Associations of food groups and cardiometabolic and inflammatory biomarkers – does the meal matter?

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Potentially eligible sample

23,881 active EPIC-Potsdam follow-up participants

1447 invitations sent out

(age and sex stratified random draw)

815 participated in the sub-study

(56% participation rate)

896 individuals

Final study sample (n=806)

7 participants excluded:

n=1 with demetia

n=8 never consuming lunch

CRP

n=779

(n=13 from 2nd blood draw)

LDL-C

n = 782

(n=4 from 2nd

blood draw)

HDL-C

n = 782

(n=4 from 2nd

blood draw)

HbA1c

n=781

(n=4 from 2nd

blood draw)

Supplementary Figure 1: Flow-chart of participants of the validation sub-study within the EPIC Potsdam cohort and participants with biomarker data

LDL-C, low density lipoprotein cholesterol; HDL-C, high density lipoprotein cholesterol; HbA1c, glycated hemoglobin; CRP, C-reactive protein.

Supplementary Table 1: Meals skipped among participants in the EPIC-Potsdam validation sub-study (n=806)

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Meals skipped | On 2 days | | On 1 day | | On 0 days | |
|  | *n* | % | *n* | % | *n* | % |
| Breakfast | 0 | 0 | 4 | 0.5 | 802 | 99.5 |
| Lunch | 4 | 0.5 | 38 | 4.7 | 764 | 94.8 |
| Dinner | 0 | 0 | 32 | 4.0 | 774 | 96.0 |

Supplementary Table 2: Correlation coefficient (Rho) between probability of consumption and consumed amount for the calculation of usual intakes using NCI method

|  |  |  |
| --- | --- | --- |
| Food group | Meal type | Rho1 |
| Vegetables | Breakfast | 0.22 |
| Lunch | 0.49 |
| Dinner | 0.43 |
| Total | 0.44 |
| Fruits | Breakfast | 0.68 |
| Lunch | 0.30 |
| Dinner | 0.17 |
| Total | 0.80 |
| Refined grains | Breakfast | 0.01 |
| Lunch | -0.17 |
| Dinner | -0.15 |
| Total | 0.50 |
| Whole grains | Breakfast | 0.32 |
| Lunch | NA2 |
| Dinner | 0.21 |
| Total | 0.65 |
| Red & processed meat | Breakfast | 0.09 |
| Lunch | -0.28 |
| Dinner | -0.04 |
| Total | 0.38 |

n = 806

1 correlation coefficient between the two random effects (probability of consumption in logistic regression model and amount when consumed in the linear regression model)

2 only the uncorrelated model was calculated due to suboptimal convergence of the model.

Supplementary Table 3: Spearman partial correlations (Rho*)* for usual intake of foods across the three meal types1

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Food group | Meal type | Breakfast  (n=806) | | Lunch  (n=806) | | Dinner  (n=806) | |
|  |  | Rho | 95%CI | Rho | 95%CI | Rho | 95%CI |
| Vegetables | Breakfast | 1.00 | . | . | . | . | . |
| Lunch | 0.11 | 0.04;0.18 | 1.00 | . | . | . |
| Dinner | 0.08 | 0.01;0.15 | 0.13 | 0.06;0.20 | 1.00 | . |
| Fruits | Breakfast | 1.00 | . | . | . | . | . |
| Lunch | 0.04 | -0.03;0.11 | 1.00 | . | . | . |
| Dinner | 0.11 | 0.04;0.18 | 0.05 | -0.02;0.13 | 1.00 | . |
| Refined grains | Breakfast | 1.00 | . | . | . | . | . |
| Lunch | 0.10 | 0.03;0.17 | 1.00 | . | . | . |
| Dinner | 0.10 | 0.03;0.17 | 0.03 | -0.04;0.10 | 1.00 | . |
| Whole grains | Breakfast | 1.00 | . | . | . | . | . |
| Lunch | 0.08 | 0.01;0.15 | 1.00 | . | . | . |
| Dinner | 0.02 | -0.05;0.09 | -0.03 | -0.10;0.04 | 1.00 | . |
| Red & processed meat | Breakfast | 1.00 | . | . | . | . | . |
| Lunch | 0.07 | 0.00;0.14 | 1.00 | . | . | . |
| Dinner | 0.13 | 0.06;0.20 | 0.06 | -0.01;0.13 | 1.00 | . |

1 adjusted for sex, age (continuous), BMI, (continuous), smoking status (never, former, current), education level (no vocational training/current training, technical college, university), current occupation (full-time, part-time/hourly, no job/retired), physical activity (continuous), and usual energy intake (continuous).

Supplementary Table 4: Associations of foods consumed at meals with cardiometabolic and inflammatory biomarkers; mutually-adjusted models as sensitivity analysis1

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Usual food intake (per 50g) | LDL-C (mmol/l) | | |  | HDL-C (mmol/l) | | |  | HbA1c (%) | | |  | CRP (mg/l)2 | | |
| β | 95% CI3 | Partial rho4 |  | β | 95% CI | Partial rho |  | β | 95% CI | Partial rho |  | β | 95% CI | Partial rho |
| Vegetables |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Breakfast | -0.37 | -0.62;-0.12 | -0.08 |  | 0.07 | -0.02;0.15 | 0.06 |  | 0.00 | -0.14;0.15 | 0.02 |  | -0.05 | -0.33;0.22 | -0.00 |
| Lunch | 0.09 | -0.34;0.53 | 0.04 |  | 0.08 | -0.07;0.22 | 0.03 |  | -0.05 | -0.31;0.20 | -0.02 |  | -0.20 | -0.93;0.53 | -0.02 |
| Dinner | 0.09 | -0.06;0.25 | 0.05 |  | 0.06 | 0.01;0.12 | 0.08 |  | -0.02 | -0.11;0.07 | -0.02 |  | -0.18 | -0.44;0.08 | -0.05 |
| Total | -0.01 | -0.12;0.10 | 0.02 |  | 0.06 | 0.02;0.10 | 0.11 |  | 0.00 | -0.06;0.07 | -0.01 |  | -0.15 | -0.31;0.01 | -0.04 |
| Fruits |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Breakfast | 0.06 | -0.02;0.14 | 0.04 |  | 0.01 | -0.02;0.03 | 0.03 |  | -0.06 | -0.10;-0.01 | -0.13 |  | -0.04 | -0.17;0.09 | -0.02 |
| Lunch | 0.10 | -0.10;0.30 | 0.02 |  | 0.02 | -0.04;0.09 | -0.02 |  | -0.04 | -0.15;0.08 | 0.01 |  | -0.01 | -0.37;0.35 | -0.00 |
| Dinner | 0.04 | -0.07;0.16 | 0.03 |  | 0.02 | -0.01;0.06 | 0.05 |  | 0.02 | -0.05;0.08 | 0.02 |  | -0.17 | -0.37;0.03 | -0.07 |
| Total | 0.02 | -0.02;0.06 | 0.02 |  | -0.00 | -0.02;0.01 | -0.02 |  | -0.00 | -0.03;0.02 | -0.03 |  | -0.06 | -0.12;0.00 | -0.07 |
| Refined grains |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Breakfast | 0.02 | -0.29;0.33 | -0.01 |  | 0.03 | -0.08;0.13 | 0.01 |  | -0.03 | -0.21;0.15 | 0.03 |  | -0.02 | -0.49;0.44 | -0.01 |
| Lunch | -0.36 | -1.44;0.71 | -0.02 |  | 0.36 | 0.00;0.72 | 0.07 |  | 0.30 | -0.33;0.92 | 0.00 |  | -0.17 | -1.85;1.52 | -0.05 |
| Dinner | 0.19 | -0.53;0.92 | -0.05 |  | -0.03 | -0.27;0.21 | -0.04 |  | -0.12 | -0.54;0.30 | -0.01 |  | 0.23 | -0.84;1.30 | 0.01 |
| Total | -0.13 | -0.35;0.10 | -0.04 |  | 0.06 | -0.01;0.14 | 0.07 |  | -0.02 | -0.15;0.12 | -0.01 |  | 0.02 | -0.34;0.38 | -0.02 |
| Whole grains |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Breakfast | -0.03 | -0.22;0.16 | -0.03 |  | -0.02 | -0.09;0.04 | -0.03 |  | 0.01 | -0.10;0.12 | 0.02 |  | -0.18 | -0.52;0.15 | -0.06 |
| Lunch | 0.75 | -0.37;1.87 | 0.09 |  | 0.00 | -0.37;0.37 | 0.03 |  | -0.34 | -0.99;0.32 | -0.07 |  | 0.95 | -0.55;2.46 | 0.00 |
| Dinner | -0.06 | -0.32;0.21 | -0.02 |  | -0.01 | -0.10;0.08 | -0.03 |  | 0.05 | -0.10;0.21 | 0.04 |  | 0.31 | -0.15;0.76 | 0.07 |
| Total | -0.03 | -0.17;0.12 | -0.04 |  | -0.00 | -0.05;0.04 | -0.04 |  | 0.04 | -0.05;0.12 | 0.04 |  | -0.00 | -0.23;0.22 | -0.01 |
| Red & processed meats |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Breakfast | -0.27 | -0.63;0.09 | -0.04 |  | -0.00 | -0.12;0.12 | -0.02 |  | 0.26 | 0.05;0.47 | 0.07 |  | 0.48 | -0.12;1.08 | 0.06 |
| Lunch | -0.22 | -0.70;0.27 | -0.05 |  | -0.03 | -0.19;0.13 | -0.01 |  | -0.11 | -0.39;0.17 | -0.01 |  | 0.10 | -0.77;0.97 | 0.01 |
| Dinner | 0.09 | -0.28;0.45 | -0.02 |  | 0.05 | -0.07;0.17 | -0.01 |  | 0.21 | 0.00;0.42 | 0.10 |  | 0.17 | -0.46;0.80 | 0.08 |
| Total | -0.06 | -0.25;0.12 | -0.04 |  | 0.01 | -0.05;0.08 | 0.00 |  | 0.06 | -0.05;0.17 | 0.08 |  | 0.21 | -0.08;0.50 | 0.06 |

CRP, C-reactive protein; HbA1c, glycated hemoglobin; HDL-C, high-density lipoprotein cholesterol; LDL-C, low-density lipoprotein cholesterol.

1 Biomarker sample sizes vary: LDL-C (n = 782), HDL-C (n = 782), HbA1c (n = 781), CRP (n = 779).

2 CRP results based on quantile regression using the median due to a skewed distribution.

3 Effect estimates (β) and corresponding 95% confidence intervals (95% CI) expressed as per 50g usual meal food intake. Values were determined by use of linear regression models. All models are adjusted for sex, age (continuous), BMI, (continuous), smoking status (never, former, current), education level (no vocational training/current training, technical college, university), current occupation (full-time, part-time/hourly, no job/retired), physical activity (continuous), usual energy intake (continuous), and total usual intakes for the other four food groups.

4 Spearman partial correlations, adjusted for sex, age (continuous), BMI, (continuous), smoking status (never, former, current), education level (no vocational training/current training, technical college, university), current occupation (full-time, part-time/hourly, no job/retired), physical activity (continuous), and usual energy intake (continuous).

Supplementary Table 5: Associations of foods consumed at meals with cardiometabolic and inflammatory biomarkers; sensitivity analysis – results among men1

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Usual food intake (per 50g) | LDL-C (mmol/l) | | |  | HDL-C (mmol/l) | | |  | HbA1c (%) | | |  | CRP (mg/l)2 | | |
| β | 95% CI3 | Partial rho4 |  | β | 95% CI | Partial rho |  | β | 95% CI | Partial rho |  | β | 95% CI | Partial rho |
| Vegetables |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Breakfast | -0.42 | -0.80;-0.05 | -0.09 |  | 0.08 | -0.04;0.20 | 0.07 |  | 0.12 | -0.13;0.37 | 0.07 |  | 0.03 | -0.7;0.76 | 0.00 |
| Lunch | -0.06 | -0.65;0.53 | 0.01 |  | 0.00 | -0.19;0.19 | 0.02 |  | 0.08 | -0.32;0.47 | 0.01 |  | -0.61 | -1.64;0.42 | -0.01 |
| Dinner | 0.06 | -0.15;0.27 | 0.03 |  | 0.02 | -0.05;0.09 | 0.02 |  | -0.03 | -0.17;0.11 | -0.03 |  | -0.17 | -0.50;0.15 | -0.05 |
| Total | -0.04 | -0.20;0.11 | -0.01 |  | 0.04 | -0.01;0.09 | 0.08 |  | 0.03 | -0.07;0.14 | 0.03 |  | -0.17 | -0.37;0.02 | -0.05 |
| Fruits |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Breakfast | 0.03 | -0.08;0.14 | 0.02 |  | 0.02 | -0.02;0.05 | 0.06 |  | -0.05 | -0.13;0.02 | -0.14 |  | 0.04 | -0.17;0.24 | -0.08 |
| Lunch | 0.26 | 0.01;0.52 | 0.07 |  | -0.02 | -0.10;0.060 | -0.06 |  | -0.00 | -0.17;0.17 | 0.02 |  | 0.02 | -0.48;0.51 | 0.00 |
| Dinner | 0.11 | -0.05;0.27 | 0.07 |  | 0.02 | -0.04;0.07 | 0.04 |  | 0.04 | -0.06;0.15 | 0.07 |  | -0.16 | -0.47;0.16 | -0.09 |
| Total | 0.05 | -0.01;0.10 | 0.06 |  | -0.01 | -0.02;0.01 | -0.05 |  | -0.00 | -0.04;0.03 | -0.04 |  | -0.04 | -0.13;0.05 | -0.08 |
| Refined grains |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Breakfast | -0.02 | -0.34;0.31 | 0.02 |  | 0.02 | -0.08;0.12 | 0.02 |  | -0.07 | -0.29;0.14 | 0.00 |  | -0.09 | -0.51;0.34 | 0.05 |
| Lunch | -0.81 | -2.21;0.58 | -0.03 |  | 0.58 | 0.14;1.02 | 0.06 |  | 0.02 | -0.90;0.94 | 0.00 |  | 0.54 | -1.52;2.60 | -0.07 |
| Dinner | -0.14 | -0.94;0.67 | -0.04 |  | -0.06 | -0.32;0.19 | -0.10 |  | 0.17 | -0.36;0.70 | 0.05 |  | -0.37 | -1.66;0.93 | -0.01 |
| Total | -0.24 | -0.50;0.02 | -0.05 |  | 0.06 | -0.02;0.14 | 0.06 |  | -0.01 | -0.18;0.16 | -0.02 |  | -0.09 | -0.53;0.36 | -0.01 |
| Whole grains |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Breakfast | 0.02 | -0.19;0.23 | -0.01 |  | -0.01 | -0.08;0.06 | -0.04 |  | -0.02 | -0.16;0.12 | -0.02 |  | -0.25 | -0.61;0.10 | -0.11 |
| Lunch | 0.99 | -0.35;2.34 | 0.12 |  | -0.05 | -0.47;0.38 | 0.01 |  | -0.16 | -1.05;0.73 | -0.08 |  | 0.31 | -1.57;2.20 | -0.11 |
| Dinner | 0.01 | -0.31;0.32 | -0.02 |  | -0.02 | -0.13;0.08 | -0.04 |  | 0.04 | -0.17;0.25 | 0.04 |  | -0.02 | -0.51;0.47 | 0.01 |
| Total | 0.03 | -0.12;0.19 | -0.01 |  | 0.00 | -0.05;0.05 | -0.01 |  | 0.01 | -0.09;0.11 | 0.01 |  | -0.17 | -0.42;0.07 | -0.11 |
| Red & processed meats |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Breakfast | -0.30 | -0.69;0.09 | -0.04 |  | -0.01 | -0.13;0.12 | -0.01 |  | 0.26 | 0.00;0.52 | 0.12 |  | 0.60 | -0.08;1.29 | 0.08 |
| Lunch | -0.20 | -0.81;0.41 | -0.06 |  | -0.02 | -0.21;0.18 | -0.04 |  | -0.26 | -0.66;0.14 | 0.02 |  | 0.48 | -0.63;1.59 | 0.06 |
| Dinner | -0.32 | -0.75;0.11 | -0.10 |  | -0.09 | -0.22;0.05 | -0.07 |  | 0.25 | -0.04;0.53 | 0.10 |  | -0.06 | -0.82;0.70 | 0.03 |
| Total | -0.26 | -0.48;-0.04 | -0.13 |  | -0.02 | -0.09;0.05 | -0.05 |  | 0.07 | -0.08;0.21 | 0.13 |  | 0.16 | -0.25;0.58 | 0.09 |

CRP, C-reactive protein; HbA1c, glycated hemoglobin; HDL-C, high-density lipoprotein cholesterol; LDL-C, low-density lipoprotein cholesterol.

1 Biomarker sample sizes vary: LDL-C (n = 397), HDL-C (n = 397), HbA1c (n = 397), CRP (n = 395).

2 CRP results based on quantile regression using the median due to a skewed distribution.

3 Effect estimates (β) and corresponding 95% confidence intervals (95% CI) expressed as per 50g usual meal food intake. Values were determined by use of linear regression models. All models are adjusted for age (continuous), BMI, (continuous), smoking status (never, former, current), education level (no vocational training/current training, technical college, university), current occupation (full-time, part-time/hourly, no job/retired), physical activity (continuous), and usual energy intake (continuous).

4 Spearman partial correlations, adjusted for sex, age (continuous), BMI, (continuous), smoking status (never, former, current), education level (no vocational training/current training, technical college, university), current occupation (full-time, part-time/hourly, no job/retired), physical activity (continuous), and usual energy intake (continuous).

Supplementary Table 6: Associations of foods consumed at meals with cardiometabolic and inflammatory biomarkers; sensitivity analysis – results among women1

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Usual food intake (per 50g) | LDL-C (mmol/l) | | |  | HDL-C (mmol/l) | | |  | HbA1c (%) | | |  | CRP (mg/l)2 | | |
| β | 95% CI3 | Partial rho4 |  | β | 95% CI | Partial rho |  | β | 95% CI | Partial rho |  | β | 95% CI | Partial rho |
| Vegetables |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Breakfast | -0.34 | -0.68;0.00 | -0.09 |  | 0.03 | -0.09;0.15 | 0.04 |  | -0.06 | -0.23;0.11 | -0.04 |  | -0.14 | -0.53;0.26 | -0.00 |
| Lunch | 0.31 | -0.32;0.95 | 0.08 |  | 0.16 | -0.06;0.39 | 0.08 |  | -0.16 | -0.48;0.16 | -0.03 |  | -0.31 | -1.28;0.66 | -0.04 |
| Dinner | 0.14 | -0.08;0.37 | 0.07 |  | 0.08 | 0.00;0.16 | 0.11 |  | -0.00 | -0.12;0.11 | -0.01 |  | -0.33 | -0.71;0.05 | -0.06 |
| Total | 0.06 | -0.09;0.21 | 0.07 |  | 0.07 | 0.01;0.12 | 0.12 |  | -0.03 | -0.10;0.05 | -0.03 |  | -0.28 | -0.52;-0.04 | -0.07 |
| Fruits |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Breakfast | 0.09 | -0.02;0.20 | 0.06 |  | 0.00 | -0.04;0.04 | 0.01 |  | -0.07 | -0.12;-0.01 | -0.12 |  | -0.11 | -0.26;0.04 | -0.01 |
| Lunch | -0.04 | -0.34;0.26 | -0.02 |  | 0.05 | -0.06;0.16 | 0.02 |  | -0.06 | -0.21;0.09 | 0.02 |  | -0.19 | -0.76;0.38 | -0.04 |
| Dinner | -0.04 | -0.20;0.13 | -0.02 |  | 0.01 | -0.05;0.07 | -0.00 |  | -0.00 | -0.08;0.08 | -0.06 |  | -0.26 | -0.55;0.02 | -0.05 |
| Total | 0.00 | -0.06;0.06 | -0.01 |  | 0.00 | -0.02;0.02 | 0.01 |  | -0.01 | -0.04;0.02 | -0.04 |  | -0.12 | -0.20;-0.03 | -0.12 |
| Refined grains |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Breakfast | -0.13 | -0.60;0.34 | -0.02 |  | 0.05 | -0.11;0.22 | 0.06 |  | 0.01 | -0.23;0.24 | 0.05 |  | 0.65 | -0.18;1.47 | -0.02 |
| Lunch | 0.20 | -1.46;1.87 | 0.00 |  | -0.01 | -0.60;0.58 | 0.03 |  | 0.50 | -0.32;1.32 | 0.03 |  | -1.50 | -4.02;1.04 | -0.08 |
| Dinner | 0.04 | -1.28;1.36 | -0.03 |  | -0.01 | -0.48;0.46 | 0.04 |  | -0.46 | -1.12;0.19 | -0.11 |  | 0.99 | -0.70;2.68 | 0.03 |
| Total | -0.08 | -0.41;0.25 | -0.04 |  | 0.05 | -0.07;0.16 | 0.08 |  | -0.02 | -0.18;0.15 | -0.01 |  | 0.34 | -0.24;0.91 | -0.00 |
| Whole grains |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Breakfast | 0.07 | -0.23;0.37 | 0.00 |  | -0.09 | -0.20;0.02 | -0.09 |  | 0.07 | -0.07;0.22 | 0.06 |  | -0.21 | -0.79;0.36 | -0.02 |
| Lunch | -0.11 | -2.09;1.87 | 0.07 |  | 0.01 | -0.70;0.71 | 0.06 |  | -0.32 | -1.30;0.66 | -0.07 |  | 1.96 | -1.34;5.25 | 0.08 |
| Dinner | -0.02 | -0.48;0.45 | 0.01 |  | -0.03 | -0.19;0.13 | -0.03 |  | 0.10 | -0.13;0.33 | 0.06 |  | 1.08 | 0.23;1.92 | 0.15 |
| Total | -0.00 | -0.25;0.24 | -0.01 |  | -0.07 | -0.16;0.01 | -0.13 |  | 0.10 | -0.03;0.22 | 0.08 |  | 0.00 | -0.46;0.47 | 0.09 |
| Red & processed meats |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Breakfast | -0.42 | -1.22;0.38 | -0.05 |  | -0.00 | -0.29;0.28 | -0.01 |  | 0.15 | -0.25;0.55 | 0.03 |  | 1.03 | -0.43;2.49 | 0.07 |
| Lunch | -0.23 | -1.04;0.59 | -0.01 |  | -0.01 | -0.3;0.28 | 0.00 |  | 0.05 | -0.36;0.45 | 0.01 |  | -0.23 | -1.55;1.08 | -0.03 |
| Dinner | 0.60 | -0.03;1.22 | 0.04 |  | 0.24 | 0.02;0.46 | 0.05 |  | 0.17 | -0.14;0.48 | 0.09 |  | 1.45 | 0.31;2.58 | 0.09 |
| Total | 0.14 | -0.17;0.46 | 0.02 |  | 0.07 | -0.04;0.18 | 0.07 |  | 0.05 | -0.10;0.21 | 0.07 |  | 0.52 | 0.05;0.99 | 0.09 |

CRP, C-reactive protein; HbA1c, glycated hemoglobin; HDL-C, high-density lipoprotein cholesterol; LDL-C, low-density lipoprotein cholesterol.

1 Biomarker sample sizes vary: LDL-C (n = 385), HDL-C (n = 385), HbA1c (n = 384), CRP (n = 384);

2 CRP results based on quantile regression using the median due to a skewed distribution.

3 Effect estimates (β) and corresponding 95% confidence intervals (95% CI) expressed as per 50g usual meal food intake. Values were determined by use of linear regression models. All models are adjusted for age (continuous), BMI, (continuous), smoking status (never, former, current), education level (no vocational training/current training, technical college, university), current occupation (full-time, part-time/hourly, no job/retired), physical activity (continuous), and usual energy intake (continuous).

4 Spearman partial correlations, adjusted for sex, age (continuous), BMI, (continuous), smoking status (never, former, current), education level (no vocational training/current training, technical college, university), current occupation (full-time, part-time/hourly, no job/retired), physical activity (continuous), and usual energy intake (continuous).

Supplementary Table 7: Associations of foods consumed at meals with cardiometabolic and inflammatory biomarkers; sensitivity analysis – results among participants with under- and normal weight (BMI < 25 kg/m2)1

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Usual food intake (per 50g) | LDL-C (mmol/l) | | |  | HDL-C (mmol/l) | | |  | HbA1c (%) | | |  | CRP (mg/l)2 | | |
| β | 95% CI3 | Partial rho4 |  | β | 95% CI | Partial rho |  | β | 95% CI | Partial rho |  | β | 95% CI | Partial rho |
| Vegetables |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Breakfast | -0.48 | -1.20;0.24 | -0.07 |  | 0.19 | -0.07;0.46 | 0.12 |  | 0.06 | -0.27;0.39 | 0.05 |  | -0.19 | -1.12;0.74 | -0.10 |
| Lunch | 0.52 | -0.28;1.32 | 0.11 |  | -0.10 | -0.39;0.20 | -0.03 |  | -0.37 | -0.74;0.00 | -0.13 |  | -0.46 | -1.27;0.36 | -0.05 |
| Dinner | 0.11 | -0.20;0.42 | 0.04 |  | 0.08 | -0.04;0.19 | 0.11 |  | -0.05 | -0.19;0.10 | -0.06 |  | -0.42 | -0.71;-0.12 | -0.16 |
| Total | 0.08 | -0.14;0.29 | 0.06 |  | 0.05 | -0.03;0.13 | 0.11 |  | -0.11 | -0.20;-0.01 | -0.14 |  | -0.34 | -0.53;-0.15 | -0.16 |
| Fruits |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Breakfast | 0.18 | 0.05;0.32 | 0.14 |  | -0.01 | -0.06;0.04 | -0.05 |  | -0.04 | -0.11;0.02 | -0.10 |  | -0.12 | -0.26;0.02 | -0.03 |
| Lunch | 0.29 | -0.10;0.68 | 0.09 |  | 0.03 | -0.12;0.17 | -0.03 |  | -0.11 | -0.30;0.07 | -0.06 |  | 0.01 | -0.61;0.62 | -0.02 |
| Dinner | 0.20 | 0.00;0.40 | 0.13 |  | 0.07 | -0.01;0.14 | 0.10 |  | -0.05 | -0.14;0.05 | -0.03 |  | 0.07 | -0.25;0.38 | 0.05 |
| Total | 0.09 | 0.02;0.17 | 0.16 |  | 0.02 | 0.00;0.05 | 0.12 |  | -0.03 | -0.06;0.00 | -0.14 |  | -0.07 | -0.16;0.02 | -0.08 |
| Refined grains |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Breakfast | -0.22 | -0.76;0.32 | -0.07 |  | -0.16 | -0.35;0.04 | -0.11 |  | -0.01 | -0.26;0.24 | 0.03 |  | 0.59 | -0.04;1.21 | 0.05 |
| Lunch | -0.18 | -2.11;1.74 | -0.05 |  | 0.13 | -0.58;0.83 | 0.10 |  | 0.25 | -0.64;1.13 | 0.08 |  | 0.65 | -1.42;2.72 | -0.12 |
| Dinner | -0.45 | -1.68;0.78 | -0.07 |  | -0.42 | -0.86;0.03 | -0.03 |  | -0.02 | -0.58;0.55 | 0.07 |  | 0.06 | -1.24;1.37 | -0.02 |
| Total | -0.26 | -0.64;0.11 | -0.15 |  | -0.06 | -0.19;0.08 | 0.00 |  | 0.08 | -0.10;0.25 | 0.04 |  | 0.19 | -0.25;0.62 | -0.02 |
| Whole grains |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Breakfast | 0.32 | -0.01;0.66 | 0.14 |  | -0.06 | -0.18;0.07 | -0.04 |  | 0.01 | -0.14;0.17 | 0.02 |  | -0.48 | -0.89;-0.07 | -0.08 |
| Lunch | -0.09 | -1.99;1.81 | 0.07 |  | 0.02 | -0.69;0.72 | 0.13 |  | 0.10 | -0.78;0.99 | -0.01 |  | 0.11 | -1.75;1.97 | -0.10 |
| Dinner | -0.16 | -0.63;0.30 | -0.01 |  | 0.04 | -0.14;0.21 | 0.00 |  | -0.06 | -0.28;0.15 | -0.04 |  | 0.30 | -0.34;0.94 | 0.08 |
| Total | 0.12 | -0.13;0.36 | 0.06 |  | 0.03 | -0.06;0.12 | 0.05 |  | -0.01 | -0.12;0.10 | 0.01 |  | -0.19 | -0.51;0.13 | -0.02 |
| Red & processed meats |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Breakfast | -0.67 | -1.40;0.07 | -0.03 |  | -0.30 | -0.57;-0.03 | -0.11 |  | 0.26 | -0.09;0.60 | 0.11 |  | 0.62 | -0.33;1.57 | 0.09 |
| Lunch | -0.49 | -1.43;0.46 | -0.09 |  | -0.04 | -0.39;0.31 | 0.02 |  | 0.05 | -0.38;0.49 | -0.12 |  | -0.19 | -1.41;1.03 | 0.01 |
| Dinner | 0.40 | -0.34;1.14 | 0.07 |  | -0.05 | -0.32;0.22 | -0.02 |  | 0.12 | -0.22;0.47 | 0.07 |  | -0.22 | -1.27;0.83 | 0.02 |
| Total | -0.11 | -0.49;0.26 | -0.02 |  | -0.06 | -0.20;0.07 | -0.02 |  | 0.11 | -0.07;0.28 | 0.02 |  | 0.06 | -0.40;0.52 | 0.04 |

CRP, C-reactive protein; HbA1c, glycated hemoglobin; HDL-C, high-density lipoprotein cholesterol; LDL-C, low-density lipoprotein cholesterol.

1 Biomarker sample sizes vary: LDL-C (n = 233), HDL-C (n = 233), HbA1c (n = 233), CRP (n = 230);

2 CRP results based on quantile regression using the median due to a skewed distribution.

3 Effect estimates (β) and corresponding 95% confidence intervals (95% CI) expressed as per 50g usual meal food intake. Values were determined by use of linear regression models. All models are adjusted for sex, age (continuous), BMI, (continuous), smoking status (never, former, current), education level (no vocational training/current training, technical college, university), current occupation (full-time, part-time/hourly, no job/retired), physical activity (continuous), and usual energy intake (continuous).

4 Spearman partial correlations, adjusted for sex, age (continuous), BMI, (continuous), smoking status (never, former, current), education level (no vocational training/current training, technical college, university), current occupation (full-time, part-time/hourly, no job/retired), physical activity (continuous), and usual energy intake (continuous).

Supplementary Table 8: Associations of foods consumed at meals with cardiometabolic and inflammatory biomarkers; sensitivity analysis – results among overweight participants (BMI 25 to < 30 kg/m2)1

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Usual food intake (per 50g) | LDL-C (mmol/l) | | |  | HDL-C (mmol/l) | | |  | HbA1c (%) | | |  | CRP (mg/l)2 | | |
| β | 95% CI3 | Partial rho4 |  | β | 95% CI | Partial rho |  | β | 95% CI | Partial rho |  | β | 95% CI | Partial rho |
| Vegetables |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Breakfast | -0.10 | -0.55;0.34 | -0.06 |  | 0.12 | -0.02;0.26 | 0.03 |  | -0.03 | -0.28;0.22 | -0.01 |  | -0.12 | -0.76;0.52 | 0.06 |
| Lunch | -0.16 | -0.83;0.50 | 0.03 |  | 0.09 | -0.12;0.30 | -0.00 |  | 0.29 | -0.09;0.66 | 0.07 |  | -0.22 | -1.55;1.12 | 0.03 |
| Dinner | 0.14 | -0.09;0.37 | 0.08 |  | 0.06 | -0.02;0.13 | 0.08 |  | 0.00 | -0.13;0.13 | -0.01 |  | -0.17 | -0.51;0.18 | -0.01 |
| Total | 0.05 | -0.12;0.21 | 0.06 |  | 0.06 | 0.01;0.11 | 0.09 |  | 0.08 | -0.01;0.18 | 0.08 |  | -0.19 | -0.41;0.02 | -0.02 |
| Fruits |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Breakfast | -0.03 | -0.15;0.09 | -0.04 |  | 0.02 | -0.02;0.05 | 0.04 |  | -0.05 | -0.11;0.02 | -0.13 |  | -0.11 | -0.31;0.09 | -0.04 |
| Lunch | 0.15 | -0.15;0.45 | 0.07 |  | -0.01 | -0.11;0.09 | -0.03 |  | 0.03 | -0.14;0.20 | 0.07 |  | 0.16 | -0.40;0.73 | 0.02 |
| Dinner | 0.01 | -0.16;0.18 | 0.00 |  | -0.02 | -0.08;0.03 | -0.01 |  | 0.01 | -0.08;0.11 | 0.02 |  | -0.32 | -0.67;0.02 | -0.14 |
| Total | -0.01 | -0.07;0.05 | -0.04 |  | -0.02 | -0.04;0.00 | -0.12 |  | 0.01 | -0.02;0.05 | 0.04 |  | -0.09 | -0.20;0.01 | -0.13 |
| Refined grains |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Breakfast | -0.02 | -0.41;0.38 | -0.02 |  | 0.04 | -0.08;0.17 | 0.08 |  | 0.04 | -0.18;0.26 | 0.05 |  | 0.19 | -0.36;0.74 | 0.01 |
| Lunch | -0.90 | -2.52;0.72 | -0.03 |  | 0.58 | 0.06;1.09 | 0.07 |  | 0.29 | -0.63;1.21 | -0.06 |  | -2.60 | -5.01;-0.17 | -0.03 |
| Dinner | -0.02 | -1.14;1.10 | -0.05 |  | 0.30 | -0.06;0.66 | 0.01 |  | -0.07 | -0.71;0.56 | -0.08 |  | 0.25 | -1.34;1.83 | 0.05 |
| Total | -0.27 | -0.58;0.04 | -0.06 |  | 0.11 | 0.01;0.21 | 0.10 |  | 0.01 | -0.17;0.19 | -0.04 |  | -0.09 | -0.61;0.43 | 0.03 |
| Whole grains |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Breakfast | -0.09 | -0.33;0.16 | -0.04 |  | -0.05 | -0.13;0.03 | -0.09 |  | 0.02 | -0.12;0.16 | 0.03 |  | -0.27 | -0.70;0.15 | -0.06 |
| Lunch | 1.39 | -0.29;3.06 | 0.02 |  | -0.13 | -0.67;0.41 | -0.07 |  | -0.46 | -1.41;0.50 | -0.09 |  | 1.68 | -0.38;3.74 | 0.08 |
| Dinner | 0.12 | -0.28;0.52 | 0.01 |  | -0.07 | -0.20;0.06 | -0.07 |  | 0.13 | -0.10;0.36 | 0.07 |  | 0.44 | -0.20;1.08 | 0.10 |
| Total | -0.03 | -0.23;0.17 | -0.04 |  | -0.07 | -0.14;-0.01 | -0.15 |  | 0.06 | -0.05;0.18 | 0.06 |  | -0.05 | -0.34;0.25 | -0.01 |
| Red & processed meats |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Breakfast | -0.30 | -0.85;0.26 | -0.05 |  | 0.09 | -0.09;0.27 | 0.06 |  | 0.10 | -0.22;0.41 | 0.00 |  | 0.12 | -0.80;1.05 | 0.04 |
| Lunch | 0.10 | -0.62;0.82 | 0.01 |  | -0.02 | -0.25;0.21 | -0.01 |  | 0.18 | -0.23;0.59 | 0.06 |  | 1.24 | -0.09;2.57 | 0.03 |
| Dinner | -0.07 | -0.63;0.49 | -0.06 |  | 0.11 | -0.07;0.29 | 0.01 |  | 0.31 | -0.01;0.62 | 0.11 |  | 0.71 | -0.08;1.50 | 0.11 |
| Total | 0.00 | -0.28;0.27 | -0.01 |  | 0.06 | -0.03;0.15 | 0.03 |  | 0.11 | -0.05;0.27 | 0.09 |  | 0.68 | 0.23;1.14 | 0.08 |

CRP, C-reactive protein; HbA1c, glycated hemoglobin; HDL-C, high-density lipoprotein cholesterol; LDL-C, low-density lipoprotein cholesterol.

1 Biomarker sample sizes vary: LDL-C (n = 365), HDL-C (n = 365), HbA1c (n = 364), CRP (n = 365);

2 CRP results based on quantile regression using the median due to a skewed distribution.

3 Effect estimates (β) and corresponding 95% confidence intervals (95% CI) expressed as per 50g usual meal food intake. Values were determined by use of linear regression models. All models are adjusted for sex, age (continuous), BMI, (continuous), smoking status (never, former, current), education level (no vocational training/current training, technical college, university), current occupation (full-time, part-time/hourly, no job/retired), physical activity (continuous), and usual energy intake (continuous).

4 Spearman partial correlations, adjusted for sex, age (continuous), BMI, (continuous), smoking status (never, former, current), education level (no vocational training/current training, technical college, university), current occupation (full-time, part-time/hourly, no job/retired), physical activity (continuous), and usual energy intake (continuous).

Supplementary Table 9: Associations of foods consumed at meals with cardiometabolic and inflammatory biomarkers; sensitivity analysis – results among obese participants (BMI > 30 kg/m2)1

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Usual food intake (per 50g) | LDL-C (mmol/l) | | |  | HDL-C (mmol/l) | | |  | HbA1c (%) | | |  | CRP (mg/l)2 | | |
| β | 95% CI3 | Partial rho4 |  | β | 95% CI | Partial rho |  | β | 95% CI | Partial rho |  | β | 95% CI | Partial rho |
| Vegetables |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Breakfast | -0.44 | -0.77;-0.12 | -0.14 |  | -0.03 | -0.13;0.07 | 0.00 |  | -0.02 | -0.27;0.23 | -0.04 |  | -0.04 | -0.64;0.55 | 0.03 |
| Lunch | 0.24 | -0.60;1.09 | 0.03 |  | 0.32 | 0.05;0.58 | 0.14 |  | -0.21 | -0.86;0.45 | -0.09 |  | -1.90 | -4.05;0.18 | -0.07 |
| Dinner | 0.08 | -0.21;0.36 | 0.02 |  | 0.04 | -0.05;0.13 | 0.02 |  | -0.06 | -0.28;0.16 | -0.05 |  | -0.08 | -0.83;0.67 | -0.03 |
| Total | -0.07 | -0.26;0.13 | -0.06 |  | 0.05 | -0.01;0.11 | 0.10 |  | -0.02 | -0.17;0.13 | -0.10 |  | -0.01 | -0.55;0.53 | 0.03 |
| Fruits |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Breakfast | 0.06 | -0.11;0.23 | 0.08 |  | 0.05 | -0.01;0.10 | 0.11 |  | -0.10 | -0.23;0.03 | -0.19 |  | 0.10 | -0.53;0.73 | 0.00 |
| Lunch | -0.04 | -0.39;0.30 | -0.06 |  | 0.05 | -0.06;0.16 | 0.03 |  | -0.02 | -0.28;0.24 | -0.04 |  | -0.45 | -1.38;0.48 | -0.05 |
| Dinner | -0.19 | -0.46;0.09 | -0.03 |  | 0.02 | -0.06;0.11 | 0.06 |  | 0.17 | -0.04;0.37 | 0.04 |  | -0.44 | -1.11;0.22 | -0.13 |
| Total | 0.00 | -0.08;0.08 | 0.03 |  | 0.00 | -0.02;0.03 | -0.02 |  | 0.00 | -0.06;0.06 | -0.06 |  | -0.06 | -0.29;0.16 | 0.00 |
| Refined grains |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Breakfast | 0.20 | -0.34;0.73 | 0.08 |  | 0.23 | 0.06;0.40 | 0.17 |  | -0.20 | -0.61;0.21 | 0.01 |  | -0.66 | -1.82;0.50 | 0.00 |
| Lunch | -0.62 | -3.00;1.77 | -0.06 |  | -0.29 | -1.04;0.46 | -0.10 |  | -0.20 | -2.02;1.62 | -0.02 |  | -1.50 | -7.27;4.33 | -0.13 |
| Dinner | 1.28 | -0.03;2.58 | -0.01 |  | -0.06 | -0.47;0.35 | -0.04 |  | -0.46 | -1.45;0.54 | -0.00 |  | 2.00 | -1.4;5.40 | -0.02 |
| Total | 0.27 | -0.15;0.69 | 0.07 |  | 0.06 | -0.07;0.20 | 0.08 |  | -0.25 | -0.57;0.07 | 0.01 |  | 0.04 | -1.01;1.08 | -0.02 |
| Whole grains |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Breakfast | -0.29 | -0.65;0.06 | -0.18 |  | 0.05 | -0.07;0.16 | 0.01 |  | 0.03 | -0.24;0.31 | 0.01 |  | -0.36 | -1.37;0.65 | -0.08 |
| Lunch | 2.17 | -0.28;4.62 | 0.25 |  | -0.05 | -0.84;0.74 | 0.08 |  | -0.83 | -2.71;1.05 | -0.02 |  | -1.50 | -7.22;4.15 | 0.03 |
| Dinner | -0.16 | -0.68;0.37 | -0.07 |  | -0.02 | -0.18;0.15 | -0.10 |  | 0.10 | -0.30;0.51 | 0.08 |  | 0.07 | -1.34;1.48 | 0.04 |
| Total | -0.11 | -0.36;0.15 | -0.09 |  | 0.02 | -0.06;0.10 | -0.06 |  | 0.07 | -0.12;0.27 | 0.07 |  | 0.01 | -0.71;0.73 | -0.01 |
| Red & processed meats |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Breakfast | -0.18 | -0.81;0.45 | -0.07 |  | 0.08 | -0.12;0.28 | -0.03 |  | 0.36 | -0.11;0.84 | 0.16 |  | 1.80 | 0.26;3.34 | 0.07 |
| Lunch | -0.67 | -1.61;0.27 | -0.15 |  | 0.04 | -0.26;0.34 | 0.02 |  | -0.79 | -1.49;-0.09 | -0.05 |  | -1.60 | -3.79;0.62 | -0.06 |
| Dinner | -0.02 | -0.61;0.57 | -0.01 |  | -0.03 | -0.21;0.16 | -0.01 |  | 0.07 | -0.37;0.51 | 0.04 |  | 0.32 | -0.91;1.55 | 0.07 |
| Total | -0.20 | -0.52;0.11 | -0.11 |  | 0.02 | -0.08;0.12 | 0.03 |  | -0.05 | -0.29;0.19 | 0.03 |  | 0.00 | -0.74;0.75 | 0.03 |

CRP, C-reactive protein; HbA1c, glycated hemoglobin; HDL-C, high-density lipoprotein cholesterol; LDL-C, low-density lipoprotein cholesterol.

1 Biomarker sample sizes may vary: LDL-C (n = 184), HDL-C (n = 184), HbA1c (n = 184), CRP (n = 184);

2 CRP results based on quantile regression using the median due to a skewed distribution.

3 Effect estimates (β) and corresponding 95% confidence intervals (95% CI) expressed as per 50g usual meal food intake. Values were determined by use of linear regression models. All models are adjusted for sex, age (continuous), BMI, (continuous), smoking status (never, former, current), education level (no vocational training/current training, technical college, university), current occupation (full-time, part-time/hourly, no job/retired), physical activity (continuous), and usual energy intake (continuous).

4 Spearman partial correlations, adjusted for sex, age (continuous), BMI, (continuous), smoking status (never, former, current), education level (no vocational training/current training, technical college, university), current occupation (full-time, part-time/hourly, no job/retired), physical activity (continuous), and usual energy intake (continuous)