Identification of dietary patterns associated with obesity in a nationally representative survey of Canadian adults: application of a priori, hybrid, and simplified dietary pattern techniques[1,2]

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ABSTRACT

Background: Analyzing the effects of dietary patterns is an important approach for examining the complex role of nutrition in the etiology of obesity and chronic diseases.

Objectives: The objectives of this study were to characterize the dietary patterns of Canadians with the use of a priori, hybrid, and simplified dietary pattern techniques, and to compare the associations of these patterns with obesity risk in individuals with and without chronic diseases (unhealthy and healthy obesity).

Design: Dietary recalls from 11,748 participants (≥18 y of age) in the cross-sectional, nationally representative Canadian Community Health Survey 2.2 were used. A priori dietary pattern was characterized with the use of the previously validated 2015 Dietary Guidelines for Americans Adherence Index (DGAI). Weighted partial least squares (hybrid method) was used to derive an energy-dense (ED), high-fat (HF), low–fiber density (LFD) dietary pattern with the use of 38 food groups. The associations of derived dietary patterns with disease outcomes were then tested with the use of multinomial logistic regression.

Results: An ED, HF, and LFD dietary pattern had high positive loadings for fast foods, carbonated drinks, and refined grains, and high negative loadings for whole fruits and vegetables (≥|0.17|). Food groups with a high loading were summed to form a simplified dietary pattern score. Moving from the first (healthiest) to the fourth (least healthy) quartiles of the ED, HF, and LFD pattern and the simplified dietary pattern scores was associated with increasingly elevated ORs for unhealthy obesity, with individuals in quartile 4 having an OR of 2.57 (95% CI: 1.75, 3.76) and 2.73 (95% CI: 1.88, 3.98), respectively (*P*-trend < 0.0001). Individuals who adhered the most to the 2015 DGAI recommendations (quartile 4) had a 53% lower OR of unhealthy obesity (*P*-trend < 0.0001). The associations of dietary patterns with healthy obesity and unhealthy nonobesity were weaker, albeit significant.

Conclusions: Consuming an ED, HF, and LFD dietary pattern and lack of adherence to the recommendations of the 2015 DGAI were associated with a significantly higher risk of obesity with and without accompanying chronic diseases. *Am J Clin Nutr* 2017;105:669–84.

Keywords: dietary patterns, partial least squares, simplified dietary pattern, Dietary Guidelines for Americans Adherence Index, obesity, chronic diseases, Canadian

INTRODUCTION

During the past few decades, the prevalence of obesity and other chronic diseases has increased dramatically worldwide. In Canada, the rate of adult obesity has increased from 6.1% in 1985 to 18.3% in 2011 (1). Analyzing the effects of dietary patterns is an important approach for examining the complex role of diet in the etiology of obesity and other chronic diseases (2, 3). This is particularly important because foods are consumed in complex combinations that can have synergistic or antagonistic effects (2). In addition, the comprehensive dietary pattern approach is more useful for developing dietary guidelines because it is easier for the public to interpret and thereby adopt an overall healthy dietary pattern (2, 3).

To identify dietary patterns associated with lower chronic disease risk, researchers have used various dietary pattern derivation techniques. In hypothesis-oriented (a priori) methods, dietary quality indexes are used to score individuals based on their adherence to dietary guidelines (4). The Dietary Guidelines for Americans Adherence Index (DGAI)[7] is the only a priori

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[2] Supplemental Figures 1–3 and Supplemental Tables 1 and 2 are available from the "Online Supporting Material" link in the online posting of the article and from the same link in the online table of contents at http://ajcn.nutrition.org.

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[7] Abbreviations used: CCHS, Canadian Community Health Survey; CNF, Canadian Nutrient File; DGA, Dietary Guidelines for Americans; DGAI, Dietary Guidelines for Americans Adherence Index; ED, energy-dense; EER, estimated energy requirement; FD, fiber density; GI, glycemic index; HF, high fat; LFD, low fiber density; PLS, partial least squares; wPLS, weighted partial least squares; %EF, percentage of energy as fat.

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index that measures diet quality in terms of adherence to 1 of the 12 energy-based USDA Food Patterns (5, 6), which were developed to reduce chronic disease risk. Recently, we updated the DGAI (6) to reflect changes in the Health and Human Services/USDA 2015 Dietary Guidelines for Americans (DGA) (2). The findings of our study confirmed the high construct validity and reliability of this index in a nationally representative survey of Canadian adults (6).

However, hybrid methods such as partial least squares (PLS) are the most-recently developed techniques for deriving dietary patterns, and combine a priori information with a posteriori statistics to create uncorrelated patterns of food groups that relate to specific outcomes of interest (7). Hybrid methods are partially exploratory or dependent on the population under study, which can lead to new knowledge about the determinants of chronic diseases in a particular population (4). However, this can also be a limitation, because dietary patterns derived by hybrid techniques may not be reproducible in other populations (4, 8). This issue may be overcome by construction of a simplified dietary pattern score in which unweighted standardized *z* scores of food groups with high correlations are summed to represent the most informative foods in a dietary pattern (8, 9).

To our knowledge, thus far, the association of dietary patterns with obesity has not been comprehensively examined with the use of energy-based a priori, hybrid, and simplified dietary pattern techniques in a large-scale nationally representative survey. The idea behind using different methods for defining dietary patterns is that each technique captures a different aspect of dietary intake (10). The objectives of this study were therefore the following: *1*) to evaluate the dietary patterns of Canadians with the use of the 2015 DGAI; *2*) to identify a dietary pattern associated with obesity [energy dense (ED), high fat (HF), and low fiber density (LFD)] with the use of the weighted partial least squares (wPLS) method; *3*) to construct a simplified dietary pattern score based on the wPLS-derived dietary pattern; and *4*) to compare the association of these 3 dietary pattern scores with the risk of obesity with and without accompanying chronic diseases (unhealthy and healthy obesity).

METHODS

Study population

This study used data from Canadian Community Health Survey (CCHS) cycle 2.2 (2004–2005), which is the only Canadian national nutrition survey available in >30 y (11, 12). Data were collected under the authority of the Statistics Act of Canada (11, 13). All data analyses were conducted at Statistics Canada's Research Data Center. Details regarding the sampling framework and survey procedures of CCHS 2.2 have been published previously (11). In brief, CCHS 2.2 is a complex multistage cross-sectional national survey that includes 35,107 Canadians from 10 provinces, representing >98% of the Canadian population (12, 13). For the purpose of this research, we excluded all pregnant (n = 175) and breastfeeding (n = 92) women, those with invalid or missing dietary recalls (n = 58) (as defined by Statistics Canada) (12), and individuals with missing values for measured anthropometric measurements, energy intake, and physical activity levels. To be able to evaluate the association of dietary patterns with lifestyle and sociodemographic characteristics, we additionally removed individuals with missing values for these variables, leaving a total of 11,748 Canadian adults (≥18 y of age) for all analyses. The sociodemographic and lifestyle characteristics of individuals included in this research were not significantly different from those who were excluded because of missing variables (data not shown).

Data collection

Trained interviewers conducted all data collection interviews, and weight and height were measured in person and at participants' homes (12). Interviewer-administered questionnaires were used to collect lifestyle and sociodemographic data, as well as medical diagnosis of chronic diseases (12). BMI was calculated by dividing the weight (kilograms) by square of height (meters), and BMI values (in kg/m^2) of 25–29.99 and ≥30 were considered as overweight and obese, respectively.

Two 24-h dietary recalls were collected with the use of the modified version of the USDA Automated Multiple Pass Method (11, 14, 15). Because the second dietary recall was collected from only 30% of the population, only the first recall was used in all analyses (11, 12). All foods and beverages consumed in the previous 24 h (midnight to midnight) were collected and their nutrient compositions were analyzed with the use of Health Canada's Canadian Nutrient File (CNF) (16). Trained dietitians coded all food items reported and disaggregated recipes and ethnic meals into their main constituents for nutrient analyses (12). Because the CNF does not include information on added sugar content of foods and beverages, the method described by Brisbois et al. (17) was used to estimate added sugar values.

Dietary glycemic index (GI) was estimated by assigning the mean values reported in the International Glycemic Index Table (18, 19) to each of the Bureau of Nutritional Sciences food categories (20), as described previously (21, 22). Dietary glycemic load was then calculated by multiplying the GI value by the grams of food carbohydrates and dividing by 100 (18, 19). Several studies have demonstrated a link between dietary GI and risk of chronic diseases, including coronary heart disease (23), diabetes (24, 25), obesity (26), and cancer (27, 28). Therefore, GI may be an important dietary factor in chronic disease risk and was investigated as an indicator of diet quality in the present study.

Dietary pattern methods

A priori dietary pattern: 2015 DGAI

Recently, we updated the 2005 DGAI (5) based on the 2015 USDA Food Patterns (2) and evaluated its validity and reliability in the Canadian population (participants of CCHS 2.2) (6). The concurrent criterion validity and face validity of the 2015 DGAI were confirmed through its consistent relation with various lifestyle, sociodemographic, and nutritional characteristics in the expected direction (6). In addition, our results confirmed that the 2015 DGAI score has wide distribution, captures multiple underlying dimensions (principal components), and is reliable, as evidenced by a high Cronbach's coefficient (α = 0.75) (6). Details of scoring criteria for the DGAI were published previously (5, 6, 29) and are summarized below. Eleven of the 20 DGAI components evaluated energy-specific food intake recommendations (based on the 12 USDA Food Patterns), including 5 vegetable subgroups (i.e., dark-green vegetables, red and orange vegetables, other vegetables, starchy vegetables, and legumes), fruits, a variety of vegetables and fruits, meat and beans, dairy, grains, and added sugar (5). Eight of the DGAI components are based on the universal healthy choice recommendations and include percentage of whole grains, fiber, 4 recommendations related to fat (total fat, SFA, cholesterol, and low-fat products), sodium, and alcohol. One of the healthy choice subscore components (*trans* fat) was not included in the present study because of the lack of *trans* fat data in the CNF. As a result, the 2015 DGAI had a maximum of 19 scores in this research.

To score each of the 19 index components, we used a proportional scoring scheme to ensure that individuals were given a continuous score ranging from 0 (nonadherence) to 1 (total adherence) proportional to their degree of compliance with the recommendations (29). Participants were penalized for overconsumption of energy-dense foods (i.e., starchy vegetables, dairy, meat and beans, and grains) by having their index score reduced proportionally up to 1.25 times the recommended intake amount (29). For overconsumption amounts ≥1.25 times the recommendation, participants were penalized by a maximum of 0.5 scores.

Hybrid dietary pattern: wPLS

wPLS regression was used to derive a dietary pattern associated with obesity risk (7). The PLS is a flexible multivariate method that enables the extraction of pattern scores based on mathematical algorithms aimed at maximizing the covariance between explanatory variables and disease-specific responses. Generally, the PLS includes knowledge about intermediary variables on the pathway to disease (7). PLS enables the discovery of important disease-specific dietary exposures that have not been previously identified in the etiology of chronic diseases (30). In the present study, the weighted nonlinear iterative PLS algorithm was used to derive dietary patterns that explained maximum variation in 3 obesity-related response variables, including energy density, percentage of energy as fat (%EF), and fiber density (FD), as well as 38 food groups as predictor variables. All dietary data were centered and scaled (standardized) for dietary pattern analyses. Reported foods were grouped into 38 standardized (*z* score) food groups according to their nutrient profile and culinary usage, within the constraints of Health Canada's Bureau of Nutritional Sciences food groups (20), to reduce subjectivity (3) (**Supplemental Table 1**). Some frequently consumed foods (e.g., tea and coffee) were kept as separate groups because they represented distinct food choices.

The response variables used in this research (energy density, %EF, and FD) were chosen a priori and were hypothesized to be on the pathway between dietary intake and obesity, as discussed previously (31–35). Currently, the WHO and the scientific community consider energy density, %EF, and FD to be key targets for improving diet quality and the prevention of chronic diseases (32–40). To calculate dietary energy density, total energy from foods (kilocalories) was divided by weight of foods (grams), with beverages excluded because they disproportionately influence energy density (41, 42). FD was derived by calculating grams of fiber intake per 1000 kcal of energy. %EF was calculated by dividing daily energy from fat (kilocalories) by total energy intake (kilocalories) and multiplying by 100.

In the present research, the first wPLS-derived dietary pattern independently explained the maximum variation in the response variable (28.2%), whereas the subsequent 2 extracted dietary patterns only explained <10% of the response variation. In addition, these latter 2 dietary patterns were not interpretable and did not represent major dietary patterns in the Canadian population. Generally, no other linear functions of predictors and response variables would have a higher amount of variation explained than the first extracted dietary pattern (7). As a result, only the first dietary pattern was retained in this research for more concise results and consistency with previous studies (33, 37, 43–45).

The importance of each of the 38 food groups (predictors) in the first wPLS-derived dietary pattern was determined through the variable importance in the projection statistic (46), which was calculated by weighting the sum of squares of PLS weights. A variable importance in the projection statistic >0.8 was used to identify food groups with a meaningful contribution to the final wPLS-derived dietary pattern. Higher scores on the first dietary pattern were positively correlated with energy density (r = 0.67) and %EF (r = 0.33), and negatively correlated with FD (r = −0.53); this pattern was therefore labeled as an "energy-dense, high-fat, and low–fiber density (ED, HF, and LFD)" dietary pattern (**Table 1**). This pattern explained 45.34%, 28.44%, and 10.88% of the variation in energy density, FD, and %EF, respectively. Each subject was assigned a dietary pattern *z* score that reflected their compliance with the ED, HF, and LFD dietary pattern (33, 34). Dietary pattern scores are in fact the product of food group intake and factor loading for the corresponding food group, summed across all 38 food groups. To ensure a sound interpretation, food groups were ranked by decreasing absolute predictor loading and only those with loadings ≥|0.17| were considered to be significant (47).

To confirm the derived dietary pattern, several secondary analyses were conducted. In the first step, we examined the robustness of the dietary pattern by randomly splitting (50%) the data 5 times (split crossvalidation) and repeating the wPLS regression analyses on one-half of the population (i.e., analyses were repeated 5 times). Dietary patterns derived in 1 subsample were confirmed in the second sample. Predictor loadings of the derived dietary patterns were materially the same, and the mean of correlation coefficients between the 5 crossvalidated dietary pattern scores was r = 0.988. In the second step, we ungrouped and entered all reported food items into the wPLS regression analyses to evaluate the effect of food grouping decisions on the resulting dietary pattern. In addition, we examined the potential variations in dietary patterns between different age and sex groups by stratifying our sample and deriving separate dietary patterns in population subgroups. Because there were no major differences in predictor loadings and the derived dietary pattern in any of these secondary confirmatory analyses, participants were analyzed together, and all subsequent regression analyses were adjusted for the potential confounding effects of age and sex, as well as energy intake, misreporting status, physical activity level, and smoking.

Simplified dietary pattern

To address the criticism regarding the lack of reproducibility of data-driven dietary patterns and their dependence on the population under study, we constructed a robust simplified dietary pattern score as proposed by Schulze et al. (8). A simplified dietary pattern score represents the sum of unweighted standardized food groups with the highest loadings on a dietary

TABLE 1
Weighted Pearson correlation coefficients between important predictors (food groups); response variables; and an energy-dense, high-fat, and low–fiber density dietary pattern score derived from the wPLS (centered and scaled) simplified dietary pattern score and the 2015 DGAI score in adult participants of the Canadian Community Health Survey, cycle 2.2[1]

	Response variables			Total dietary pattern scores		
	Energy density	Fiber density	% Energy from fat	Energy-dense, high-fat, and low–fiber density pattern (wPLS)	Simplified dietary pattern[2]	2015 DGAI[3]
Predictor variables[4]						
Positive association						
Fast foods	0.30	−0.17	0.15	0.51	0.45	−0.22
Carbonated drinks	0.24	−0.25	−0.02[5]	0.46	0.42	−0.24
Refined grains	0.22	−0.20	0.04	0.42	0.41	−0.17
Solid fats	0.20	−0.15	0.30	0.38	0.36	−0.20
Processed meats	0.11	−0.13	0.16	0.30	0.34	−0.18
Cheese	0.16	−0.16	0.24	0.30	0.30	−0.25
Baked goods	0.27	−0.10	0.10	0.29	0.33	−0.04
Gravies, sauces, and dressings	0.07	−0.09	0.16	0.25	0.16	−0.14
Sugars and syrups	0.20	−0.10	−0.01[6]	0.25	0.29	−0.06
Inverse association						
Whole fruits	−0.39	0.32	−0.15	−0.45	−0.35	0.33
Dark-green vegetables	−0.27	0.18	0.01[6]	−0.31	−0.35	0.17
Other vegetables and juices	−0.26	0.16	−0.01[6]	−0.26	−0.28	0.23
Orange vegetables	−0.27	0.21	−0.03[7]	−0.25	−0.25	0.14
Yogurt	−0.17	0.09	−0.08	−0.24	−0.28	0.15
Response variables						
Energy density	1.00	−0.44	0.41	0.67	0.66	−0.50
Fiber density		1.00	−0.29	−0.53	−0.51	0.55
% Energy from fat			1.00	0.33	0.28	−0.33
Total dietary pattern scores						
wPLS				1.00	0.95	−0.57
Simplified dietary pattern					1.00	−0.54

[1] n = 11,748. All P values are <0.0001 unless otherwise noted. DGAI, Dietary Guidelines for Americans Adherence Index; wPLS, weighted partial least squares.
[2] Sum of standardized intake of fast foods; carbonated drinks; refined grains; solid fats; processed meats; cheese; baked goods; gravies, sauces, and dressings; and sugars and syrups (all with weights of 1), and whole fruits, dark-green vegetables, other vegetables and juices, orange vegetables, and yogurt (all with weights of −1).
[3] Ranged from 0 to 19 possible points, with higher scores indicating more healthful and varied dietary patterns.
[4] Food groups that contributed the most to the wPLS-derived dietary pattern score (predictor loading ≥|0.17|).
[5] $P = 0.042$.
[6] Not significant ($P \geq 0.05$) based on weighted Pearson correlation analyses.
[7] $P = 0.002$.

pattern, omitting the less informative food groups and weights (i.e., foods with predictor loadings <|0.17|) (8). Previous studies have shown that simplified dietary pattern scores closely approximate the dietary pattern scores derived from factor analysis or the reduced-rank regression with the extra advantage of being reproducible in future studies (8); however, application of this technique to the PLS-derived pattern is unknown.

In the present study, a simplified dietary pattern score was constructed from the food groups with the highest loadings (≥|0.17|) on the wPLS-derived dietary pattern. The following 14 food groups had predictor loadings ≥|0.17|; therefore, their standardized intake was summed up to build the simplified dietary pattern score while retaining the direction of loading (8, 48): fast foods; carbonated drinks; refined grains; solid fat; processed meat; cheese; baked goods; gravies, sauces, and dressings; and sugars and syrups (each weighted 1), and whole fruits, dark-green vegetables, other vegetables and juices, orange vegetables, and yogurt (each weighted −1) (**Figure 1**). As derived by the wPLS technique, a higher simplified dietary pattern score in this research indicated an ED, HF, and LFD dietary pattern (lower diet quality). Overall, 49.18% of all response variation was explained by these 14 key food groups, with whole fruits (9.18%), solid fat (5.17%), fast food (4.73%), carbonated drinks (3.94%), and orange vegetables (3.83%) explaining the most response variation (data not shown).

Handling dietary misreporting

Previously, our group demonstrated a high prevalence of selective and differential misreporting (under- and overreporting) in Canadian adolescents and adults (49). In addition, we confirmed that misreporting bias may reverse or hide diet-disease relations, and therefore needs to be adjusted for in nutritional surveys (49). In the present study, each participant was classified as underreporter, plausible reporter, or overreporter by comparison of their reported energy intake with estimated energy requirements (EERs). EERs were calculated with the use of the Institute of Medicine factorial equations, which require participants' sex, age, physical activity level (sedentary, low-active, moderately active, and high-active), and measured weight and height (50). Individuals' energy intake amounts were then directly compared with their EERs with the use of predefined cutoffs for their agreement (49, 51, 52). Based on the CCHS 2.2 data, individuals were categorized as underreporters if their energy intake was <70% of their EERs. Participants whose energy intake was 70–142% of their EERs and >142% of their EERs were classified as plausible reporters and overreporters, respectively (±1 SD) (49). All dietary analyses in this research were adjusted in addition for the misreporting bias as recommended previously (49).

Statistical analyses

All tables and figures include the actual *P* values to enable interpretation of results with or without Bonferroni adjustment (Bonferroni-corrected $P = 0.05/n$, where n equals the number of tests). Variance was estimated with the use of a bootstrap balanced repeated replication technique to account for the complex sampling framework of CCHS 2.2 (53, 54). Briefly, the balanced repeated replication technique generates a replicate weight by randomly selecting a sample with replacement from the original population and applying all the adjustments to the selected sample. In line with Statistics Canada's guidelines, this procedure was repeated 500 times to generate 500 sample survey weights, which were then used to estimate variances (55). All analyses were weighted to ensure a nationally representative sample, with the use of the sampling survey weights calculated by Statistics Canada based on respondent classes with similar socioeconomic profiles (12). All data analyses were conducted with the use of SAS 9.4 and JMP Genomics 11.2 (SAS Institute).

Dietary pattern scores were treated as both continuous and categorical in series of complementary statistical analyses. To test the correlations between dietary pattern scores and their constituent food groups, weighted Pearson correlation analysis was conducted (Table 1 and **Table 2**). Linearity assumption of the relation between dietary pattern scores and BMI (continuous) was closely examined by the weighted LOESS procedure. For categorical analyses, participants were divided into quartiles based on the population distribution of dietary pattern scores, with participants in the highest quartile being the most adherent to the dietary pattern. To reduce extraneous variability and confounding effects (56), all nutritional analyses were performed in terms of energy intake with the use of the density approach as described previously (57, 58). Weighted multivariable linear regression and least-squares means were used to examine the association of dietary pattern quartiles and the continuous variables (food groups, nutrients, DGAI score, food intake subscore, healthy choice subscore, age, and BMI) and categorical variables (other sociodemographic variables), respectively (**Tables 3–5**). The *P*-trend for continuous variables across the quartile categories of the dietary pattern scores represented *P* values associated with the weighted linear regression coefficient. To test the linear trend for categorical variables, we

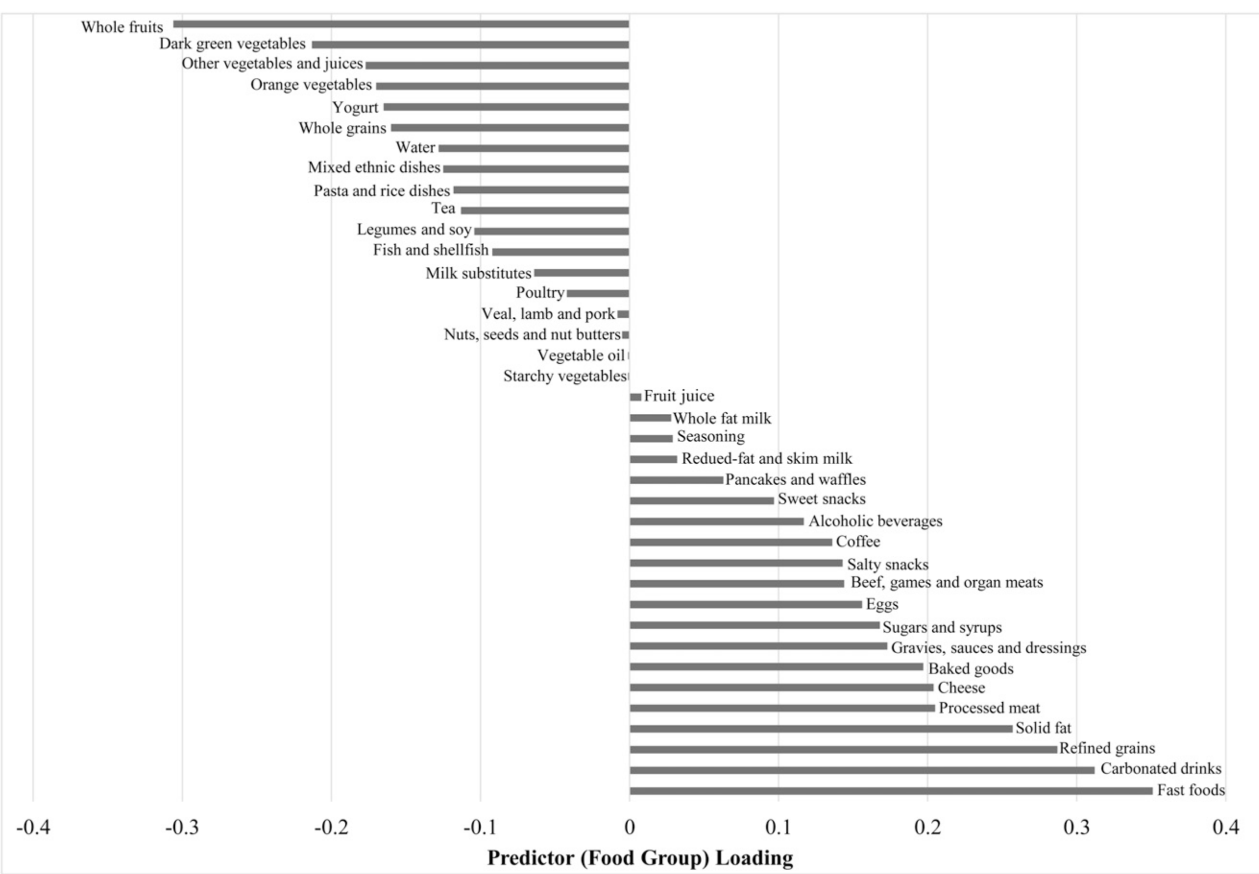

FIGURE 1 Predictor loadings for the energy-dense, high-fat, and low–fiber density dietary pattern derived from weighted partial least squares analysis (centered and scaled) in adult participants of the Canadian Community Health Survey, cycle 2.2 (n = 11,748).

set the median value of each quartile to each participant in the same quartile and treated the resulting value as a continuous variable in weighted logistic regression analyses. Modeling the medians, rather than simply modeling the quartile number, better reflected the underlying distribution and the trend across quartiles and ensured that absolute exposure differences between quartiles were taken into account.

The relation between dietary pattern score quartiles and obesity risk was examined with the use of the weighted multinomial logistic regression and generalized logit model (**Figure 2**). The ORs (95% CIs) of obesity were also examined in terms of a 1 SD increase in dietary pattern *z* scores (continuous) (**Supplemental Figures 1–3**). Quartile 1 was the referent category in all regression analyses for consistency. All analyses included potential confounders in successive models (available from the author on request), and only the most informative models are presented for brevity. Model 1 was adjusted for age, sex, and misreporting status (underreporting, plausible reporting, and overreporting); model 2 was adjusted for model 1 variables and energy intake; model 3 was adjusted for model 2 variables and physical activity (inactive, moderately active, and active); and model 4 was adjusted for model 3 variables and smoking status (daily, occasional, former, and never).

Because of the importance of differentiating obesity phenotypes (59), regression analyses were also stratified to investigate the association of dietary pattern quartiles and obesity in individuals with ≥1 chronic disease (unhealthy obesity), those without any chronic disease (healthy obesity), and those who were nonobese with at least one chronic disease (unhealthy nonobese) (**Figure 3**). Chronic diseases were determined with the use of self-reported medical diagnoses of diabetes, cardiovascular diseases, and cancer. Consistent with previous studies (60), we pooled the presence of all chronic diseases (diabetes, cardiovascular diseases, and cancer), because the latest DGA aims

TABLE 2
Weighted Pearson correlation coefficients between components of the 2015 DGAI (food intake subscore and healthy choice subscore) and an energy-dense, high-fat, and low–fiber density dietary pattern score derived from the wPLS (centered and scaled), as well as the simplified dietary pattern score, in adult participants of the Canadian Community Health Survey, cycle 2.2[1]

	A priori dietary pattern score (2015 DGAI)			Hybrid dietary pattern scores	
	Total DGAI score[2]	Food intake subscore[3]	Healthy choice subscore[4]	Energy-dense, high-fat, and low–fiber density pattern (wPLS)	Simplified dietary pattern[5]
DGAI food intake subscore					
Dark-green vegetables	0.45	0.57	0.08	−0.22	−0.22
Red and orange vegetables	0.33	0.40	0.07	−0.17	−0.18
Legumes	0.23	0.36	−0.03	−0.06	−0.10
Starchy vegetables	0.17	0.28	−0.04	0.15	0.15
Other vegetables	0.39	0.59	−0.03	−0.24	−0.25
Fruits	0.43	0.40	0.22	−0.34	−0.28
Variety of fruits and vegetables	0.69	0.90	0.09	−0.32	−0.32
Grains	0.11	0.15	0.01[6]	0.10	0.11
Meat and beans	0.20	0.35	−0.07	0.08	0.06
Dairy	0.10	0.26	−0.12	0.10	0.07
Added sugar	0.21	0.33	−0.03	−0.25	−0.26
Food intake subscore	0.73	1.00	0.03		
DGAI healthy choice subscore					
Whole grain	0.36	0.08	0.45	−0.22	−0.22
Dietary fiber density	0.64	0.33	0.59	−0.57	−0.54
Total fat	0.37	0.06	0.48	−0.18	−0.15
SFA	0.45	0.06	0.60	−0.31	−0.29
Cholesterol	0.33	−0.10	0.58	−0.27	−0.28
Low-fat dairy products	0.29	0.11	0.31	−0.15	−0.16
Low-fat meat products	0.24	0.16	0.18	−0.07	−0.04
Sodium	0.21	−0.22	0.53	−0.29	−0.25
Alcohol	0.20	−0.05	0.34	−0.10	−0.05
Healthy choice subscore	0.71				
Hybrid dietary pattern scores					
wPLS		−0.3	−0.51		
Simplified dietary pattern		−0.31	−0.47		

[1] n = 11,748. All P values are <0.0001 unless otherwise noted. DGAI, Dietary Guidelines for Americans Adherence Index; wPLS, weighted partial least squares.

[2] DGAI scores ranged from 0 to 19 possible points, with higher scores indicating more healthful and varied dietary patterns.

[3] Food intake subscores ranged from 0 to 11 possible points and were evaluated based on energy level.

[4] Healthy choice subscores ranged from 0 to 8 possible points and were evaluated on the same calorie level for all individuals.

[5] The simplified dietary pattern score is the sum of standardized intake of fast foods; carbonated drinks; refined grains; solid fats; processed meats; cheese; baked goods; gravies, sauces, and dressings; and sugars and syrups (all with weights of 1), and whole fruits, dark-green vegetables, other vegetables and juices, orange vegetables, and yogurt (all with weights of −1).

[6] Not significant ($P \geq 0.05$) based on weighted Pearson correlation analyses.

TABLE 3

Weighted mean daily intake of informative food groups (predictor loadings ≥|0.17|) across the quartile categories of the ED, HF, and LFD dietary pattern score derived from weighted partial least squares (centered and scaled) and simplified dietary pattern score in adult participants of the Canadian Community Health Survey, cycle 2.2[1]

	ED, HF, and LFD dietary pattern score quartiles				Simplified dietary pattern score quartiles[3]			
Predictors[2]	1 (Healthiest)	2	3	4 (Least healthy)	1 (Healthiest)	2	3	4 (Least healthy)
Positive association								
Fast foods	55.9 ± 5.7	85.8 ± 6.4	120.8 ± 6.5	233.2 ± 9.8	60.3 ± 6.3	88.4 ± 6.2	126.4 ± 6.8	219.1 ± 9.9
Carbonated drinks	101.2 ± 15.2	167.0 ± 15.8	251.1 ± 18.6	500.1 ± 24.3	110.1 ± 16.2	176.0 ± 16.1	253.4 ± 17.6	477.3 ± 26.1
Refined grains	30.3 ± 2.7	42.9 ± 2.7	55.5 ± 3.1	89.2 ± 3.5	29.5 ± 2.7	41.0 ± 2.7	60.1 ± 3.0	86.7 ± 3.5
Solid fats	13.5 ± 1.4	20.6 ± 1.6	25.1 ± 1.8	43.1 ± 2.8	13.1 ± 1.5	20.0 ± 1.5	26.1 ± 1.7	43.1 ± 2.8
Processed meats	7.7 ± 2.1	13.2 ± 2.1	17.8 ± 2.4	37.5 ± 3.8	6.8 ± 2.0	11.6 ± 2.1	16.9 ± 2.3	41.4 ± 3.8
Cheese	16.2 ± 2.4	23.4 ± 2.3	27.9 ± 2.6	41.1 ± 3.4	16.2 ± 2.4	21.4 ± 2.2	27.9 ± 2.7	43.1 ± 3.2
Baked goods	32.5 ± 3.3	45.4 ± 3.5	62.7 ± 3.7	81.2 ± 5.0	28.7 ± 3.3	44.9 ± 3.5	59.5 ± 3.9	89.0 ± 5.0
Gravies, sauces, and dressings	14.4 ± 1.7	16.3 ± 1.8	19.8 ± 2.4	33.0 ± 2.6	17.0 ± 1.8	19.5 ± 2.5	19.6 ± 2.1	26.8 ± 2.5
Sugars and syrups	14.7 ± 2.1	19.0 ± 1.6	25.2 ± 1.7	31.6 ± 2.5	13.1 ± 1.6	19.3 ± 2.2	23.7 ± 1.7	34.6 ± 2.4
Inverse association								
Whole fruits	281.1 ± 13.2	138.6 ± 7.0	89.3 ± 7.3	21.7 ± 9.7	261.3 ± 12.2	136.1 ± 9.6	98.0 ± 7.5	46.1 ± 9.2
Dark-green vegetables	70.7 ± 7.5	28.3 ± 2.6	21.4 ± 3.1	11.7 ± 4.2	73.1 ± 7.5	26.8 ± 2.5	23.5 ± 3.2	10.6 ± 4.2
Other vegetables and juices	146.6 ± 7.9	88.2 ± 5.6	53.8 ± 3.9	35.8 ± 5.2	144.7 ± 7.9	90.6 ± 6.2	57.7 ± 3.9	35.2 ± 5.0
Orange vegetables	105.5 ± 5.7	67.4 ± 4.2	46.1 ± 4.0	22.9 ± 3.3	102.0 ± 5.9	65.5 ± 4.2	51.5 ± 3.9	25.3 ± 3.3
Yogurt	48.0 ± 4.0	18.4 ± 2.5	11.1 ± 2.1	2.4 ± 2.4	52.6 ± 3.8	17.0 ± 2.5	8.8 ± 1.8	3.0 ± 2.3

[1] Values (grams per day) are means ± SEs, $n = 11{,}748$. Estimates are weighted least squares means and bootstrapped variances (balanced repeated replication technique). Covariate-adjusted associations were determined with the use of the weighted multivariable linear regression. Means are adjusted for age, sex, energy intake, and misreporting status (underreporting, plausible reporting, and overreporting) (cutoff for plausible reporting: energy intake and estimated energy requirement ≥0.7 and ≤1.42). The *P*-trend was estimated with the use of the dietary pattern score in its continuous form and represents the *P* value associated with the linear regression coefficient. All *P*-trends are <0.0001. ED, energy-dense; HF, high-fat; LFD, low–fiber density.

[2] Food groups that contributed the most to the dietary pattern score (predictor loading ≥|0.17|).

[3] The sum of standardized intake of fast foods; carbonated drinks; refined grains; solid fats; processed meats; cheese; baked goods; gravies, sauces, and dressings; and sugars and syrups (all with weights of 1), and whole fruits, dark-green vegetables, other vegetables and juices, orange vegetables, and yogurt (all with weights of −1).

to reduce the cumulative risk of diet-related chronic diseases at the population level, which is critical from a public health perspective (2). Finally, subgroup analyses were also performed within the strata of sex, age, misreporting, physical activity, and smoking status.

RESULTS

Part A: Identification of dietary patterns

The mean values for each of the 3 obesity-related response variables used in the wPLS regression are presented in **Supplemental Table 2**. As expected, the adjusted mean values of energy density, %EF, and FD were significantly different by BMI categories, with obese participants consuming a diet higher in energy density and %EF and lower in FD than that of normal-weight individuals ($P < 0.001$). Predictor loadings for the ED, HF, and LFD dietary pattern derived from the wPLS are presented in Figure 1 to represent the magnitude and direction of contribution of each food group to the nonsimplified dietary pattern score. Generally, the strongest predictor loading on the ED, HF, and LFD dietary pattern was for fast foods (+0.35), carbonated drinks (+0.31), and refined grains (+0.29) on one side, and whole fruits (−0.31), dark-green vegetables (−0.21), and other vegetables and juices (−0.18) on the other, the magnitude of which was about double that of the sugars and syrups group (+0.17) and yogurt (−0.17) (Figure 1).

The correlations of important predictors (food groups) with obesity-related response variables and total dietary pattern *z* scores are presented in Table 1. The correlations of food groups (predictors) with the ED, HF, and LFD dietary pattern score were the highest for fast foods ($r = 0.51$; positive) and whole fruits ($r = -0.45$; negative) ($P < 0.0001$). Even though these predictors were not used for constructing the 2015 DGAI, the majority of them had a moderate correlation with the total 2015 DGAI score ($P < 0.0001$). Importantly, the ED, HF, and LFD dietary pattern score was highly correlated with the simplified dietary pattern score ($r = 0.95$), whereas the associations of the ED, HF, and LFD and the simplified dietary pattern scores with the 2015 DGAI score were moderate at $r = -0.57$ and $r = -0.54$, respectively. When components of the 2015 DGAI were examined individually, higher scores on the ED, HF, and LFD dietary pattern were negatively correlated with all 2015 DGAI component scores, except for the weak positive associations for starchy vegetables ($r = 0.15$), grains ($r = 0.10$), meat and beans ($r = 0.08$), and dairy ($r = 0.10$) (Table 2). Overall, the correlations of the ED, HF, and LFD dietary pattern score with the 2015 DGAI food intake subscore and healthy choice subscore were $r = -0.3$ and $r = -0.51$, respectively.

Part B: Association between dietary pattern scores and nutritional and lifestyle profiles

Participants were classified into quartiles based on the ED, HF, and LFD dietary pattern score, as well as the simplified dietary pattern score, with higher quartiles corresponding to a less healthy dietary pattern (Table 3). As expected from the

TABLE 4

Weighted analysis of the sociodemographic and lifestyle characteristics across the quartile categories of the ED, HF, and LFD dietary pattern score derived from weighted partial least squares (centered and scaled) and simplified dietary pattern score in adult participants of the Canadian Community Health Survey, cycle 2.2[1]

	ED, HF, and LFD dietary pattern score quartiles				Simplified dietary pattern score quartiles[2]			
	1 (Healthiest)	2	3	4 (Least healthy)	1 (Healthiest)	2	3	4 (Least healthy)
DGAI score[3]	10.4 ± 0.1	9.1 ± 0.1	8.3 ± 0.1	7.5 ± 0.1	10.4 ± 0.1	9.1 ± 0.1	8.3 ± 0.1	7.5 ± 0.1
Food intake subscore[4]	4.6 ± 0.1	3.9 ± 0.1	3.5 ± 0.1	3.5 ± 0.1	4.7 ± 0.1	3.8 ± 0.1	3.5 ± 0.1	3.5 ± 0.1
Healthy choice subscore[5]	5.7 ± 0.1	5.2 ± 0.1	4.8 ± 0.1	3.9 ± 0.1	5.7 ± 0.1	5.2 ± 0.1	4.8 ± 0.1	4.0 ± 0.1
Female, %	59.2 ± 3.2	60.9 ± 2.8	46.1 ± 3.9	33.8 ± 2.3	58.1 ± 3.1	58.9 ± 3.4	47.8 ± 3.0	35.0 ± 2.6
Age, y	49.5 ± 0.5	48.4 ± 0.7	46.3 ± 0.5	40.1 ± 0.5	49.3 ± 0.5	48.3 ± 0.7	45.8 ± 0.5	40.7 ± 0.5
BMI, kg/m^2	25.6 ± 0.2	26.6 ± 0.3	26.6 ± 0.2	27.3 ± 0.2	25.5 ± 0.2	26.7 ± 0.3	26.5 ± 0.2	27.2 ± 0.2
Obese, %	14.1 ± 1.1	19.2 ± 1.5	19.2 ± 1.3	21.8 ± 1.4	14.6 ± 1.2	18.6 ± 1.4	19.1 ± 1.3	21.8 ± 1.3
Obese with ≥1 chronic disease, %	8.4 ± 0.7	10.0 ± 0.9	11.8 ± 1.0	13.4 ± 1.0	8.3 ± 0.6	10.2 ± 0.8	11.9 ± 1.1	13.2 ± 1.0
Low-active participants, %	46.0 ± 2.2	53.5 ± 2.1	56.0 ± 2.5	58.5 ± 1.8	46.3 ± 2.0	54.5 ± 2.4	54.7 ± 2.4	58.4 ± 1.9
Current daily smokers, %	10.6 ± 0.8	16.3 ± 1.3	19.7 ± 1.2	26.3 ± 1.6	11.2 ± 0.8	17.5 ± 1.2	20.1 ± 1.3	24.0 ± 1.6
Multivitamin users, %	42.8 ± 2.4	42.1 ± 2.2	37.6 ± 2.1	35.8 ± 1.9	43.5 ± 2.5	40.4 ± 2.3	38.7 ± 2.2	35.8 ± 1.8
Drank alcohol in the previous 12 mo, %	74.2 ± 2.1	79.9 ± 2.0	83.4 ± 1.4	84.9 ± 1.3	76.7 ± 2.1	78.4 ± 1.8	82.5 ± 1.5	84.7 ± 1.3
Highest household education, %								
Less than secondary school	7.8 ± 0.8	11.8 ± 0.9	12.0 ± 0.9	13.9 ± 1.1	8.1 ± 0.8	12.0 ± 0.9	12.4 ± 0.9	13.1 ± 1.1
Postsecondary education	76.1 ± 1.6	66.9 ± 1.8	66.4 ± 1.8	62.5 ± 1.8	75.5 ± 1.7	66.4 ± 1.8	65.7 ± 1.8	64.2 ± 1.9
Highest respondent education, %								
Less than secondary school	18.3 ± 1.4[6]	26.3 ± 1.6	25.6 ± 1.4	31.0 ± 1.5	19.1 ± 1.6	25.3 ± 1.6	25.8 ± 1.4	30.7 ± 1.5
Postsecondary education	51.5 ± 2.0[6]	39.9 ± 2	40.9 ± 1.7	34.5 ± 1.5	50.2 ± 2.2	41.3 ± 2.1	40.6 ± 1.8	35.0 ± 1.5
Marital status, %								
Married	26.8 ± 11.1[7]	20.9 ± 9.4	21.3 ± 9.7	22.5 ± 10.2	27.0 ± 11.3[8]	22.5 ± 9.8	19.2 ± 8.9	23.1 ± 10.3
Single or never married	39.3 ± 13.1	47.2 ± 13.8	46.7 ± 14.0	45.0 ± 14.0	39.0 ± 13.3	44.9 ± 13.6	49.9 ± 14.0	44.1 ± 13.9
Immigrant, %	35.2 ± 3.5	24.3 ± 3.2	14.1 ± 2.0	10.7 ± 1.3	33.5 ± 3.5	23.2 ± 2.9	16.7 ± 2.1	11.0 ± 1.5
Aboriginal, %	0.7 ± 0.3	1.0 ± 0.3	1.2 ± 0.4	1.6 ± 0.5	0.8 ± 0.3[9]	0.9 ± 0.3	1.3 ± 0.4	1.5 ± 0.5
Caucasian, %	73.6 ± 2.4	84.7 ± 2.3	91.5 ± 1.3	93.7 ± 0.8	75.2 ± 2.6	84.8 ± 2.1	90.8 ± 1.2	92.8 ± 1.0
<5 vegetables and fruits consumed/d, %	53.0 ± 2.9	68.4 ± 2.0	75.2 ± 2.1	80.5 ± 1.5	53.8 ± 2.8	67.9 ± 2.2	75.0 ± 2.0	80.2 ± 1.7
Excellent self-perceived health, %	22.7 ± 1.4	20.9 ± 1.4	19.4 ± 1.3	16.8 ± 1.0	23.7 ± 1.4	19.9 ± 1.3	18.9 ± 1.2	17.2 ± 1.1
Low stress level, %	40.9 ± 2.1[10]	42.1 ± 2.4	37.2 ± 2.2	37.3 ± 1.7	41.9 ± 2.1[11]	40.6 ± 2.2	37.2 ± 2.2	37.7 ± 1.8
Highest income group, %	38.4 ± 2.0[6]	40.5 ± 2.6	42.8 ± 3.2	40.8 ± 3.1	39.2 ± 1.9[6]	41.8 ± 2.8	40.6 ± 3.0	40.8 ± 3.1
Employed and at work during the previous week, %	44.3 ± 2.2[6]	47.1 ± 2.3	44.1 ± 2.5	48.8 ± 2.0	45.4 ± 2.1[6]	46.4 ± 2.3	45.2 ± 2.3	47.3 ± 2.2
Urban resident, %	85.9 ± 1.2	83.0 ± 1.7	79.8 ± 1.9	76.9 ± 1.7	84.9 ± 1.4	83.4 ± 1.8	78.9 ± 1.7	78.4 ± 1.7

[1] Values are actual means and percentages ± SEs. n = 11,748. Estimates are weighted least-squares means or percentages with bootstrapped variances (balanced repeated replication technique). Covariate-adjusted associations between dietary pattern quartiles and continuous and categorical variables were determined with the use of weighted multivariable linear regression and least-squares means, respectively. Values are adjusted for age and sex, unless otherwise noted. Age is adjusted for sex only and sex is adjusted for age only. The P-trend was estimated with the use of the dietary pattern score in its continuous form and represents the P value associated with the linear regression coefficient for continuous variables and the logistic regression coefficient for categorical variables. All P-trends are <0.0001 unless otherwise specified. DGAI, Dietary Guidelines for Americans Adherence Index; ED, energy-dense; HF, high-fat; LFD, low–fiber density.

[2] Sum of standardized intake of fast foods; carbonated drinks; refined grains; solid fats; processed meats; cheese; baked goods; gravies, sauces, and dressings; and sugars and syrups (all with weights of 1), and whole fruits, dark-green vegetables, other vegetables and juices, orange vegetables, and yogurt (all with weights of −1).

[3] Scores ranged from 0 to 19 possible points, with higher scores indicating more healthful and varied dietary patterns.

[4] Scores ranged from 0 to 11 possible points and were evaluated based on energy level.

[5] Scores ranged from 0 to 8 possible points and were evaluated on the same calorie level for all individuals.

[6] Not significant ($P \geq 0.05$) based on weighted regression analyses.

[7] P-trend = 0.044.

[8] P-trend = 0.0003.

[9] P-trend = 0.009.

[10] P-trend = 0.042.

[11] P-trend = 0.037.

TABLE 5

Weighted mean daily intake of macro- and micronutrients, reported as percentage of energy or per 1000 kcal [density approach (57)], across quartile categories of the ED, HF, and LFD dietary pattern score derived from weighted partial least squares (centered and scaled) and simplified dietary pattern score in adult participants of the Canadian Community Health Survey, cycle 2.2[1]

	ED, HF, and LFD dietary pattern score quartiles				Simplified dietary pattern score quartiles[2]			
	1 (Healthiest)	2	3	4 (Least healthy)	1 (Healthiest)	2	3	4 (Least healthy)
Energy intake, kcal	2377 ± 26	2366 ± 30	2402 ± 30	2677 ± 31	2400 ± 27	2364 ± 29	2402 ± 33	2669 ± 31
Total fat, % energy	27.1 ± 0.4	30.7 ± 0.4	32.3 ± 0.4	35.5 ± 0.3	27.8 ± 0.4	30.4 ± 0.4	32.3 ± 0.5	35.1 ± 0.3
Fiber density, g/1000 kcal	12.2 ± 0.2	8.5 ± 0.2	7.0 ± 0.1	5.9 ± 0.1	12.1 ± 0.2	8.5 ± 0.2	7.0 ± 0.1	6.3 ± 0.1
Energy density, kcal/g	0.7 ± 0.0	1.2 ± 0.1	1.2 ± 0.0	1.2 ± 0.0	0.7 ± 0.0	1.2 ± 0.1	1.2 ± 0.0	1.2 ± 0.0
Saturated fat, % energy	7.9 ± 0.2	9.9 ± 0.2	10.8 ± 0.2	12.2 ± 0.2	8.1 ± 0.2	9.7 ± 0.2	10.8 ± 0.2	12.2 ± 0.2
MUFA, % energy	107 ± 0.2	12.2 ± 0.2	12.9 ± 0.2	14.3 ± 0.2	10.9 ± 0.2	12.2 ± 0.2	12.9 ± 0.2	14.1 ± 0.2
PUFA, % energy	5.4 ± 0.1[3]	5.6 ± 0.1	5.6 ± 0.1	5.8 ± 0.1	5.6 ± 0.1[3]	5.5 ± 0.1	5.6 ± 0.1	5.7 ± 0.1
Linoleic acid, % energy	4.2 ± 0.1[4]	4.4 ± 0.1	4.5 ± 0.1	4.7 ± 0.1	4.3 ± 0.1[5]	4.3 ± 0.1	4.5 ± 0.1	4.7 ± 0.1
Linolenic acid, % energy	0.8 ± 0.0[3]	0.8 ± 0.0	0.8 ± 0.0	0.8 ± 0.0	0.8 ± 0.0[6]	0.7 ± 0.0	0.8 ± 0.0	0.8 ± 0.0
Protein, % energy	16.9 ± 0.3	16.9 ± 0.3	16.1 ± 0.3	14.7 ± 0.2	17.3 ± 0.2	16.7 ± 0.3	16.2 ± 0.3	14.5 ± 0.2
Alcohol, % energy	2.1 ± 0.2[3]	3.1 ± 0.3	4.4 ± 0.4	2.8 ± 0.3	2.1 ± 0.2[3]	3.5 ± 0.3	3.7 ± 0.4	2.1 ± 0.3
Carbohydrate, % energy	54.1 ± 0.5	49.5 ± 0.5	47.6 ± 0.5	47.3 ± 0.4	52.8 ± 0.5	49.5 ± 0.5	47.8 ± 0.5	48.3 ± 0.4
Added sugar, % energy	6.9 ± 0.3	9.7 ± 0.4	11.1 ± 0.3	13.6 ± 0.3	6.9 ± 0.3	9.9 ± 0.4	11.0 ± 0.3	13.5 ± 0.3
Cholesterol density, mg/1000 kcal	102.4 ± 3.9	131.1 ± 5.1	144.5 ± 4.6	146.8 ± 3.7	100.8 ± 3.9	120.3 ± 4.7	146.8 ± 4.7	153.3 ± 3.7
Calcium density, mg/1000 kcal	454.9 ± 9.9	418.2 ± 8.9	409.6 ± 7.8	404.1 ± 7.5	463.5 ± 9.5	411.9 ± 9.2	405.5 ± 8.2	405.9 ± 7.3
Vitamin A density in retinol activity equivalent, μg/1000 kcal	465.4 ± 31.5	350.4 ± 12.7	287.5 ± 12.0	271.3 ± 11.5	470.7 ± 31.5	338.7 ± 13.9	293.7 ± 11.4	273.8 ± 11.1
Vitamin D density, μg/1000 kcal	3.2 ± 0.2	3.1 ± 0.1	2.8 ± 0.1	2.5 ± 0.1	3.0 ± 0.2[7]	3.1 ± 0.2	2.8 ± 0.1	2.6 ± 0.1
Vitamin C density, mg/1000 kcal	95.3 ± 2.5	67.8 ± 2.5	52.3 ± 2.2	42.1 ± 1.7	92.8 ± 2.5	67.1 ± 2.4	53.0 ± 2.2	44.6 ± 1.7
Sodium density, g/1000 kcal	1545 ± 28	1508 ± 40	1463 ± 22	1583 ± 26	1590 ± 28	1471 ± 40	1451 ± 24	1589 ± 25
Thiamin density, mg/1000 kcal	1.0 ± 0.01	0.9 ± 0.0	0.8 ± 0.0	0.8 ± 0.0	1.0 ± 0.0	0.8 ± 0.0	0.8 ± 0.0	0.8 ± 0.0
Riboflavin density, mg/1000 kcal	1.0 ± 0.0	0.9 ± 0.0	0.9 ± 0.0	0.9 ± 0.0	1.0 ± 0.0	0.9 ± 0.0	0.9 ± 0.0	0.9 ± 0.0
Niacin density in niacin equivalent, mg/1000 kcal	20.6 ± 0.3	20.4 ± 0.4	18.7 ± 0.3	17.1 ± 0.3	20.8 ± 0.3	20.1 ± 0.4	18.9 ± 0.3	16.9 ± 0.3
Vitamin B-6 density, mg/1000 kcal	1.2 ± 0.0	1.0 ± 0.0	0.8 ± 0.0	0.7 ± 0.0	1.2 ± 0.0	1.0 ± 0.0	0.8 ± 0.0	0.7 ± 0.0
Vitamin B-12 density, μg/1000 kcal	2.5 ± 0.2	2.1 ± 0.1	2.1 ± 0.1	1.9 ± 0.1	2.6 ± 0.2[8]	2.1 ± 0.1	2.1 ± 0.1	1.9 ± 0.1
Naturally occurring folate density,[9] μg/1000 kcal	161.4 ± 4.2	115.1 ± 2.5	97.0 ± 2.1	82.7 ± 1.8	162 ± 4.2	111.0 ± 2.1	97.8 ± 2.1	85.5 ± 1.8
Folacin density from food sources,[10] μg/1000 kcal	232.3 ± 4.6	179.3 ± 2.5	157.5 ± 2.7	135.0 ± 2.2	227.7 ± 4.4	174.6 ± 2.6	159.8 ± 3.1	141.3 ± 2.3
Phosphorus density, mg/1000 kcal	718.0 ± 9.3	662.2 ± 8.5	631.5 ± 7.4	593.6 ± 7.5	725.7 ± 8.4	656.1 ± 10.7	627.5 ± 7.7	595.7 ± 6.8

(Continued)

The American Journal of Clinical Nutrition

TABLE 5 (*Continued*)

	ED, HF, and LFD dietary pattern score quartiles				Simplified dietary pattern score quartiles[2]			
	1 (Healthiest)	2	3	4 (Least healthy)	1 (Healthiest)	2	3	4 (Least healthy)
Magnesium density, mg/1000 kcal	200.0 ± 2.9	167.5 ± 3.8	144.3 ± 1.6	124.9 ± 1.9	200.4 ± 2.9	165.8 ± 3.4	144.2 ± 1.9	126.3 ± 1.9
Iron density, mg/1000 kcal	7.9 ± 0.1	7.0 ± 0.1	6.6 ± 0.1	6.2 ± 0.1	8.0 ± 0.1	6.9 ± 0.1	6.5 ± 0.1	6.2 ± 0.1
Zinc density, mg/1000 kcal	5.8 ± 0.1	5.5 ± 0.1	5.2 ± 0.1	5.1 ± 0.1	6.0 ± 0.1	5.6 ± 0.1	5.2 ± 0.1	4.9 ± 0.1
Potassium density, mg/1000 kcal	1922 ± 22	1566 ± 20	1366 ± 15	1215 ± 16	1916 ± 23	1578 ± 20	1367 ± 16	1218 ± 15
Caffeine density, mg/1000 kcal	71.6 ± 4.5	102 ± 10.5	112.2 ± 5.8	127.0 ± 5.9	81.0 ± 4.4	115.9 ± 11.2	107.6 ± 5.2	112.6 ± 5.5
Moisture density,[11] g/1000 kcal	1751 ± 42	1432 ± 43	1258 ± 25	1221 ± 26	1650 ± 34	1444 ± 44	1335 ± 41	1242 ± 26
Glycemic index	27.8 ± 0.5	33.2 ± 1.5	30.3 ± 0.5	29.4 ± 0.5	27.0 ± 0.5	33.1 ± 1.5	30.8 ± 0.5	29.6 ± 0.5
Breakfast skippers, %	7.7 ± 1.0[12]	9.6 ± 1.3	10.0 ± 1.2	11.8 ± 1.2	7.7 ± 1.0[13]	10.4 ± 1.4	9.3 ± 1.1	11.7 ± 1.2
Energy from solid fats and added sugars, %	21.7 ± 0.6	29.0 ± 0.6	34.5 ± 0.6	41.3 ± 0.7	21.9 ± 0.5	29.6 ± 0.6	33.5 ± 0.7	41.1 ± 0.6

[1] Values are means ± SEs. n = 11,748. Estimates are weighted least-squares means and bootstrapped variances (balanced repeated replication technique). Covariate-adjusted associations were determined with the use of weighted multivariable linear regression. Values are adjusted for age, sex, and misreporting status (underreporting, plausible reporting, and overreporting) (cutoff for plausible reporting: energy intake and estimated energy requirement $\geq$ 0.7 and $\leq$1.42). The P-trend was estimated with the use of the dietary pattern score in its continuous form and represents the P value associated with the linear regression coefficient. All P value for trends are $<$0.0001 unless otherwise specified. ED, energy-dense; HF, high-fat; LFD, low–fiber density.

[2] Sum of standardized intake of fast foods; carbonated drinks; refined grains; solid fat; processed meat; cheese; baked goods; gravies, sauces, and dressings; and sugars and syrups (all with weights of 1), and whole fruits, dark-green vegetables, other vegetables and juices, orange vegetables, and yogurt (all with weights of −1).

[3] Not significant ($P \geq 0.05$) based on weighted linear regression analyses.

[4] P-trend = 0.0005.

[5] P-trend = 0.0043.

[6] P-trend = 0.0197.

[7] P-trend = 0.0056.

[8] P-trend = 0.0051.

[9] Includes various forms of folate found naturally in food.

[10] Sum of naturally occurring folate and folic acid without considering their different bioavailabilities.

[11] The water content that is abundant in fruits and vegetables such as tomatoes, romaine lettuce, and grapefruit.

[12] P-trend = 0.007.

[13] P-trend = 0.0259.

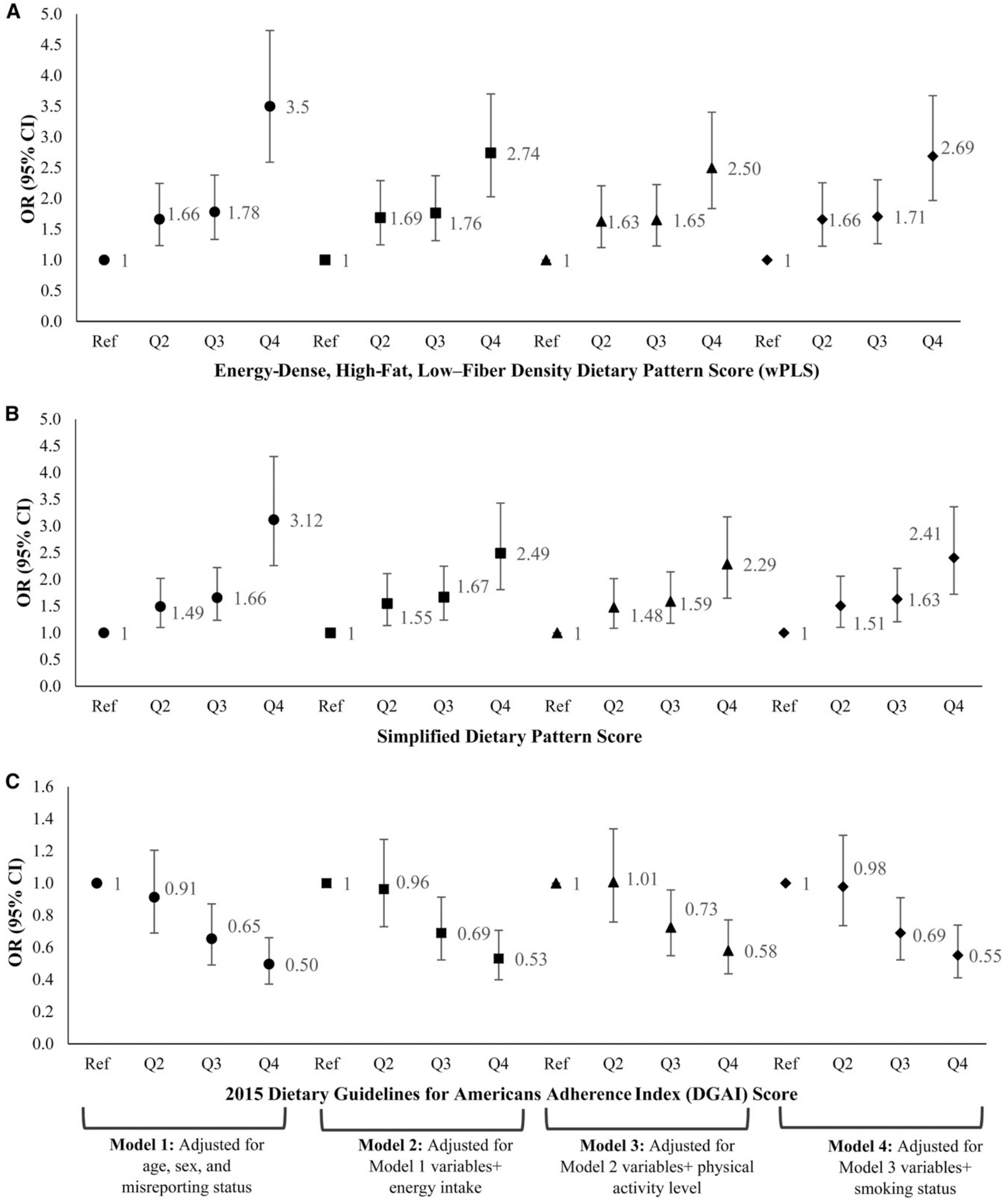

FIGURE 2 Weighted multivariate-adjusted ORs and 95% CIs for the risk of obesity [BMI (in kg/m^2) ≥30] across the quartile categories of the energy-dense, high-fat, and low–fiber density dietary pattern score derived from wPLS (centered and scaled) (A), the simplified dietary pattern score (B), and the 2015 Dietary Guidelines for Americans Adherence Index score (C) in adult participants of the Canadian Community Health Survey, cycle 2.2 (n = 11,748). Estimates are weighted ORs and bootstrapped CIs (balanced repeated replication technique) based on the multinomial logistic regression and generalized logit model. The *P*-trend represents the *P* value associated with the logistic regression coefficient for the dietary pattern score as a continuous variable. All *P*-trends are <0.0001. The simplified dietary pattern score is the sum of the standardized intake of fast foods; carbonated drinks; refined grains; solid fats; processed meats; cheese; baked goods; gravies, sauces, and dressings; and sugars and syrups (all with weights of 1); and whole fruits, dark-green vegetables, other vegetables and juices, orange vegetables, and yogurt (all with weights of −1). Dietary Guidelines for Americans Adherence Index scores ranged from 0 to 19 possible points, with higher scores indicating more healthful and varied dietary patterns. Q, quartile; Ref, reference; wPLS, weighted partial least squares.

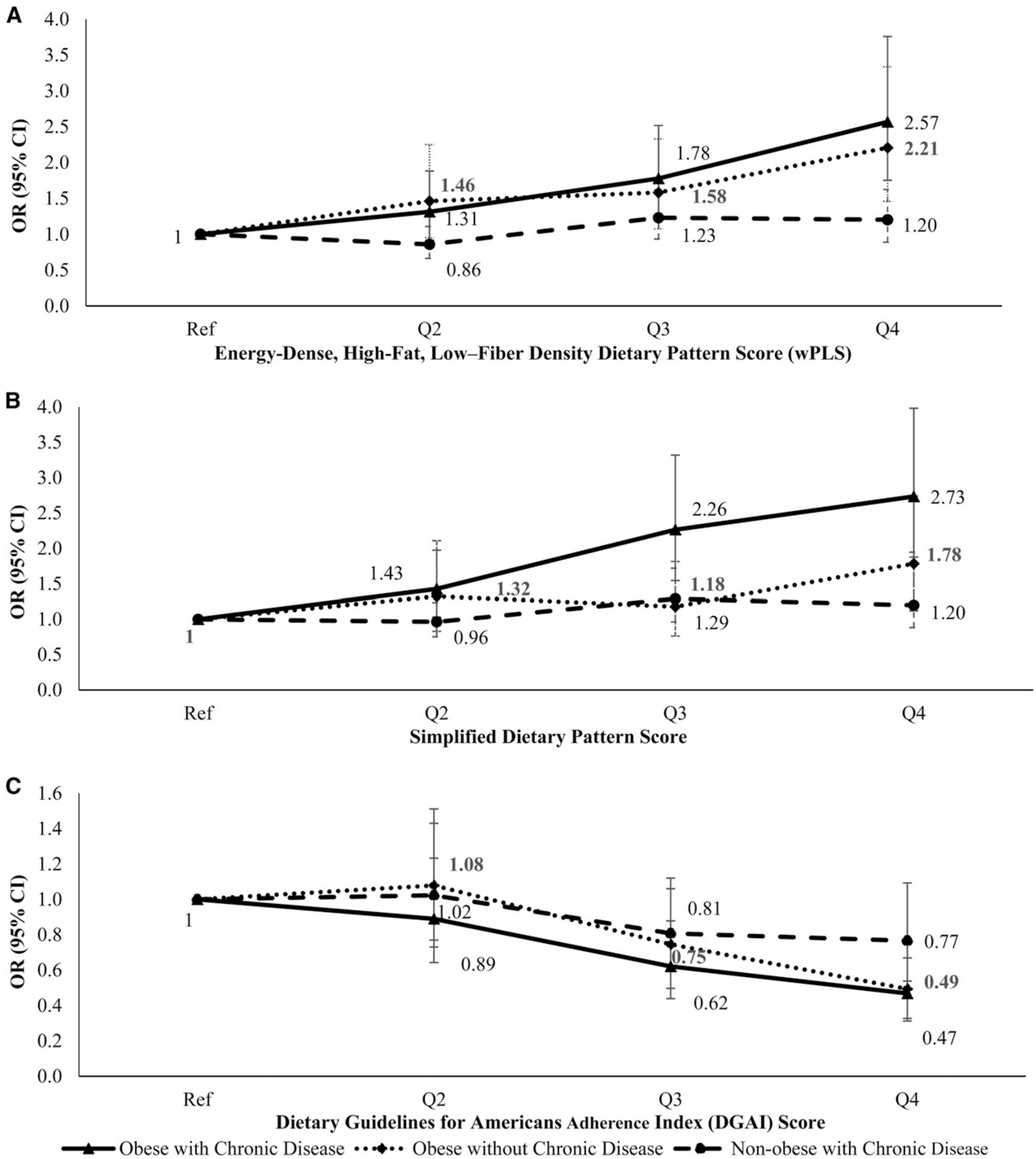

FIGURE 3 Weighted multivariate-adjusted joint classification of obesity risk with ≥1 chronic disease across the quartile categories of the energy-dense, high-fat, and low–fiber density dietary pattern score derived from wPLS (centered and scaled) (A), simplified dietary pattern score (B), and 2015 Dietary Guidelines for Americans Adherence Index (DGAI) score (C) in adult participants of the Canadian Community Health Survey, cycle 2.2 (n = 11,748). Estimates are weighted ORs and bootstrapped CIs (balanced repeated replication technique) based on the multinomial logistic regression and generalized logit model. Models are adjusted for age, sex, energy intake, physical activity level, smoking, and misreporting status (underreporter, plausible reporter, and overreporter) (cutoff for plausible reporting: energy intake/estimated energy requirement ≥0.7 and ≤1.42). The P-trend represents the P value associated with the logistic regression coefficient for the dietary pattern score as a continuous variable. Obese with chronic disease: P-trend < 0.0001; obese without chronic disease: P-trend < 0.0005 (A), P-trend < 0.0222 (B), and P-trend < 0.0004 (C); and nonobese with chronic disease: P-trend < 0.0848 (A), P-trend < 0.1015 (B), and P-trend < 0.045 (C). Nonobese without chronic disease is the reference category. The simplified dietary pattern score is the sum of standardized intake of fast foods; carbonated drinks; refined grains; solid fats; processed meats; cheese; baked goods; gravies, sauces, and dressings; and sugars and syrups (all with weights of 1), and whole fruits, dark-green vegetables, other vegetables and juices, orange vegetables, and yogurt (all with weights of −1). Dietary Guidelines for Americans Adherence Index scores ranged from 0 to 19 possible points, with higher scores indicating more healthful and varied dietary patterns. Q, quartile, Ref, reference, wPLS, weighted partial least squares.

The American Journal of Clinical Nutrition

correlation matrix and predictor loadings, mean intake of fast foods; carbonated drinks; refined grains; solid fats; processed meats; cheese; baked goods; gravies, sauces, and dressings; and sugars and syrups increased monotonically by moving from the first quartile (healthiest) of the dietary pattern score to the fourth (least healthy) (P-trend $<$ 0.0001). In contrast, there was a negative linear trend between dietary pattern score quartiles and adjusted mean intake of whole fruits, dark-green vegetables, other vegetables and juices, orange vegetables, and yogurt (P-trend $<$ 0.0001). Generally, there was an ∼2- to 4-fold difference in food group intake of participants in the first compared with the fourth quartile of the dietary pattern scores (P-trend $<$ 0.0001).

The sociodemographic and lifestyle characteristics of participants across the quartiles of the ED, HF, and LFD dietary pattern and simplified dietary pattern scores are presented in Table 4. Moving from the first to the fourth quartile of the ED, HF, and LFD dietary pattern score, the mean 2015 DGAI score and its food intake and healthy choice subscores decreased by 2.9, 1.1, and 1.8, respectively (P-trend $<$ 0.0001). Compared with the first quartile, participants in the highest quartile of the ED, HF, and LFD dietary pattern score were less likely to be female (33.8% ± 2.3% compared with 59.2% ± 3.2%, respectively), older (40.1 ± 0.5 compared with 49.5 ± 0.5 y, respectively), and a multivitamin user (35.8% ± 1.9% compared with 42.8% ± 2.4%, respectively) (P-trend $<$ 0.0001). In addition, there was a linear trend toward a higher prevalence of obesity (21.8% ± 1.4% in quartile 4 compared with 14.1% ± 1.1% in quartile 1) and being obese with ≥1 chronic disease (13.4% ± 1.0% compared with 8.4% ± 0.7%, respectively) by increasing quartiles of the ED, HF, and LFD dietary pattern score (P-trend $<$ 0.0001). Similar findings were observed across the quartiles of the simplified dietary pattern score.

The macro- and micronutrient intake across the quartile categories of the ED, HF, and LFD dietary pattern and simplified dietary pattern scores are presented in Table 5. After adjusting for age, sex, and misreporting status, quartile 4 participants had on average 300-kcal/d higher energy intake than those in quartile 1 (P-trend $<$ 0.0001). By design of the wPLS algorithm in this study, participants in quartile 4 had a higher percentage of energy as total fat (35.5% ± 0.3% compared with 27.1% ± 0.4%, respectively) and energy density (1.2 ± 0.0 compared with 0.7 ± 0.0 kcal/g, respectively), whereas their fiber density intake (5.9 ± 0.1 compared with 12.2 ± 0.2 g/1000 kcal, respectively) was significantly lower than in those in the first quartile (P-trend $<$ 0.0001). In addition, the percentage of participants who skipped breakfast (11.8% ± 1.2% compared with 7.7% ± 1%, respectively) and percentage of energy from solid fats and added sugars (41.3% ± 0.7% compared with 21.7% ± 0.6%, respectively) were significantly higher in the fourth quartile category than in the first (P-trend $<$ 0.05).

Part C: Association between dietary pattern scores and obesity

The multivariate-adjusted ORs for the risk of obesity across the quartile categories of the ED, HF, and LFD dietary pattern score are presented in Figure 2A, the simplified dietary pattern score is presented in Figure 2B, and the 2015 DGAI score is presented in Figure 2C. Moving from the lowest quartile (healthiest) of the ED, HF, and LFD dietary pattern score to the highest (least healthy), the risk of obesity mutually adjusted for all potential confounders (Model 4: age, sex, energy intake, misreporting, physical activity, and smoking) increased from an OR of 1.66 (95% CI: 1.22, 2.26) in quartile 2 to an OR of 1.71 (95% CI: 1.26, 2.30) in quartile 3 and an OR of 2.69 (95% CI: 1.97, 3.67) in quartile 4 (P-trend $<$ 0.0001). Similar-size adjusted ORs were observed for obesity risk across the quartiles of simplified dietary pattern score (P-trend $<$ 0.0001). Moving from quartile 1 to quartile 4 (healthiest) of the 2015 DGAI score decreased the risk of obesity in the fully adjusted model (OR: 0.55; 95% CI: 0.41, 0.74; P-trend $<$ 0.0001).

When participants were jointly classified for the risk of obesity, as well as having ≥1 chronic disease, differences were observed between individuals with healthy and unhealthy obesity phenotypes in the magnitude of their association with dietary pattern scores (Figure 3). Following an ED, HF, and LFD dietary pattern was associated with an increased risk of unhealthy obesity, from an OR of 1.31 (95% CI: 0.92, 1.88) in quartile 2 to an OR of 1.78 (95% CI: 1.25, 2.52) in quartile 3 and an OR of 2.57 (95% CI: 1.75, 3.76) in quartile 4 (P-trend $<$ 0.0001). Even though the risk of healthy obesity and being nonobese with ≥1 chronic disease also increased across the quartiles of the ED, HF, and LFD dietary pattern score, the magnitude of this increase was slightly weaker than that of the unhealthy obese phenotype. Classifying individuals according to the simplified dietary pattern score resulted in similar-size ORs for the risk of different obesity phenotypes (Figure 3B). Similarly, the highest quartile of the 2015 DGAI score (healthiest) was associated with a significantly lower risk of unhealthy obesity (OR: 0.47; 95% CI: 0.33, 0.67), healthy obesity (OR: 0.49; 95% CI: 0.31, 0.78), and being nonobese with ≥1 chronic disease (OR: 0.77; 95% CI: 0.54, 1.09) than that for the first quartile (least healthy) (P-trend $<$ 0.05).

Finally, we used continuous dietary pattern z scores in relation to obesity risk in strata of sex, age, reporting accuracy, physical activity, and smoking status after controlling for confounding variables (Supplemental Figures 1–3). The OR of obesity increased significantly per 1 SD increment in the ED, HF, and LFD dietary pattern z score in most of the examined subgroups. Each 1 SD increase in the ED, HF, and LFD dietary pattern z score corresponded with an OR of 1.43 (95% CI: 1.15, 1.77) for obesity in highly active individuals, followed by an OR of 1.31 (95% CI: 1.10, 1.55) in those who had moderate physical activity (P $<$ 0.002). Negative associations were observed between 1-SD increase in the 2015 DGAI z score and obesity in all population subgroups, even though the association did not reach statistical significance for male subjects, underreporters, and ever smokers (daily, occasional, or former) (Supplemental Figure 3).

DISCUSSION

In this nationally representative survey of Canadian adults, we observed a strong and consistent relation between an ED, HF, and LFD dietary pattern and the risk of obesity. This effect was significant in subpopulations with and without accompanying chronic diseases, as well as in different population subgroups (based on age, sex, reporting accuracy, physical activity, and smoking status). The simplified dietary pattern score was similarly associated with obesity phenotypes in population subgroups. Comparing these 2 dietary pattern scores with the 2015

DGAI score confirmed that the hybrid and a priori methods can be used as complementary techniques for defining dietary patterns, because they each have different strengths and target different aspects of dietary intake. Overall, the benefits of following an overall healthy dietary pattern (a priori) were compatible to those of avoiding unhealthy dietary patterns (hybrid).

The dietary pattern identified through the wPLS regression in the present study was very similar to the patterns derived to explain obesity in previous research, including the European Prospective Investigation into Cancer and Nutrition–Potsdam cohort and the UK Avon Longitudinal Study of Parents and Children, which found HF, ED, and low-fiber foods to be the main predictors of subsequent weight gain (33, 48). With the use of principal component analysis and cluster analysis in the Baltimore Study, dietary patterns high in reduced-fat dairy, high-fiber grains and cereals, and vegetables and fruits, and low in meats, soda, refined grains, and HF dairy products, were significantly associated with lower weight gain prospectively (61, 62). Similarly, an energy-dense, high–saturated fat and low-fiber dietary pattern with high loadings of fast foods and snacks and low loadings of fruits and vegetables was shown to increase body weight, waist circumference, blood pressure, serum insulin, and lipid profile during a 10-y follow-up in severely obese Swedish adults (37).

In the present study, adherence to the validated 2015 DGAI (6) was associated with an ∼50% lower risk of both obesity phenotypes, with consistent results in most population subgroups. This finding is in agreement with those of the other studies that showed an inverse relation between adherence to the Health and Human Services/USDA DGA and risk of obesity, metabolic syndrome, insulin resistance, and coronary artery disease (5, 29, 63–67). Potential mechanisms underlying these beneficial effects may include the lower energy density, added sugar, saturated fat, and processed meat content of the USDA Food Patterns, as well as their higher recommendations for the intake of fiber, fruits, vegetables, and whole grains, which have all been shown to reduce chronic disease risk (2).

The wPLS regression identified fast foods and whole fruits as the most important contributors to the obesity risk (loading criterion) in Canadian adults. In fact, predictor loadings for these food groups were almost double those of the yogurt and sugars and syrups groups, which were also significant ($\geq|0.17|$). This indicates that when the intake of all other food groups is held constant, a 1-SD change in fast food or whole fruit intake has double the effects on total dietary pattern scores compared with a similar change in intake of yogurt and sugars and syrups. Particularly, the protective effects of fruits and vegetables would have been demonstrated even more if we classified whole fruits, dark-green vegetables, other vegetables and juices, and orange vegetables into one food group, because these foods are the top negative drivers of the total wPLS-derived dietary pattern score (Figure 1). This point reinforces the importance of efforts to encourage fruit and vegetable consumption as part of a healthy dietary pattern, rather than focusing exclusively on the exclusion of HF or high energy–dense foods, such as sugars and syrups.

This study has several strengths. To our knowledge, this is the first and the largest nationally representative study to examine dietary patterns of Canadians in relation to a wide range of lifestyle and nutritional behaviors, as well as chronic disease risk. In fact, the main methodologic challenge we addressed was to incorporate sampling survey and bootstrapping weights in all algorithms to be able to characterize dietary patterns at the national population level. A simplified dietary pattern score was also constructed from the wPLS output for comparison and to facilitate the generalization of results in other populations (8), even though score components were still data-driven, preserving the advantages of hybrid dietary pattern techniques. The use of measured anthropometric measurements, confounder adjustments, and sensitivity analyses were other strengths of this research. In addition, all analyses controlled for the systematic selective and differential misreporting bias, as described previously (49).

The findings of this research should be considered in light of the limitations. Random nondifferential measurement error associated with the use of single dietary recall was inevitable, and therefore the associations observed are likely to have been attenuated (68). In addition, the presence of chronic diseases was determined with the use of self-reported data, which may have been confounded by age, because older individuals are more likely to be tested and be aware of chronic diseases. Furthermore, the large number of statistical tests conducted in this study may have statistical implications. However, it is noteworthy that adjusting for multiple comparisons with the use of conventional methods increases the probability of missing relevant associations (69), which is problematic when evaluating diet-disease relations (70, 71). In the present study, it was decided to report the actual *P* values and use previous observations and biological plausibility to interpret the results, in line with previous studies (72). Another potential limitation is that the statistical analyses were conducted under several assumptions, including homoscedasticity, residual normality, and independence, under the generalized linear model framework. Finally, because of the cross-sectional design of this survey, causal and temporal inference is limited (73).

In conclusion, in this study, higher scores for the ED, HF, and LFD dietary pattern and simplified dietary pattern were associated with an ∼2 times higher risk of obesity with and without chronic diseases. Moreover, better compliance with the 2015 DGA guidelines was associated with an ∼50% lower OR of obesity with and without accompanying chronic diseases. These results support the growing evidence that there is >1 approach for healthy eating, and that foods can be combined differently for achieving an optimal dietary pattern (74). A comparison of the 2015 DGAI components with food groups derived from the wPLS technique clearly demonstrates that a high intake of whole fruits, dark-green vegetables, other vegetables, and orange vegetables and limiting refined grains, solid fats, and added sugars are the major elements of a healthy diet in Canada, regardless of the method used for defining dietary patterns. However, the wPLS method was able to identify some additional foods specific to the Canadian population that were not considered in the 2015 DGAI, including fast foods; carbonated drinks; processed meats; cheese; baked goods; gravies, sauces, and dressings (factors contributing to obesity); and yogurt (a factor protective against obesity). These findings need to be confirmed in longitudinal studies to determine whether future a priori indexes should consider any of these food groups as index components. Future longitudinal studies are also needed to further document the benefits of adherence to a dietary pattern in line with the 2015 DGA and compare results to diets low in energy density and %EF and high in FD at the population level. Collectively, findings of this nationally representative survey can be used to generate hypotheses for future research, which can in turn inform public health policies for the prevention of diet-related chronic diseases in the Canadian population (75, 76) and others consuming Western-type diets (74).

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Online Supplemental Material.

Supplemental Table 1. Food groups used for dietary pattern analyses in the Canadian Community Health Survey, cycle 2.2.

Food Group	Food Items
Fast Foods	Pizza, sandwiches, submarines, hamburgers & cheeseburgers, and hot dog dishes; breakfast combinations (with egg, cheese, ham, etc.); fried or roasted potatoes; frozen dinners
Mixed Ethnic Dishes	Mexican dishes, Chinese dishes and soups
Pasta and Rice Dishes	Pasta, rice and cereal grain dishes
Refined Grains	White bread and breakfast cereal, other breads (rolls, bagels, pita bread, croutons, dumplings, matzo, tortilla, crackers and crispbreads)
Whole Grains	Whole wheat bread, other whole grain bread; whole grain and high fiber breakfast cereal (whole grain, oats and high fibre breakfast cereals)
Pancakes and Waffles	Pancakes and waffles
Baked Goods	Muffins and English muffins; croissants, piecrusts & phyllo dough; biscuits and cookies; squares & bars; cakes, cheesecakes, shortcakes and brownies; sweet rolls and breads; pies (pop tarts) and pie shells; dry mixes (cakes, muffins, pancakes); Danishes, doughnuts and turnovers; donuts; filled crepes, blintzes, cobblers and other pastries
Starchy Vegetables	Potatoes, corn, peas
Orange Vegetables	Red and orange vegetables (carrots, squashes, and tomatoes)
Dark Green Vegetables	Broccoli, lettuces & leafy greens (spinach, mustard greens, etc.)
Other Vegetables and Juices	Beans, cabbage and kale, cauliflower, celery, mushrooms, onion, green onions, leeks, garlic, peppers, other vegetables (cucumber, immature beans, Brussel sprouts, beets, turnips), vegetable juices
Legumes and Soy	Legumes and food made with vegetable proteins (tofu)
Whole Fruits	Citrus fruits (oranges, grapefruits, lemons, etc.), apple, banana, cherries, grapes and raisins, melons (cantaloupe, honeydew, watermelon), peaches, nectarines, pears, pineapple, plums and prunes, strawberries, other fruits (blueberries, dates, kiwis, fruit salads, dry fruits etc.)
Fruit Juice	Fruit juice
Whole-Fat Milk	Whole milk
Reduce-Fat and Skim Milk	Skim milk, reduced fat milk (1% and 2%)
Milk Substitutes	Milk substitutes including evaporated milk, condensed milk and other types of milk
Cheese	Cottage and other types of cheeses
Yogurt	Yogurts
Eggs	Eggs and frozen egg substitutes
Fish and Shellfish	Fish and shellfishes
Nuts, Seeds and Nut Butters	Nuts, seeds and nut butters and spreads
Beef, Game and Organ Meats	Beef, liver and liver pate, offal, and game meat
Veal, Lamb and Pork	Veal, lamb, and pork meat
Poultry	Chicken, turkey and other birds
Processed Meat	Sausages (fresh and cured), luncheon meats (canned and cold cuts), cured ham
Sugars and Syrups	Sugars (white and brown), jams, jellies and marmalade, other sugars (syrups, molasses, honey, etc.)

Sweet Snacks	Confectionary (candies, popsicle, sherbert, jello, dessert toppings and pudding mixes, chocolate bar, etc.); frozen dairy products (e.g., ice cream, ice milk); malted milk, instant breakfast; sweet desserts
Salty Snacks	Potato chips, tortilla chips, popcorn, plain & pretzels
Carbonated Drinks	Non-alcoholic beverages (all soft and fruit flavoured drinks)
Alcoholic Beverages	Spirits (gin, whisky, vodka, etc.), liqueurs (mint cream, etc.), wine, beers and coolers
Tea	Tea
Coffee	Coffee
Water	Water (well and mineral)
Solid Fat	Creams (whipping, table, half & half, sour), butter, tub margarine, block margarine, animal fat, shortening
Vegetable Oil	Vegetable Oil
Gravies, Sauces and Dressings	Gravies, sauces (white, béarnaise, soya, tartar, ketchup, etc.), salad dressings (with or without oil)
Seasonings	Seasonings (salt, pepper, vinegar, etc.), spices, others

Online Supplemental Material.

Supplemental Table 2. Mean intakes of obesity-related response variables among normal weight, overweight and obese adult participants of the Canadian Community Health Survey, cycle 2.2 (n=11,748)[1].

Response Variables	Normal weight	Overweight	Obese
Energy Density, *kcal/g*			
Model 1[2]	1.9±0.0[4,5]	2.0±0.0[6]	2.1±0.0
Model 2[3]	1.9±0.0[4,5]	2.0±0.0[6]	2.1±0.0
Energy from Fat, *%*			
Model 1[2]	31.2±0.3[5]	31.5±0.4[6]	33.0±0.4
Model 2[3]	31.5±0.3[5]	31.8±0.4[6]	33.3±0.4
Fiber Density, *g/1000 kcal*			
Model 1[2]	8.6±0.2[5]	8.4±0.2[6]	7.5±0.2
Model 2[3]	8.5±0.1[5]	8.3±0.2[6]	7.5±0.2

[1]Covariate-adjusted associations were determined using the weighted multivariable linear regression.
[2]Model 1: Adjusted for age, sex and misreporting status (under-reporting, plausible-reporting and over-reporting) (cut-off for plausible reporting: 0.7≤Energy Intake/Estimated Energy Requirement≤1.42)
[3]Model 2: Adjusted for variables in Model 1 as well as physical activity level and smoking status
[4]Significantly different between normal-weight and overweight (p<0.02)
[5]Significantly different between normal-weight and obese (p<0.001)
[6]Significantly different between overweight and obese (p<0.001)

Online Supplemental Material.

Supplemental Figure 1. Weighted multivariate-adjusted odds ratios (OR) and 95% confidence intervals (CI) for the obesity risk (BMI≥30 kg/m^2) according to a standardized increase (1 SD) in the energy dense, high fat, and low fiber density dietary pattern score derived from the weighted partial least squares (wPLS) (centered and scaled) among different adult subgroups in the Canadian Community Health Survey, cycle 2.2 (n=11,748).

NS: Not Significant
Estimates are weighted odds ratios and bootstrapped confidence intervals (Balanced Repeated Replication technique) based on the multinomial logistic regression- generalized logit model.
Models are adjusted for age, sex, energy intake, physical activity level, smoking and misreporting status (under-reporter, plausible reporter and over-reporter) (cut-off for plausible reporting: 0.7≤Energy Intake/Estimated Energy Requirement≤1.42), unless when these variables are evaluated as the main subgroup.
The p-value is associated with logistic regression coefficient.

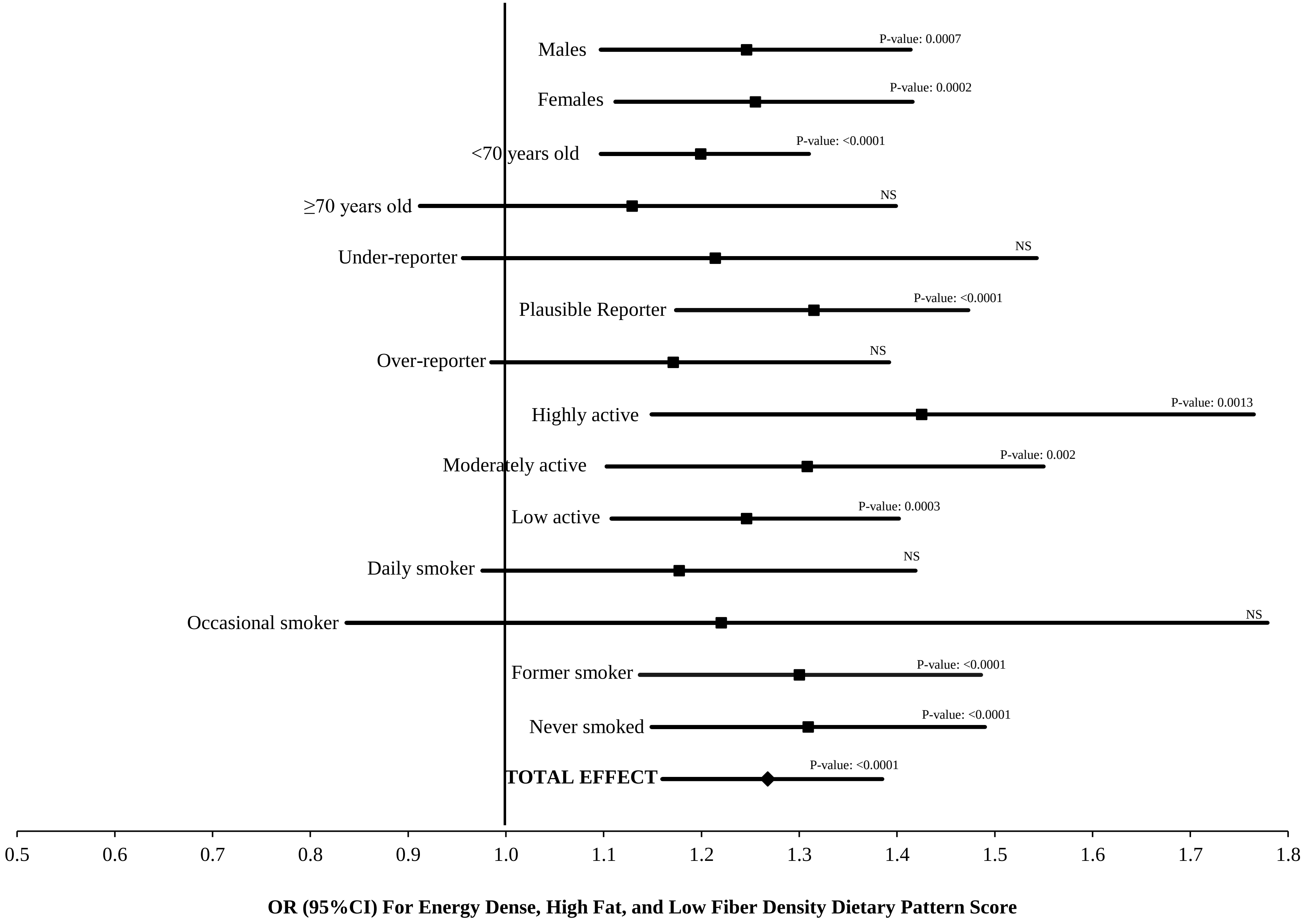
Supplemental Figure 2. Weighted multivariate-adjusted odds ratios (OR) and 95% confidence intervals (CI) for the obesity risk (BMI≥30 kg/m^2) according to a standardized increase (1 SD) in the simplified dietary pattern score among different adult subgroups in the Canadian Community Health Survey, cycle 2.2 (n=11,748).

NS: Not Significant
Estimates are weighted odds ratios and bootstrapped confidence intervals (Balanced Repeated Replication technique) based on the multinomial logistic regression- generalized logit model.
Models are adjusted for age, sex, energy intake, physical activity level, smoking and misreporting status (under-reporter, plausible reporter and over-reporter) (cut-off for plausible reporting: 0.7≤Energy Intake/Estimated Energy Requirement≤1.42), unless when these variables are evaluated as the main subgroup.
The p-value is associated with logistic regression coefficient.
Simplified dietary pattern score is the sum of standardized intakes of fast foods, carbonated drinks, refined grains, solid fats, processed meats, cheese, baked goods, gravies, sauces and dressings, sugars and syrups (all with +1 weights), and whole fruits, dark green vegetables, other vegetables and juices, orange vegetables and yogurt (all with -1 weights).

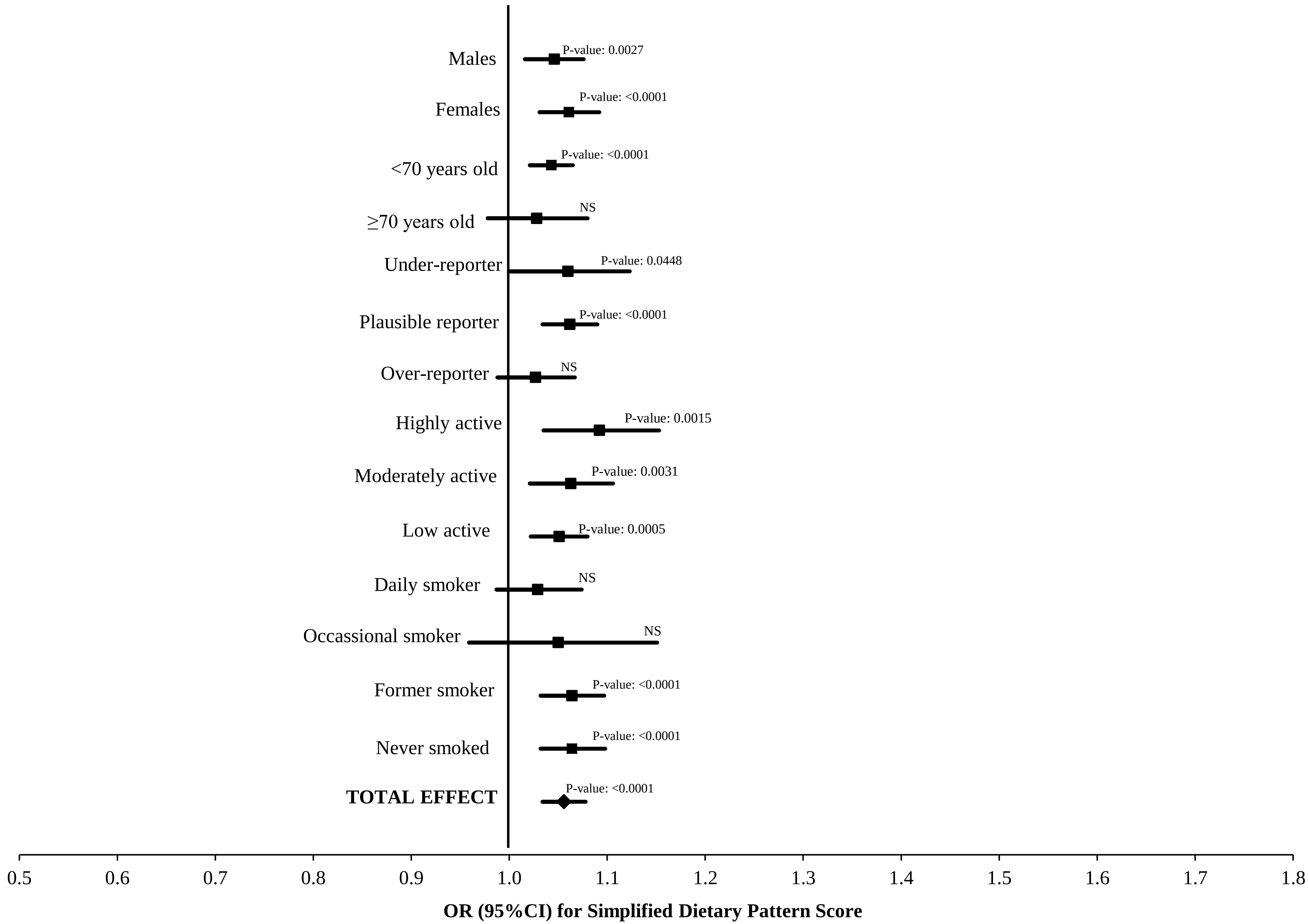
Supplemental Figure 3. Weighted multivariate-adjusted odds ratios (OR) and 95% confidence intervals (CI) for the obesity risk (BMI≥30 kg/m^2) according to a standardized increase (1 SD) in the 2015 Dietary Guidelines for Americans Adherence Index (DGAI) score among different adult subgroups in the Canadian Community Health Survey, cycle 2.2 (n=11,748).

NS: Not Significant
Estimates are weighted odds ratios and bootstrapped confidence intervals (Balanced Repeated Replication technique) based on the multinomial logistic regression- generalized logit model.
Models are adjusted for age, sex, energy intake, physical activity level, smoking and misreporting status (under-reporter, plausible reporter and over-reporter) (cut-off for plausible reporting: 0.7≤Energy Intake/Estimated Energy Requirement≤1.42), unless when these variables are evaluated as the main subgroup.
The p-value is associated with logistic regression coefficient.
Dietary Guidelines for Americans Adherence Index (DGAI) scores ranged from 0-19 possible points with higher scores indicating more healthful and varied dietary patterns.

Online Supplemental Material.
Supplemental Figure 1.



Online Supplemental Material.
Supplemental Figure 2.



Online Supplemental Material.
Supplemental Figure 3.