**Supplementary Table 1 Subcategories of macronutrients and food groups.**

| **Subcategories of macronutrients** | **Food groups** |
| --- | --- |
| **High-quality carbohydrates** | whole grains (ounce equivalent), legumes (cup equivalent), whole fruits (cup equivalent), and non-starchy vegetables (cup equivalent) |
| **Low-quality carbohydrates** | refined grains (ounce equivalent), fruit juice (cup equivalent), potato (cup equivalent), other starchy vegetables (cup equivalent), and added sugars (teaspoon equivalent) |
| **Animal protein** | red meat (ounce equivalent), processed meat (ounce equivalent), poultry (ounce equivalent), seafood (ounce equivalent), dairy (cup equivalent), and eggs (ounce equivalent) |
| **Plant protein** | whole grains (ounce equivalent), refined grains (ounce equivalent), legumes (cup equivalent), nuts (ounce equivalent), and soy (ounce equivalent) |

**Supplementary Table 2** Characteristics in terms of quartile of Δratio of energy consumption between dinner and breakfast: NHANES, 2003–2016

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Variables | Quintile 1  (N = 6971) | Quintile 2  (N = 6981) | Quintile 3  (N = 6987) | Quintile4  (N = 6972) | P-value |
| Age, years | 48.93 (0.37) | 47.55 (0.36) | 46.89 (0.32) | 46.75 (0.36) | <0.001\* |
| Female, % | 3772 (54.90) | 3533 (51.58) | 3514 (50.10) | 3685 (53.11) | <0.001\* |
| Non-Hispanic white, % | 2459 (59.52) | 3323 (70.43) | 3620 (73.11) | 3586 (71.96) | <0.001\* |
| BMI, kg/m2 | 28.57 (0.14) | 28.84 (0.13) | 28.79 (0.14) | 28.83 (0.12) | 0.174 |
| Waist circumstance, cm | 97.97 (0.33) | 98.88 (0.32) | 98.90 (0.36) | 98.71 (0.30) | 0.002\* |
| College graduate or above, % | 1253 (23.72) | 1759 (31.27) | 1863 (32.61) | 1665 (29.27) | <0.001\* |
| >$100,000 annual household income, % | 592 (13.56) | 877 (17.72) | 985 (20.41) | 864 (17.01) | <0.001\* |
| Exercise regularly, % | 1458 (25.12) | 1602 (26.47) | 1674 (27.17) | 1619 (25.86) | 0.270 |
| Current smoker, % | 1347 (20.89) | 1573 (22.87) | 1619 (22.48) | 1801 (27.05) | <0.001\* |
| Current drinker, % | 4456 (67.78) | 4739 (73.09) | 4963 (75.58) | 4860 (74.41) | <0.001\* |
| Medicine use for lower blood sugar, % | 823 (8.45) | 666 (6.89) | 615 (6.54) | 579 (5.36) | <0.001\* |
| Medicine use for hypertension, % | 2047 (23.57) | 1971 (23.48) | 1829 (22.17) | 1905 (22.92) | 0.537 |
| Medicine use for cholesterol, % | 1429 (17.08) | 1334 (16.85) | 1269 (15.99) | 1294 (17.10) | 0.466 |
| Total energy, kcal/day | 1965.19 (12.64) | 2140.32 (11.50) | 2158.33 (14.07) | 1933.04 (12.28) | <0.001\* |
| Energy at breakfast, kcal/day | 664.23 (7.11) | 411.10 (4.13) | 302.14 (4.04) | 200.13 (3.45) | <0.001\* |
| Energy at dinner, kcal/day | 325.13 (5.69) | 559.05 (4.43) | 812.72 (5.93) | 1226.00 (10.09) | <0.001\* |
| Total fat, g/day | 73.77 (0.62) | 81.43 (0.57) | 83.20 (0.67) | 74.41 (0.62) | <0.001\* |
| Total protein, g/day | 77.36 (0.62) | 84.17 (0.60) | 84.84 (0.57) | 77.33 (0.62) | <0.001\* |
| SFA, g/day | 24.00 (0.25) | 26.55 (0.22) | 27.40 (0.24) | 24.28 (0.22) | <0.001\* |
| Dietary fiber, g/day | 16.73 (0.19) | 17.50 (0.16) | 17.12 (0.20) | 15.25 (0.17) | <0.001\* |
| Dietary cholesterol, mg/day | 294.97 (3.58) | 293.54 (3.22) | 287.62 (3.01) | 257.54 (3.12) | <0.001\* |
| Dietary supplements use, % | 3503 (54.19) | 3671 (55.39) | 3680 (56.51) | 3446 (51.82) | 0.001\* |
| AHEI | 52.67 (0.23) | 56.19 (0.23) | 56.63 (0.26) | 52.56 (0.23) | <0.001\* |
| Hypercholesterolemia, % | 3069 (41.77) | 2880 (40.62) | 2874 (40.97) | 2874 (41.32) | 0.772 |

All data analyses in the present study were based on weighted estimates with sample weights provided by the NHANES. Continuous variables were presented as mean (standard error). Categorical variables were presented as n (%). *P* values were calculated by general linear model for continuous variables adjusting for age and the chi-squared test for categorical variables.

BMI, body mass index; SFA, saturated fatty acid; AHEI, alternative healthy eating index

\*P < 0.05

**Supplementary Table 3** Association between ratio of energy and macronutrients consumption at breakfast, dinner, and Δratio and the odds ratios of being hypercholesterolemia in participants without breakfast skipping.

|  |  |  |  |
| --- | --- | --- | --- |
| Ratio of energy and macronutrients | Hypercholesterolemia, OR (95% CI) | | |
| Breakfast | Dinner | ΔRatio |
| Energy |  |  |  |
| Q1 | 1.00 (ref) | 1.00 (ref) | 1.00 (ref) |
| Q2 | 0.93 (0.82-1.05) | 0.98 (0.85-1.13) | 1.00 (0.88-1.15) |
| Q3 | 0.73 (0.63-0.84) | 1.03 (0.89-1.19) | 1.09 (0.95-1.25) |
| Q4 | 0.84 (0.73-0.96) | 1.08 (0.94-1.23) | 1.15 (0.99-1.33) |
| P for trend | **0.001\*** | 0.216 | **0.034\*** |
| Carbohydrate |  |  |  |
| Q1 | 1.00 (ref) | 1.00 (ref) | 1.00 (ref) |
| Q2 | 0.92 (0.82-1.04) | 0.99 (0.83-1.17) | 1.10 (0.95-1.27) |
| Q3 | 0.87 (0.76-0.99) | 1.09 (0.95-1.26) | 1.16 (1.01-1.33) |
| Q4 | 0.91 (0.80-1.03) | 1.10 (0.95-1.27) | 1.20 (1.04-1.39) |
| P for trend | 0.123 | 0.123 | **0.010\*** |
| Fat |  |  |  |
| Q1 | 1.00 (ref) | 1.00 (ref) | 1.00 (ref) |
| Q2 | 0.89 (0.78-1.01) | 0.97 (0.84-1.13) | 1.04 (0.90-1.19) |
| Q3 | 0.79 (0.68-0.91) | 0.97 (0.84-1.14) | 1.10 (0.94-1.27) |
| Q4 | 0.82 (0.72-0.94) | 1.00 (0.86-1.16) | 1.11 (0.96-1.27) |
| P for trend | **0.005\*** | 0.906 | 0.125 |
| Protein |  |  |  |
| Q1 | 1.00 (ref) | 1.00 (ref) | 1.00 (ref) |
| Q2 | 0.87 (0.75-1.01) | 0.99 (0.86-1.14) | 1.12 (0.96-1.32) |
| Q3 | 0.89 (0.77-1.03) | 1.00 (0.88-1.13) | 1.16 (1.01-1.32) |
| Q4 | 0.79 (0.68-0.91) | 0.98 (0.83-1.14) | 1.13 (0.97-1.32) |
| P for trend | **0.002\*** | 0.818 | 0.142 |

Models were adjusted for age, sex, ethnicity, income, education, exercise, smoke, alcohol intake, BMI, prescription medication used for lower blood sugar, prescription medication used for hypertension, and prescription medication used for cholesterol, total intake of energy, fat, protein, SFA, high-quality carbohydrate, animal protein, dietary fiber, dietary cholesterol, AHEI, supplement use, and breakfast skipping.

BMI, body mass index; SFA, saturated fatty acid; AHEI, alternative healthy eating index; Q, quintile

\*P < 0.05

**Supplementary Table 4** Association between ratio of subcategories of macronutrients consumption at breakfast, dinner, and ΔRatio and the odds ratios of being hypercholesterolemia in participants without breakfast skipping.

|  |  |  |  |
| --- | --- | --- | --- |
| Ratio of subcategories of macronutrients | Hypercholesterolemia, OR (95% CI) | | |
| Breakfast | Dinner | ΔRatio |
| High-quality carbohydrates |  |  |  |
| Q1 | 1.00 (ref) | 1.00 (ref) | 1.00 (ref) |
| Q2 | 0.93 (0.79-1.10) | 0.91 (0.77-1.08) | 0.95 (0.81-1.10) |
| Q3 | 0.95 (0.81-1.12) | 1.00 (0.88-1.15) | 0.99 (0.86-1.13) |
| Q4 | 0.93 (0.79-1.09) | 0.95 (0.80-1.13) | 1.07 (0.92-1.25) |
| P for trend | 0.508 | 0.870 | 0.246 |
| Low-quality carbohydrates |  |  |  |
| Q1 | 1.00 (ref) | 1.00 (ref) | 1.00 (ref) |
| Q2 | 0.93 (0.80-1.08) | 1.04 (0.88-1.22) | 1.15 (1.01-1.31) |
| Q3 | 0.93 (0.80-1.08) | 1.22 (1.06-1.41) | 1.26 (1.12-1.43) |
| Q4 | 0.83 (0.73-0.94) | 1.10 (0.96-1.27) | 1.25 (1.10-1.42) |
| P for trend | **0.010\*** | 0.063 | **<0.001\*** |
| SFA |  |  |  |
| Q1 | 1.00 (ref) | 1.00 (ref) | 1.00 (ref) |
| Q2 | 0.85 (0.75-0.97) | 0.98 (0.85-1.14) | 0.95 (0.81-1.12) |
| Q3 | 0.73 (0.62-0.85) | 0.94 (0.81-1.08) | 1.04 (0.88-1.22) |
| Q4 | 0.83 (0.71-0.96) | 1.04 (0.91-1.19) | 1.08 (0.92-1.27) |
| P for trend | **0.012\*** | 0.570 | 0.161 |
| USFA |  |  |  |
| Q1 | 1.00 (ref) | 1.00 (ref) | 1.00 (ref) |
| Q2 | 0.92 (0.80-1.05) | 1.00 (0.85-1.17) | 1.13 (0.97-1.31) |
| Q3 | 0.79 (0.68-0.93) | 0.97 (0.82-1.15) | 1.17 (1.02-1.35) |
| Q4 | 0.83 (0.72-0.96) | 0.99 (0.86-1.14) | 1.15 (0.99-1.33) |
| P for trend | **0.006\*** | 0.863 | 0.084 |
| Animal protein |  |  |  |
| Q1 | 1.00 (ref) | 1.00 (ref) | 1.00 (ref) |
| Q2 | 0.93 (0.82-1.06) | 0.97 (0.84-1.14) | 0.93 (0.80-1.09) |
| Q3 | 0.81 (0.70-0.95) | 1.03 (0.89-1.20) | 0.98 (0.86-1.13) |
| Q4 | 0.87 (0.76-1.01) | 1.07 (0.93-1.23) | 1.09 (0.93-1.28) |
| P for trend | 0.056 | 0.241 | 0.178 |
| Plant protein |  |  |  |
| Q1 | 1.00 (ref) | 1.00 (ref) | 1.00 (ref) |
| Q2 | 0.86 (0.75-0.97) | 0.96 (0.83-1.11) | 1.21 (1.04-1.40) |
| Q3 | 0.85 (0.74-0.98) | 1.06 (0.90-1.25) | 1.17 (0.99-1.39) |
| Q4 | 0.78 (0.69-0.89) | 1.00 (0.86-1.15) | 1.22 (1.07-1.39) |
| P for trend | **<0.001\*** | 0.721 | **0.010\*** |

Models were adjusted for age, sex, ethnicity, income, education, exercise, smoke, alcohol intake, BMI, prescription medication used for lower blood sugar, prescription medication used for hypertension, and prescription medication used for cholesterol, total intake of energy, fat, protein, SFA, high-quality carbohydrate, animal protein, dietary fiber, dietary cholesterol, AHEI, supplement use, and breakfast skipping.

BMI, body mass index; SFA, saturated fatty acid; USFA, unsaturated fatty acid; AHEI, alternative healthy eating index; Q, quintile

\*P < 0.05

**Supplementary Table 5** Substitution effects with one cup/ounce/tsp equivalent decrease of food at dinner and simultaneous one cup/ounce/tsp equivalent increase at breakfast with hypercholesterolemia in participants without breakfast skipping

|  |  |
| --- | --- |
| **Substitution effect** | **Hypercholesterolemia OR (95% CI)** |
| **High-quality carbohydrate** |  |
| Whole grains | 0.97 (0.85-1.10) |
| Legumes | 0.85 (0.51-1.41) |
| Whole fruits | 0.93 (0.77-1.12) |
| Non-starchy vegetables | 0.94 (0.81-1.08) |
| **Low-quality carbohydrate** |  |
| Refined grains | 0.95 (0.91-0.99) \* |
| Fruit juice | 1.04 (0.81-1.34) |
| Potato | 1.06 (0.76-1.47) |
| Other starchy vegetable | 1.78 (0.84-3.76) |
| Added sugar | 0.97 (0.96-0.99) \* |
| **Animal protein** |  |
| Red meat | 1.03 (0.95-1.11) |
| Processed meat | 0.96 (0.92-1.00) \* |
| Poultry | 0.95 (0.88-1.03) |
| Seafood | 0.94 (0.86-1.04) |
| Dairy | 0.94 (0.85-1.04) |
| Eggs | 0.86 (0.70-1.05) |
| **Plant protein** |  |
| Whole grains | 0.97 (0.85-1.10) |
| Refined grains | 0.95 (0.91-0.99) \* |
| Legumes | 0.85 (0.51-1.41) |
| Nuts | 0.84 (0.75-0.95) \* |
| Soy | 1.16 (0.79-1.70) |

Models were adjusted for age, sex, ethnicity, income, education, exercise, smoke, alcohol intake, BMI, prescription medication used for lower blood sugar, prescription medication used for hypertension, prescription medication used for cholesterol, total intake of energy, fat, protein, SFA, high-quality carbohydrates, animal protein, dietary fiber, dietary cholesterol, AHEI, supplement use, and breakfast skipping. For each food, models were additionally adjusted for the daily total intake of this kind of food.

BMI, body mass index; SFA, saturated fatty acid; AHEI, alternative healthy eating index

\*P < 0.05

**Supplementary Table 6** Association between percentage energy from macronutrients at breakfast, dinner, and Δ(percentage energy from macronutrients at dinner - breakfast) and the odds ratios of being hypercholesterolemia.

|  |  |  |  |
| --- | --- | --- | --- |
| Ratio of energy and macronutrients | Hypercholesterolemia, OR (95% CI) | | |
| Breakfast | Dinner | ΔRatio |
| Carbohydrate |  |  |  |
| Q1 | 1.00 (ref) | 1.00 (ref) | 1.00 (ref) |
| Q2 | 0.96 (0.82-1.11) | 1.02 (0.89-1.18) | 1.13 (1.00-1.28) |
| Q3 | 0.88 (0.76-1.02) | 1.02 (0.90-1.16) | 1.24 (1.09-1.41) |
| Q4 | **0.85 (0.74-0.99)** | 1.04 (0.91-1.19) | 1.14 (0.99-1.32) |
| P for trend | 0.020 | 0.529 | 0.065 |
| Fat |  |  |  |
| Q1 | 1.00 (ref) | 1.00 (ref) | 1.00 (ref) |
| Q2 | 0.90 (0.77-1.06) | 1.01 (0.87-1.16) | 1.03 (0.90-1.19) |
| Q3 | **0.77 (0.65-0.91)** | 0.97 (0.85-1.10) | 1.03 (0.89-1.18) |
| Q4 | **0.79 (0.69-0.92)** | 0.99 (0.86-1.14) | **1.16 (1.02-1.33)** |
| P for trend | **0.001** | 0.833 | 0.017 |
| Protein |  |  |  |
| Q1 | 1.00 (ref) | 1.00 (ref) | 1.00 (ref) |
| Q2 | **0.84 (0.72-0.97)** | 0.98 (0.87-1.10) | 1.16 (1.01-1.32) |
| Q3 | **0.77 (0.66-0.91)** | 0.95 (0.85-1.06) | 1.09 (0.96-1.24) |
| Q4 | **0.76 (0.66-0.87)** | 1.01 (0.87-1.16) | 1.13 (0.97-1.32) |
| P for trend | **<0.001** | 0.920 | 0.219 |

Models were adjusted for age, sex, ethnicity, income, education, exercise, smoke, alcohol intake, BMI, prescription medication used for lower blood sugar, prescription medication used for hypertension, and prescription medication used for cholesterol, total intake of energy, fat, protein, SFA, high-quality carbohydrate, animal protein, dietary fiber, dietary cholesterol, AHEI, supplement use, and breakfast skipping.

BMI, body mass index; AHEI, alternative healthy eating index; Q, quintile

\*P < 0.05

**Supplementary Table 7** Association between macronutrients consumption at breakfast, dinner, and Δ(dinner - breakfast) measured in energy-adjusted form (units per 1000 kcal per day) and the odds ratios of being hypercholesterolemia.

|  |  |  |  |
| --- | --- | --- | --- |
| Macronutrients in energy-adjusted form | Hypercholesterolemia, OR (95% CI) | | |
| Breakfast | Dinner | ΔRatio |
| High-quality carbohydrates |  |  |  |
| Q1 | 1.00 (ref) | 1.00 (ref) | 1.00 (ref) |
| Q2 | 0.97 (0.84-1.13) | 0.95 (0.82-1.09) | 0.95 (0.83-1.10) |
| Q3 | 0.92 (0.79-1.06) | 0.91 (0.78-1.06) | 1.00 (0.88-1.13) |
| Q4 | **0.92 (0.77-1.11)** | **1.00 (0.84-1.19)** | **1.03 (0.90-1.18)** |
| P for trend | **0.394** | 0.808 | 0.473 |
| Low-quality carbohydrates |  |  |  |
| Q1 | 1.00 (ref) | 1.00 (ref) | 1.00 (ref) |
| Q2 | 0.91 (0.81-1.04) | 1.00 (0.88-1.14) | 1.20 (1.07-1.35) |
| Q3 | 0.88 (0.76-1.03) | 1.04 (0.91-1.20) | 1.28 (1.15-1.43) |
| Q4 | **0.77 (0.68-0.87)** | **1.01 (0.88-1.15)** | **1.17 (1.02-1.34)** |
| P for trend | **<0.001** | 0.814 | 0.022 |
| SFA |  |  |  |
| Q1 | 1.00 (ref) | 1.00 (ref) | 1.00 (ref) |
| Q2 | 1.02 (0.85-1.21) | 0.91 (0.81-1.02) | 0.95 (0.82-1.10) |
| Q3 | 0.85 (0.71-1.02) | 0.90 (0.79-1.02) | 1.07 (0.93-1.25) |
| Q4 | 0.85 (0.71-1.01) | 0.98 (0.87-1.11) | 1.09 (0.95-1.25) |
| P for trend | 0.007 | 0.932 | 0.069 |
| USFA |  |  |  |
| Q1 | 1.00 (ref) | 1.00 (ref) | 1.00 (ref) |
| Q2 | 0.90 (0.76-1.07) | 1.03 (0.89-1.19) | 1.05 (0.92-1.21) |
| Q3 | 0.80 (0.68-0.94) | 0.97 (0.85-1.10) | 1.07 (0.94-1.21) |
| Q4 | 0.77 (0.67-0.89) | 0.98 (0.86-1.13) | **1.15 (1.01-1.31)** |
| P for trend | <0.001 | 0.686 | 0.041 |
| Animal protein |  |  |  |
| Q1 | 1.00 (ref) | 1.00 (ref) | 1.00 (ref) |
| Q2 | **0.92 (0.80-1.05)** | 0.99 (0.87-1.12) | 0.88 (0.76-1.03) |
| Q3 | **0.82 (0.71-0.95)** | 0.98 (0.85-1.14) | 1.04 (0.91-1.19) |
| Q4 | **0.85 (0.73-0.98)** | 1.03 (0.86-1.24) | 1.07 (0.90-1.27) |
| P for trend | **0.039** | 0.672 | 0.219 |
| Plant protein |  |  |  |
| Q1 | 1.00 (ref) | 1.00 (ref) | 1.00 (ref) |
| Q2 | **0.95 (0.83-1.09)** | 1.01 (0.89-1.14) | 1.08 (0.95-1.23) |
| Q3 | **0.83 (0.71-0.96)** | 1.05 (0.90-1.23) | 1.12 (0.98-1.30) |
| Q4 | **0.89 (0.77-1.02)** | 1.06 (0.92-1.22) | **1.14 (1.01-1.29)** |
| P for trend | **0.039** | 0.358 | 0.040 |

Models were adjusted for age, sex, ethnicity, income, education, exercise, smoke, alcohol intake, BMI, prescription medication used for lower blood sugar, prescription medication used for hypertension, and prescription medication used for cholesterol, total intake of energy, fat, protein, SFA, high-quality carbohydrate, animal protein, dietary fiber, dietary cholesterol, AHEI, supplement use, and breakfast skipping.

BMI, body mass index; SFA, saturated fatty acid; USFA, unsaturated fatty acid; AHEI, alternative healthy eating index; Q, quintile

\*P < 0.05

**Supplementary Table 8** Association between ratio of energy and macronutrients consumption at breakfast, dinner, and Δratio and the odds ratios of being hypercholesterolemia.

|  |  |  |  |
| --- | --- | --- | --- |
| Macronutrients in energy-adjusted form | Hypercholesterolemia, OR (95% CI) | | |
| Breakfast | Dinner | ΔRatio |
| Energy |  |  |  |
| Q1 | 1.00 (ref) | 1.00 (ref) | 1.00 (ref) |
| Q2 | 1.03 (0.77-1.37) | 1.02 (0.79-1.33) | 1.16 (0.86-1.58) |
| Q3 | 0.74 (0.52-1.04) | 0.90 (0.69-1.19) | 1.13 (0.88-1.44) |
| Q4 | 0.84 (0.59-1.20) | 1.19 (0.89-1.59) | **1.31 (1.01-1.71)** |
| P for trend | 0.151 | 0.262 | **0.058** |
| High-quality carbohydrates |  |  |  |
| Q1 | 1.00 (ref) | 1.00 (ref) | 1.00 (ref) |
| Q2 | 1.10 (0.81-1.49) | 0.88 (0.68-1.15) | 0.93 (0.68-1.27) |
| Q3 | 1.00 (0.71-1.40) | 1.23 (0.93-1.62) | 0.94 (0.71-1.25) |
| Q4 | 1.18 (0.85-1.62) | 1.05 (0.79-1.41) | 0.99 (0.72-1.36) |
| P for trend | 0.367 | 0.373 | 0.958 |
| Low-quality carbohydrates |  |  |  |
| Q1 | 1.00 (ref) | 1.00 (ref) | 1.00 (ref) |
| Q2 | 0.83 (0.64-1.07) | 1.26 (0.96-1.64) | 1.01 (0.78-1.29) |
| Q3 | 0.88 (0.65-1.18) | 1.36 (1.03-1.79) | 1.15 (0.89-1.48) |
| Q4 | 0.79 (0.60-1.04) | 1.26 (0.96-1.67) | 1.20 (0.90-1.59) |
| P for trend | 0.140 | 0.104 | 0.139 |
| SFA |  |  |  |
| Q1 | 1.00 (ref) | 1.00 (ref) | 1.00 (ref) |
| Q2 | 1.24 (0.88-1.73) | 0.69 (0.52-0.91) | 0.98 (0.76-1.27) |
| Q3 | 0.87 (0.61-1.24) | 0.83 (0.66-1.04) | 1.00 (0.78-1.29) |
| Q4 | 0.91 (0.64-1.28) | 0.95 (0.74-1.22) | 1.22 (0.95-1.56) |
| P for trend | 0.101 | 0.654 | 0.094 |
| USFA |  |  |  |
| Q1 | 1.00 (ref) | 1.00 (ref) | 1.00 (ref) |
| Q2 | 1.20 (0.80-1.78) | 0.82 (0.62-1.08) | 1.04 (0.78-1.36) |
| Q3 | 0.92 (0.65-1.29) | 0.78 (0.62-0.98) | 0.88 (0.71-1.09) |
| Q4 | 0.92 (0.63-1.35) | 0.96 (0.72-1.26) | 1.20 (0.90-1.60) |
| P for trend | 0.200 | 0.873 | 0.246 |
| Animal protein |  |  |  |
| Q1 | 1.00 (ref) | 1.00 (ref) | 1.00 (ref) |
| Q2 | 1.02 (0.78-1.34) | 0.85 (0.63-1.15) | 0.90 (0.68-1.24) |
| Q3 | 0.85 (0.63-1.14) | 0.93 (0.70-1.24) | 0.85 (0.64-1.13) |
| Q4 | 1.12 (0.85-1.49) | 1.10 (0.81-1.47) | 1.13 (0.80-1.58) |
| P for trend | 0.537 | 0.371 | 0.461 |
| Plant protein |  |  |  |
| Q1 | 1.00 (ref) | 1.00 (ref) | 1.00 (ref) |
| Q2 | 1.04 (0.81-1.34) | 0.98 (0.75-1.29) | 1.31 (1.02-1.68) |
| Q3 | 0.93 (0.68-1.25) | 1.23 (0.92-1.65) | 1.26 (0.92-1.73) |
| Q4 | 0.80 (0.61-1.07) | 1.04 (0.77-1.40) | 1.30 (0.95-1.78) |
| P for trend | 0.136 | 0.535 | 0.164 |

Models were adjusted for age, sex, ethnicity, income, education, exercise, smoke, alcohol intake, BMI, prescription medication used for lower blood sugar, prescription medication used for hypertension, and prescription medication used for cholesterol, total intake of energy, fat, protein, SFA, high-quality carbohydrate, animal protein, dietary fiber, dietary cholesterol, AHEI, supplement use, breakfast skipping, and non-HDL-C level (mmol/L).

BMI, body mass index; SFA, saturated fatty acid; USFA, unsaturated fatty acid; AHEI, alternative healthy eating index; Q, quintile

\*P < 0.05

**Supplementary Table 9** Association between the ratio of energy and macronutrient consumption at breakfast, dinner, and Δratio and the odds ratios of being hypercholesterolemia.

|  |  |  |  |
| --- | --- | --- | --- |
| Ratio of energy and macronutrients | Hypercholesterolemia, OR (95% CI) | | |
| Breakfast | Dinner | ΔRatio |
| Energy |  |  |  |
| Q1 | 1.00 (ref) | 1.00 (ref) | 1.00 (ref) |
| Q2 | 0.86 (0.74-0.99) | 0.95 (0.82-1.09) | 1.04 (0.91-1.19) |
| Q3 | 0.70 (0.60-0.80) | 0.99 (0.87-1.13) | 1.09 (0.96-1.25) |
| Q4 | 0.75 (0.65-0.87) | 1.02 (0.90-1.15) | 1.16 (1.01-1.34) |
| P for trend | **<0.001\*** | 0.565 | **0.040\*** |
| Carbohydrate |  |  |  |
| Q1 | 1.00 (ref) | 1.00 (ref) | 1.00 (ref) |
| Q2 | 0.94 (0.80-1.10) | 0.96 (0.82-1.12) | 1.03 (0.91-1.17) |
| Q3 | 0.86 (0.75-1.00) | 1.05 (0.92-1.20) | 1.16 (1.02-1.31) |
| Q4 | 0.89 (0.76-1.03) | 1.05 (0.93-1.19) | 1.15 (1.01-1.31) |
| P for trend | 0.092 | 0.242 | **0.022\*** |
| Fat |  |  |  |
| Q1 | 1.00 (ref) | 1.00 (ref) | 1.00 (ref) |
| Q2 | 0.91 (0.78-1.07) | 0.97 (0.84-1.12) | 1.05 (0.91-1.22) |
| Q3 | 0.75 (0.63-0.89) | 0.97 (0.85-1.10) | 1.04 (0.91-1.21) |
| Q4 | 0.79 (0.67-0.93) | 0.99 (0.87-1.13) | 1.12 (0.97-1.29) |
| P for trend | **0.003\*** | 0.987 | 0.123 |
| Protein |  |  |  |
| Q1 | 1.00 (ref) | 1.00 (ref) | 1.00 (ref) |
| Q2 | 0.90 (0.76-1.06) | 0.99 (0.87-1.13) | 1.09 (0.96-1.23) |
| Q3 | 0.83 (0.70-0.99) | 0.98 (0.87-1.10) | 1.08 (0.96-1.22) |
| Q4 | 0.76 (0.64-0.89) | 1.01 (0.87-1.16) | 1.14 (0.98-1.32) |
| P for trend | **<0.001\*** | 0.906 | 0.113 |

Models were adjusted for age, sex, ethnicity, income, education, exercise, smoke, alcohol intake, BMI, prescription medication used for lower blood sugar, prescription medication used for hypertension, and prescription medication used for cholesterol, total intake of energy, fat, protein, SFA, high-quality carbohydrate, animal protein, dietary fiber, dietary cholesterol, AHEI, supplement use, breakfast skipping and fasting time.

BMI, body mass index; AHEI, alternative healthy eating index; Q, quintile

\*P < 0.05

**Supplementary Table 10** Association between the ratio of subcategories of macronutrient consumption at breakfast, dinner, and ΔRatio and the odds ratios of being hypercholesterolemia.

|  |  |  |  |
| --- | --- | --- | --- |
| Ratio of subcategories of macronutrients | Hypercholesterolemia, OR (95% CI) | | |
| Breakfast | Dinner | ΔRatio |
| High-quality carbohydrates |  |  |  |
| Q1 | 1.00 (ref) | 1.00 (ref) | 1.00 (ref) |
| Q2 | 0.95 (0.82-1.11) | 0.95 (0.82-1.10) | 1.00 (0.88-1.14) |
| Q3 | 0.94 (0.79-1.11) | 0.98 (0.87-1.11) | 0.92 (0.81-1.05) |
| Q4 | 0.94 (0.81-1.10) | 1.00 (0.85-1.17) | 1.09 (0.94-1.26) |
| P for trend | 0.538 | 0.801 | 0.323 |
| Low-quality carbohydrates |  |  |  |
| Q1 | 1.00 (ref) | 1.00 (ref) | 1.00 (ref) |
| Q2 | 0.97 (0.84-1.11) | 0.99 (0.85-1.17) | 1.15 (1.01-1.31) |
| Q3 | 0.95 (0.83-1.09) | 1.16 (1.02-1.33) | 1.20 (1.05-1.36) |
| Q4 | 0.86 (0.76-0.97) | 1.04 (0.91-1.19) | 1.19 (1.05-1.35) |
| P for trend | **0.015\*** | 0.164 | **0.004\*** |
| SFA |  |  |  |
| Q1 | 1.00 (ref) | 1.00 (ref) | 1.00 (ref) |
| Q2 | 1.01 (0.87-1.17) | 1.00 (0.88-1.14) | 1.01 (0.87-1.17) |
| Q3 | 0.80 (0.68-0.94) | 0.94 (0.83-1.07) | 1.09 (0.94-1.26) |
| Q4 | 0.86 (0.72-1.01) | 1.01 (0.90-1.14) | 1.12 (0.97-1.30) |
| P for trend | 0.010\* | 0.889 | 0.058 |
| USFA |  |  |  |
| Q1 | 1.00 (ref) | 1.00 (ref) | 1.00 (ref) |
| Q2 | 0.99 (0.83-1.18) | 0.97 (0.83-1.14) | 1.07 (0.93-1.23) |
| Q3 | 0.78 (0.66-0.92) | 0.97 (0.84-1.12) | 1.07 (0.94-1.22) |
| Q4 | 0.87 (0.73-1.03) | 0.98 (0.86-1.11) | 1.10 (0.96-1.27) |
| P for trend | 0.023\* | 0.868 | 0.179 |
| Animal protein |  |  |  |
| Q1 | 1.00 (ref) | 1.00 (ref) | 1.00 (ref) |
| Q2 | 0.87 (0.76-1.00) | 0.95 (0.82-1.09) | 0.94 (0.82-1.09) |
| Q3 | 0.79 (0.68-0.92) | 0.99 (0.86-1.14) | 0.96 (0.85-1.09) |
| Q4 | 0.82 (0.72-0.94) | 1.05 (0.92-1.20) | 1.06 (0.92-1.22) |
| P for trend | **0.014\*** | 0.321 | 0.324 |
| Plant protein |  |  |  |
| Q1 | 1.00 (ref) | 1.00 (ref) | 1.00 (ref) |
| Q2 | 0.85 (0.75-0.95) | 0.94 (0.81-1.09) | 1.10 (0.96-1.26) |
| Q3 | 0.86 (0.75-0.99) | 1.04 (0.90-1.20) | 1.16 (1.00-1.36) |
| Q4 | 0.80 (0.70-0.91) | 0.96 (0.84-1.11) | 1.13 (1.01-1.28) |
| P for trend | **0.002\*** | 0.915 | **0.044\*** |

Models were adjusted for age, sex, ethnicity, income, education, exercise, smoke, alcohol intake, BMI, prescription medication used for lower blood sugar, prescription medication used for hypertension, and

prescription medication used for cholesterol, total intake of energy, fat, protein, SFA, high-quality carbohydrate, animal protein, dietary fiber, dietary cholesterol, AHEI, supplement use, breakfast skipping and fasting time.

BMI, body mass index; SFA, saturated fatty acid; USFA, unsaturated fatty acid; AHEI, alternative healthy eating index; Q, quintile

\*P < 0.05

**Supplementary Table 11** Substitution effects of replacing one cup/ounce/tsp foods consumption at dinner with breakfast with the risk of prevalent hypercholesterolemia.

|  |  |
| --- | --- |
| **Substitution effect** | **Hypercholesterolemia OR (95% CI)** |
| **High-quality carbohydrate** |  |
| Whole grains | 0.93 (0.83-1.05) |
| Legumes | 0.87 (0.54-1.40) |
| Whole fruits | 0.94 (0.79-1.12) |
| Non-starchy vegetables | 0.94 (0.82-1.07) |
| **Low-quality carbohydrate** |  |
| Refined grains | 0.97 (0.94-1.01) |
| Fruit juice | 0.97 (0.78-1.21) |
| Potato | 1.08 (0.79-1.47) |
| Other starchy vegetable | 1.81 (0.89-3.68) |
| Added sugar | **0.98 (0.97-0.99) \*** |
| **Animal protein** |  |
| Red meat | 1.00 (0.93-1.07) |
| Processed meat | **0.96 (0.93-1.00) \*** |
| Poultry | 0.97 (0.90-1.05) |
| Seafood | 0.93 (0.87-1.01) |
| Dairy | 0.96 (0.87-1.05) |
| Eggs | 0.89 (0.74-1.06) |
| **Plant protein** |  |
| Whole grains | 0.93 (0.83-1.05) |
| Refined grains | 0.97 (0.94-1.01) |
| Legumes | 0.87 (0.54-1.40) |
| Nuts | **0.83 (0.74-0.94) \*** |
| Soy | 1.13 (0.78-1.63) |

Models were adjusted for age, sex, ethnicity, income, education, exercise, smoke, alcohol intake, BMI,

prescription medication used for lower blood sugar, prescription medication used for hypertension,

prescription medication used for cholesterol, total intake of energy, fat, protein, SFA, high-quality carbohydrates, animal protein, dietary fiber, dietary cholesterol, AHEI, supplement use, breakfast skipping, and fasting time. For each food, models were additionally adjusted for the total daily intake of this kind of food.

BMI, body mass index; SFA, saturated fatty acid; AHEI, alternative healthy eating index