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# Nutrition Science



## Dietary and Activity Assessment

### **Perspective: Opportunities and Challenges of Technology Tools in Dietary and Activity Assessment: Bridging Stakeholder Viewpoints**

Sai Krupa Das, Akari J Miki, Caroline M Blanchard, Edward Sazonov, Cheryl H Gilhooly, Sujit Dey, Colton B Wolk, Chor San Khoo, et. al. *Advances in Nutrition*, Sept. 20. doi.org/10.1093/advances/nmab103. [Article link](#)

**Significance:** This review provides a unique perspective on the different needs, priorities and challenges of three groups of scientists involved in measurement and application of energy metabolism. But with advances in technology involving smart sensors, mobile devices, imaging and AI, these cross-functional improvements open opportunities for future research on personalized health.



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The science and tools of measuring energy intake and output in humans have rapidly advanced in the last decade. Engineered devices such as wearables and sensors, software applications, and Web-based tools are now ubiquitous in both research and consumer environments. The assessment of energy expenditure in particular has progressed from reliance on self-report instruments to advanced technologies requiring collaboration across multiple disciplines, from optics to accelerometry. In contrast, assessing energy intake still heavily relies on self-report mechanisms. Although these tools have improved, moving from paper-based to online reporting, considerable room for refinement remains in existing tools, and great opportunities exist for novel, transformational tools, including those using spectroscopy and chemo-sensing. This report reviews the state of the science, and the opportunities and challenges in existing and emerging technologies, from the perspectives of 3 key stakeholders: researchers, users, and developers. Each stakeholder approaches these tools with unique requirements: researchers are concerned with validity, accuracy, data detail and abundance, and ethical use; users with ease of use and privacy; and developers with high adherence and utilization, intellectual property, licensing rights, and monetization. Cross-cutting concerns include frequent updating and integration of the food and nutrient databases on which assessments rely, improving accessibility and reducing disparities in use, and maintaining reliable technical assistance. These contextual challenges are discussed in terms of opportunities and further steps in the direction of personalized health.

## Protein

### **Association Between Protein Intake and Mortality in Older Patients Receiving Parenteral Nutrition: A Retrospective Observational Study**

Hiroyuki Tamiya, Hideo Yasunaga, Tatsuya Hosoi, Hayato Yamana, Hiroki Matsui, Kiyohide Fushimi, Masahiro Akishita, Sumito Ogawa. *The American Journal of Clinical Nutrition*, Sept. 28 doi.org/10.1093/ajcn/nqab292. [Article link](#)

**Significance:** Malnutrition and mortality in elderly inpatients is often understudied. A five-year retrospective observational study on parenteral nutrition and mortality in elderly Japanese inpatients, found positive relationship between mortality rate at post operative day 90, and infused amino acid intake.

**Background:** Malnutrition of inpatients is often overlooked and remains a serious concern. However, there are few



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studies on the relations between infused energy and amino acid intakes and clinical outcomes in older patients on parenteral nutrition. **Objectives:** We aimed to determine the short-term outcomes of infused energy and amino acid intakes in older patients receiving parenteral nutrition. **Methods:** We conducted a retrospective observational study using a national inpatient database covering >1000 hospitals in Japan. Participants were those who underwent central venous (CV) port insertion between 2011 and 2016, were aged  $\geq 65$  y, and did not have cancer. Based on the types and amounts of products used for enteral feeding and intravenous feeding on postoperative day (POD) 7 after CV port insertion, the infused energy and amino acid intakes were estimated. The primary end point was mortality on POD 90. Multivariable logistic regression was performed to investigate the relations of infused energy and amino acid intakes with mortality on POD 90. **Results:** A total of 10,153 patients aged  $\geq 65$  y who underwent CV port insertion were included. The mortality rates at 90 d after central venous port insertion were 14.9% and 14.0% (risk difference, 0.9%; 95% CI: -0.5%, 2.3%;  $P = 0.216$  with infused energy intakes  $< 20$  and  $\geq 20$  kcal/kg, respectively, and 15.4% and 13.2% (risk difference, 2.2%; 95% CI: 0.9%, 3.6%;  $P = 0.001$  with infused amino acid intakes  $< 0.8$  and  $\geq 0.8$  g/kg, respectively. The differences were retained after adjustment for multiple variables including hospital, age, sex, BMI, emergency admission, and 27 major underlying diseases. The OR for the  $\geq 0.8$ -g/kg group compared with the  $< 0.8$ -g/kg group was 0.87 (95% CI: 0.77, 0.99;  $P = 0.028$ ). **Conclusions:** A positive relation between infused amino acid intake and mortality was found in older patients receiving parenteral nutrition.

## Lipids

### Impact of Low-Fat and Full-Fat Dairy Foods on Fasting Lipid Profile and Blood Pressure: Exploratory Endpoints of a Randomized Controlled Trial

Kelsey A Schmidt, Gail Cromer, Maggie S Burhans, Jessica N Kuzma, Derek K Hagman, Imashi Fernando, Merideth Murray, et. al. *The American Journal of Clinical Nutrition*, Volume 114, Issue 3, September 2021, Pages 882–892, doi.org/10.1093/ajcn/nqab131. [Article link](#)

**Significance:** An RCT study found no difference in fasting lipid profile or blood pressure in adults with metabolic syndromes given either diets rich in full-fat dairy or limited in dairy or rich in low-fat dairy. Dairy fat when incorporated in a complex whole food may not adversely impact some CVD risk factors.

**Background:** Dietary guidelines traditionally recommend low-fat dairy because dairy's high saturated fat content is thought to promote cardiovascular disease (CVD). However, emerging evidence indicates that dairy fat may not negatively impact CVD risk factors when consumed in foods with a complex matrix. **Objective:** The aim was to compare the effects of diets limited in dairy or rich in either low-fat or full-fat dairy on CVD risk factors. **Methods:** In this randomized controlled trial, 72 participants with metabolic syndrome completed a 4-wk run-in period, limiting their dairy intake to  $\leq 3$  servings/wk of nonfat milk. Participants were then randomly assigned to 1 of 3 diets, either continuing the limited-dairy diet or switching to a diet containing 3.3 servings/d of either low-fat or full-fat milk, yogurt, and cheese for 12 wk. Exploratory outcome measures included changes in the fasting lipid profile and blood pressure. **Results:** In the per-protocol analysis ( $n = 66$ ), there was no intervention effect on fasting serum total, LDL, and HDL cholesterol; triglycerides; free fatty acids; or cholesterol content in 38 isolated plasma lipoprotein fractions ( $P > 0.1$  for all variables in repeated-measures ANOVA). There was also no intervention effect on diastolic blood pressure, but a significant intervention effect for systolic blood pressure ( $P = 0.048$ ) with a trend for a decrease in the low-fat dairy diet ( $-1.6 \pm 8.6$  mm Hg) compared with the limited-dairy diet ( $+2.5 \pm 8.2$  mm Hg in post hoc testing). Intent-to-treat results were consistent for all endpoints, with the exception that systolic blood pressure became nonsignificant ( $P = 0.08$ ). **Conclusions:** In men and women with metabolic syndrome, a diet rich in full-fat dairy had no effects on fasting lipid profile or blood pressure compared with diets limited in dairy or rich in low-fat dairy. Therefore, dairy fat, when consumed as part of complex whole foods, does not adversely impact these classic CVD risk factors.

## Carbohydrate

### Effects of a Low-Carbohydrate Diet on Insulin-Resistant Dyslipoproteinemia—A Randomized Controlled Feeding Trial

Cara B Ebbeling, Amy Knapp, Ann Johnson, Julia M W Wong, Kimberly F Greco, Clement Ma, Samia Mora, David S Ludwig. *The American Journal of Clinical Nutrition*, Sept 28. doi.org/10.1093/ajcn/nqab287. [Article link](#)

**Significance:** A diet low in carbohydrate but high in saturated fat was shown in overweight adults to improve insulin-resistant dyslipoproteinemia and lipoprotein(a), with little effect on LDL cholesterol. This suggests carbohydrate restriction effect on lowering CVD risks may be independent of body weight, warranting further multi-center studies.

**Background:** Carbohydrate restriction shows promise for diabetes but concerns regarding high saturated fat content of

low-carbohydrate diets limit widespread adoption. **Objectives:** This preplanned ancillary study aimed to determine how diets varying widely in carbohydrate and saturated fat affect cardiovascular disease (CVD) risk factors during weight-loss maintenance. **Methods:** After 10–14% weight loss on a run-in diet, 164 participants (70% female; BMI = 32.4 ± 4.8 kg/m<sup>2</sup>) were randomly assigned to 3 weight-loss maintenance diets for 20 wk. The prepared diets contained 20% protein and differed 3-fold in carbohydrate (Carb) and saturated fat as a proportion of energy (Low-Carb: 20% carbohydrate, 21% saturated fat; Moderate-Carb: 40%, 14%; High-Carb: 60%, 7%). Fasting plasma samples were collected prerandomization and at 20 wk. Lipoprotein insulin resistance (LPIR) score was calculated from triglyceride-rich, high-density, and low-density lipoprotein particle (TRL-P, HDL-P, LDL-P) sizes and subfraction concentrations (large/very large TRL-P, large HDL-P, small LDL-P). Other outcomes included lipoprotein(a), triglycerides, HDL cholesterol, LDL cholesterol, adiponectin, and inflammatory markers. Repeated measures ANOVA was used for intention-to-treat analysis. **Results:** Retention was 90%. Mean change in LPIR (scale 0–100) differed by diet in a dose-dependent fashion: Low-Carb (−5.3; 95% CI: −9.2, −1.5), Moderate-Carb (−0.02; 95% CI: −4.1, 4.1), High-Carb (3.6; 95% CI: −0.6, 7.7), P = 0.009. Low-Carb also favorably affected lipoprotein(a) [−14.7% (95% CI: −19.5, −9.5), −2.1 (95% CI: −8.2, 4.3), and 0.2 (95% CI: −6.0, 6.8), respectively; P = 0.0005], triglycerides, HDL cholesterol, large/very large TRL-P, large HDL-P, and adiponectin. LDL cholesterol, LDL-P, and inflammatory markers did not differ by diet. **Conclusions:** A low-carbohydrate diet, high in saturated fat, improved insulin-resistant dyslipoproteinemia and lipoprotein(a), without adverse effect on LDL cholesterol. Carbohydrate restriction might lower CVD risk independently of body weight, a possibility that warrants study in major multicentered trials powered on hard outcomes.



## Low- and No-Calorie Sweeteners

### Sugar-Sweetened Beverages, Artificially Sweetened Beverages, and Breast Cancer Risk: Results From 2 Prospective US Cohorts

Andrea Romanos-Nanclares, Laura C Collins, Frank B Hu, Walter C Willett, Bernard A Rosner, Estefania Toledo, A Heather Eliassen. *The Journal of Nutrition*, Volume 151, Issue 9, September 2021, Pages 2768–2779, doi.org/10.1093/jn/nxab172. [Article link](#)

**Significance:** Analysis of 11,379 breast cancer cases from two Nurses Health Studies found no overall association between breast cancer risk and sugar or artificial sweetened beverages consumption. No increased risk of breast cancer was found for artificially sweetened beverage intake, but slightly higher risk with sugar sweetened beverage intake in lean females.

**Background:** Whether consumption of sugar-sweetened beverages (SSBs) or artificially sweetened beverages (ASBs) is associated with the risk of breast cancer is of public health interest. **Objectives:** We sought to evaluate associations between consumption of SSBs and ASBs and risks of total and subtype-specific breast cancer. **Methods:** We followed 82,713 women from the Nurses' Health Study (1980 to 2016) and 93,085 women from the Nurses' Health Study II (1991 to 2017). Cumulatively averaged intakes of SSBs and ASBs from FFQs were tested for associations with incident breast cancer cases and subtypes using Cox regression models. We also evaluated the associations stratified by menopausal status, physical activity, BMI, and alcohol intake. **Results:** We documented 11,379 breast cancer cases during 4,655,153 person-years of follow-up. Consumption of SSBs or ASBs was not associated with total breast cancer risk: pooled HRs comparing extreme categories ( $\geq 1$ /day compared with  $< 1$ /month) were 1.03 (95% CI, 0.95–1.12) and 0.96 (95% CI, 0.91–1.02), respectively. We observed a suggestive interaction by BMI using pooled data (P-interaction = 0.08), where a modestly higher risk of breast cancer with each serving per day increment of SSBs was found in lean women (HR, 1.06; 95% CI, 1.01–1.11) but not among overweight or obese women (HR, 1.00; 95% CI, 0.95–1.06). Moreover, in the pooled, fully adjusted analysis, compared to infrequent consumers ( $< 1$ /month), those who consumed  $\geq 1$  serving of ASBs per day had a lower risk of luminal A breast tumors (HR, 0.90; 95% CI, 0.80–1.01; P-trend = 0.02). **Conclusions:** Although no significant associations were observed overall, consumption of SSBs was associated with a slightly higher risk of breast cancer among lean women. This finding could have occurred by chance and needs confirmation. Our findings also suggest no substantial increase in the risk of breast cancer with consumption of ASBs.

## Cognitive Health

### Vitamin D Deficiency Is Associated with Disrupted Cholesterol Homeostasis in Patients with Mild Cognitive Impairment

Wen Liu, Cui Zhou, Yushan Wang, Huiyan Yu, Xiaona Zhang, Tao Wang, Lijing Wang, et. al. *The Journal of Nutrition*, Sept. 11, doi.org/10.1093/jn/nxab296. [Article link](#)

**Significance:** A study conducted in Shanxi China found a significance difference in serum 25(OH)D concentrations in mildly cognitive impaired subjects and matched healthy pairs. An inverse correlation was also found between serum 25(OH)D level and lipids, and oxysterols and cognitive impairment.

**Background:** Several studies have reported that dietary and serum concentrations of vitamin D and cholesterol are correlated with mild cognitive impairment (MCI) and Alzheimer's disease (AD). However, little is known about whether 25 hydroxyvitamin D [25(OH)D], lipids, and oxysterols are related to cognitive function. **Objective:** This study sought to explore the relations between 25(OH)D, lipids, oxysterols, and cognitive function. **Methods:** In this study, about 209 MCI patients and 209 age- and gender-matched healthy controls were recruited from the Shanxi province of China (49.5% male; median [IQR] age: 63 [59–66] y). Serum concentrations of 25(OH)D, lipids, and oxysterols were measured using ultra-performance LC-MS. Cognitive performance was determined via comprehensive mental, verbal, and auditory cognitive tests. Dietary information was collected using a semiquantitative FFQ and 3 consecutive days of 24-h dietary recalls. Logistic regression analyses, Spearman's correlation, and partial correlation analyses were used to explore correlation between the variables. **Results:** Participants with vitamin D deficiency [serum 25(OH)D <20.0 ng/mL] were 3 times more likely to develop MCI compared to those with adequate vitamin D ( $\geq 30$  ng/mL) concentrations. The AUC of 25(OH)D was 0.72 and the cut-off was 16.5 ng/mL (sensitivity: 50.3%, specificity: 84.4%). Serum 25(OH)D concentrations were negatively correlated with total cholesterol (TC) ( $r = -0.19$ ,  $P = 0.02$ ), LDL-cholesterol ( $r = -0.17$ ,  $P = 0.04$ ), and 24S,25-epoxycholesterol (24S,25-epoxy-CHO) ( $r = -0.21$ ,  $P = 0.01$ ). Conversely, the Montreal Cognitive Assessment (MoCA) ( $r = 0.185$ ,  $P < 0.001$ ) and symbol digit modalities test (SDMT) ( $r = 0.11$ ,  $P = 0.03$ ) scores were positively correlated with serum 25(OH)D concentrations. **Conclusion:** The study identified significant differences in serum 25(OH)D concentrations between MCI patients and cognitive healthy controls, and there was a correlation between serum concentrations of 25(OH)D, lipids, and oxysterols and cognitive impairment among people.

## Sodium

### Targeting the Dietary Na: K Ratio—Considerations for Design of an Intervention Study to Impact Blood Pressure

David J Baer, Andrew Althouse, Mindy Hermann, Janice Johnson, Kevin C Maki, Matti Marklund, Liffert Vogt, Donald Wesson, Virginia A Stallings. *Advances in Nutrition*, Sept. 7. doi.org/10.1093/advances/. [Article link](#)

**Significance:** This expert review provides stepwise decision recommendations for designing future intervention trials on the sodium-to-potassium ratio in a way that addresses current data gaps and can be translated into dietary guidance. The clarity of the research question, intended use of the outcomes, study population and duration, blood pressure measurement, and type of dietary intervention are all important in future research.



This work was supported by IAFNS [Sodium Committee](#)

Despite medical, dietary, and lifestyle recommendations and drug advancements, hypertension persists as among the most prevalent noncommunicable diseases in the US population, and control remains elusive. Uncontrolled hypertension may increase the risk of serious illness from various other health challenges, including cardiovascular and renal responses. Adoption of a healthy diet is a consistent core element of lifestyle modifications that are recommended for mitigation of hypertension. The dietary sodium-to-potassium ratio is recognized as having promising potential in the regulation of blood pressure. In fact, the understanding of the relation between this ratio and blood pressure was documented as a key evidence gap in the 2019 National Academies of Sciences, Engineering, and Medicine report that revised recommended intake levels for both sodium and potassium. Although notable animal and human evidence supports this point, fundamental to developing a specific dietary recommendation for a sodium-to-potassium ratio is a well-designed human intervention trial. The successful translatability of such a trial will require careful consideration of study elements, including the study population, duration, blood pressure measurement, and dietary intervention, among other factors. This paper addresses these decision points and serves as supporting documentation for a research group or organization with the interest and means to address this important data gap, which will undoubtedly be foundational for advancing dietary guidance and would inform the next iteration of Dietary Reference Intakes for sodium and potassium.

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## Effect of Salt Substitution on Cardiovascular Events and Death

Bruce Neal, Yangfeng Wu, Xiangxian Feng, Ruijuan Zhang, Yuhong Zhang, Jingpu Shi, Jianxin Zhang, et al. *N Engl J Med* 2021; 385:1067-1077, Sept. 16. DOI: 10.1056/NEJMoa2105675. [Article link](#)

**Significance:** A study conducted in rural China involving over 10,000 subjects with history of stroke or aged 60 + years with hypertension, concluded that substitution of regular salt (100% NaCl) with a sodium-potassium salt mixture (75% NaCl and 25% KCl) resulted in a decrease in stroke and cardiovascular events and all-cause mortality, and no significance difference in hyperkalemia between the two salt intake groups.

**Background:** Salt substitutes with reduced sodium levels and increased potassium levels have been shown to lower blood pressure, but their effects on cardiovascular and safety outcomes are uncertain. **Methods:** We conducted an open-label, cluster-randomized trial involving persons from 600 villages in rural China. The participants had a history of stroke or were 60 years of age or older and had high blood pressure. The villages were randomly assigned in a 1:1 ratio to the intervention group, in which the participants used a salt substitute (75% sodium chloride and 25% potassium chloride by mass, or to the control group, in which the participants continued to use regular salt (100% sodium chloride). The primary outcome was stroke, the secondary outcomes were major adverse cardiovascular events and death from any cause, and the safety outcome was clinical hyperkalemia. **Results:** A total of 20,995 persons were enrolled in the trial. The mean age of the participants was 65.4 years, and 49.5% were female, 72.6% had a history of stroke, and 88.4% a history of hypertension. The mean duration of follow-up was 4.74 years. The rate of stroke was lower with the salt substitute than with regular salt (29.14 events vs. 33.65 events per 1000 person-years; rate ratio, 0.86; 95% confidence interval [CI], 0.77 to 0.96;  $P=0.006$ , as were the rates of major cardiovascular events (49.09 events vs. 56.29 events per 1000 person-years; rate ratio, 0.87; 95% CI, 0.80 to 0.94;  $P<0.001$  and death (39.28 events vs. 44.61 events per 1000 person-years; rate ratio, 0.88; 95% CI, 0.82 to 0.95;  $P<0.001$ ). The rate of serious adverse events attributed to hyperkalemia was not significantly higher with the salt substitute than with regular salt (3.35 events vs. 3.30 events per 1000 person-years; rate ratio, 1.04; 95% CI, 0.80 to 1.37;  $P=0.76$ ). **Conclusion:** Among persons who had a history of stroke or were 60 years of age or older and had high blood pressure, the rates of stroke, major cardiovascular events, and death from any cause were lower with the salt substitute than with regular salt.

## Gut Microbiome

### Systematic Review of the Effects of Oat Intake on Gastrointestinal Health

Ezra Valido, Jivko Stoyanov, Alessandro Bertolo, Anneke Hertig-Godeschalk, Ramona Maria Zeh, Joelle Leonie Flueck, Beatrice Minder, et. al. *The Journal of Nutrition*, Sept. 6, doi.org/10.1093/jn/nxab245. [Article link](#)

**Significance:** Though oat intake has been associated with improvement of beneficial gut bacterial groups in individuals without GI disease and those with Celiac disease, a recent review of the current state and quality of research drew variable findings and few firm conclusions.

**Background:** Oats are a food source with multiple health benefits that could support beneficial bacterial groups and provide important bioactive compounds for the gut. **Objectives:** This review explores the association between oat intake, gastrointestinal (GI) symptoms, and microbial community changes in individuals with celiac disease (CeD), irritable bowel syndrome (IBS), and inflammatory bowel disease (IBD) and without GI disease. **Methods:** Four databases and Google Scholar were systematically searched from inception until April 29, 2021. Clinical trials, observational studies, and in vitro studies with human gut-derived samples were included. **Results:** There were 84 articles [23 randomized controlled trials (RCTs), 21 nonrandomized trials, 8 observational studies, and 32 in vitro studies] included. Oat intake increased total bacterial count, Lactobacilli spp., and Bifidobacterium spp. in healthy individuals and those with CeD. There was an increased concentration of short-chain fatty acids and improved gut permeability with oat intake but with no significant quality-of-life difference. In some individuals with CeD, consumption of certain oat types was associated with worsening of GI symptoms. We found no studies reporting on IBS and only 3 for IBD. The quality of RCTs showed some concerns mostly in domains of randomization (73.9%), whereas the quality of evidence of non-RCTs, observational studies, and in vitro studies was satisfactory. **Conclusions:** Oat intake was associated with the increase of beneficial bacterial groups in individuals without GI disease and those with CeD. Most studies showed no changes in GI symptoms with oat consumption. In vitro studies in CeD provide insight to oat-sensitive individuals and their GI mucosa, but the clinical studies remain limited, precluding our ability to draw firm conclusions. The prevalence of oat sensitivity in individuals with CeD should be further explored as this could improve clinical management and facilitate inclusion of oat in the diet for this population.

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## Plant-Based Diet Index and Metabolic Risk in Men: Exploring the Role of the Gut Microbiome

Yanping Li, Dong D Wang, Ambika Satija, Kerry L Ivey, Jun Li, Jeremy E Wilkinson, Ruifeng Li, Megu et. al.  
The Journal of Nutrition, Volume 151, Issue 9, September 2021, Pages 2780–2789, doi.org/10.1093/jn/nxab175.

[Article link](#)

**Significance:** Increasing adherence to a healthy plant-based diet in adult men improved gut microbial abundance and diversity, pathways for amino acids metabolism and pyruvate fermentation.

**Background:** Healthy plant-based diet index (hPDI) is associated with a lower risk of cardiometabolic conditions, but its association as well as interactions with microbiome have not been elucidated. **Objectives:** We aimed to investigate the interrelations between hPDI, gut microbiome, and cardiometabolic risk markers. **Methods:** hPDI was derived from dietary assessments by a validated FFQ and was examined in relation to metagenomic profiles of 911 fecal samples collected from 303 men aged  $71 \pm 4$  y with an average BMI (in kg/m<sup>2</sup>) of  $25.2 \pm 3.6$  in the Men's Lifestyle Validation Study. Principal coordinate (PCo) analysis based on Bray–Curtis dissimilarity was conducted, and interactions between hPDI and PCo were examined by using a metabolic risk score composed of blood lipids, BMI, and glycated hemoglobin. **Results:** After multivariable adjustment, hPDI was significantly associated with the relative abundance of 7 species and 9 pathways. In particular, higher hPDI was significantly associated with a higher relative abundance of *Bacteroides cellulosilyticus* and *Eubacterium eligens*, amino acid biosynthesis pathways (L-isoleucine biosynthesis I and III and L-valine biosynthesis), and the pathway of pyruvate fermentation to isobutanol. A favorable association between hPDI and the metabolic risk score was more pronounced among men with a higher PCo characterized by higher abundance of *Bacteroides uniformis* and lower abundance of *Prevotella copri*. At the individual species level, a similar interaction was also observed between hPDI and *P. copri*, as well as with *Clostridium clostridioforme* or *Blautia hydrogenotrophica* (all P-interaction < 0.01). **Conclusion:** A greater adherence to a healthy plant-based diet by older men was associated with a microbial profile characterized by a higher abundance of multiple species, including *B. cellulosilyticus* and *E. eligens*, as well as pathways in amino acid metabolism and pyruvate fermentation. In addition, inverse associations between healthy plant-based diet and human metabolic risk may partially depend on microbial compositions.