7 CFG serving of meat and alternatives.

Figure A20 Trajectory graph of *Unsaturated Fat*, displayed by subgroups.



Overall, there was no significant change in unsaturated fat intake in any of the four subgroups at 12 months.