HHS Public Access

Author manuscript

J Acad Nutr Diet. Author manuscript; available in PMC 2022 November 01.

Published in final edited form as:

J Acad Nutr Diet. 2021 November ; 121(11): 2233–2241.e1. doi:10.1016/j.jand.2021.06.009.

Healthy Eating Index-2015 scores among adults based on observed versus recalled dietary intake

Sharon I. Kirkpatrick, PhD RD [Associate Professor],
School of Public Health and Health Systems, University of Waterloo, Waterloo, ON, Canada

Kevin W. Dodd, PhD [Mathematical Statistician],
Division of Cancer Prevention, National Cancer Institute, Bethesda, MD

Nancy Potischman, PhD [Nutritional Epidemiologist],
Office of Dietary Supplements, National Institutes of Health, Rockville, MD

Thea Palmer Zimmerman, MS RD [Research Nutritionist],
Westat, Rockville, MD

Deirdre Douglass, MS RD [Research Nutritionist],
Westat, Rockville, MD

Patricia M. Guenther, PhD RD [Research Professor],
Department of Nutrition and Integrative Physiology, University of Utah, Salt Lake City, UT

Carrie Durward, PhD [Associate Professor],
Department of Nutrition, Dietetics and Food Sciences, Utah State University, Logan, UT

Abiodun T. Atoloye, PhD [Postdoctoral Research Associate],
Rudd Center for Food Policy and Obesity, University of Connecticut, Hartford, CT

Lisa L. Kahle, BA [Programmer],
Information Management Services, Inc., Rockville, MD

Amy F. Subar, PhD RD [Nutritionist (retired)],
Division of Cancer Control and Population Sciences, National Cancer Institute, Bethesda, MD

Jill Reedy, PhD RD [Branch Chief]
Division of Cancer Control and Population Sciences, National Cancer Institute, Bethesda, MD

Abstract

(corresponding author and contact for reprints) Sharon I. Kirkpatrick PhD RD, Associate Professor, School of Public Health and Health Systems, University of Waterloo, Waterloo, ON, Canada, 519-888-4567 x37054, sharon.kirkpatrick@uwaterloo.ca.

Author contributions: SIK conceptualized and led the drafting of the manuscript. SIK and KWD oversaw the analyses and LLK conducted the analyses. All authors contributed critical content and edits.

Conflict of interest disclosure: There are no conflicts of interest to report.

Background.—The construct and predictive validity of the Healthy Eating Index (HEI) have been demonstrated, but it is unclear how error in reported dietary intake may affect scores.

Objective.—These analyses examined concordance between HEI-2015 scores based on observed versus reported intake among adults.

Design.—Data were from two feeding studies (Food and Eating Assessment STudy, or FEAST, I and II) in which true intake was observed for three meals on one day. The following day, participants completed an unannounced 24-hour dietary recall.

Participants/setting.—FEAST I (2012) included 81 men and women, aged 20 to 70 years living in the Washington, DC area. FEAST II (2016) included 302 women, aged ≥18 years, with low household incomes and living in the Washington, DC area. In FEAST I, recalls were completed independently using the Automated Self-Administered 24-hour Dietary Assessment Tool (ASA24-2011) or interviewer-administered using the Automated Multiple-Pass Method. In FEAST II, recalls were completed using ASA24-2016, independently or in a small group setting with assistance.

Main outcome measures.—HEI-2015 scores were calculated using the population ratio method.

Statistical analyses performed.—T-tests determined if differences between scores based on observed and reported intake were different from zero. FEAST I data were stratified by sex and in FEAST II, analyses were repeated by education and body mass index (BMI).

Results.—Differences in total HEI-2015 scores between observed and reported intake ranged from −1.3 to 5.8 points among those completing ASA24 independently in both studies, compared to −2.5 points in the small group setting. For interviewer-administered recalls, the differences were −1.1 for men and 2.3 for women. In FEAST II, total HEI-2015 scores derived from observed intake were lower than scores derived from reported intake among those who had completed high school or less (−3.2, SE 1.1, $p<0.01$) and those with BMI≥30 (−2.8, SE 1.1, $p=0.01$).

Conclusions.—HEI-2015 scores based on 24-hour dietary recall data are generally well estimated.

Keywords

24-hour recall; Healthy Eating Index; dietary intake; dietary patterns; validation

Introduction

Food and beverage consumption is typically captured using self-report methods in surveillance, epidemiologic, and intervention studies.[1] To inform best practices for data collection, analysis, and interpretation, a growing body of research documents the extent and nature of measurement error affecting data derived from these methods.[2-10] Such research often focuses on particular dietary components. For example, validation studies using recovery biomarkers have examined energy, protein, potassium, and sodium, as well as corresponding densities.[2-10] Within feeding studies, the emphasis likewise tends to be on accuracy of intake estimates for energy and particular nutrients and food groups.[11-13]

Within nutrition research, however, there is increasing recognition of the complexity of eating patterns.[14] This complexity encompasses multidimensionality in that humans consume a range of foods and beverages in different combinations, with implications for health.[14,15] Varied methods have been developed to capture multidimensionality, including *a priori* dietary indices that measure alignment of intake with pre-established guidelines.[16,17] A commonly-used example is the Healthy Eating Index (HEI),[18-21] which assesses adherence to the Dietary Guidelines for Americans (DGA)[15] through the inclusion of adequacy and moderation components. The 2005, 2010, and 2015 versions of the HEI, each of which is density based, have been shown to capture diet quality independently of energy intake and to distinguish among subgroups with known differences in diet quality.[22-24] Further, among adults, higher HEI-2015 scores are associated with lower risk of death from all causes, as well as cancer and cardiovascular disease,[25-29] demonstrating the index's predictive validity.

Biomarker-based validation studies have shown that densities (e.g., protein intake relative to energy intake) are less affected by bias than are absolute intakes (e.g., protein intake),[8,9] potentially suggesting scores on the density-based HEI may be less affected by bias than scores based on absolute intakes. However, differences in HEI scores from true versus reported intake have not been empirically documented. The objective of these analyses was to examine concordance between HEI-2015 scores based on observed intake versus intake reported on a 24-hour dietary recall among adults. It was hypothesized that scores based on observed and true dietary intake would be similar.

Methods

Data sources

Data were drawn from two feeding studies in which intakes for three meals on one day were unobtrusively documented.[11,12,30] The primary objective was to assess the criterion validity of the Automated Self-Administered 24-hour Dietary Assessment Tool (ASA24).[31] Participants who lived in the Washington, DC area who met the eligibility criteria for each study and were willing to attend two study center visits were recruited by EurekaFacts, a research firm based in Rockville, MD, using a database of research volunteers that contained details on sex, age range, and race/ethnic identity. Recruitment and screening were conducted by telephone, and eligible and enrolled participants were mailed a welcome package with two consecutive dates for visiting the study center. A reminder call was made the night before the first scheduled study center visit.

The first study (Food and Eating Assessment STudy, or FEAST, I) was carried out in 2012 with 81 men and women aged 20 to 70 years, with quota sampling used to recruit a diverse sample of adults based on age, sex, and race/ethnic identity.[11,30] Potential participants were excluded if they had previously participated in a research study, were currently dieting, or had any formal training in nutrition. This study was approved by the National Cancer Institute Institutional Review Board and the Westat Institutional Review Board. Two conditions were tested: half of the sample (n=40) completed a 24-hour dietary recall using ASA24 and half (n=41) completed an interviewer-administered recall conducted using the US Department of Agriculture's Automated Multiple-Pass Method (AMPM).[5]

The second study (FEAST II)[12] was carried out in 2016 with 302 women aged ≥18 years with incomes below the thresholds for the Supplemental Nutrition Assistance Program.[32] Women were included because of a focus of the study on the potential usage of ASA24 to evaluate nutrition education programs, the participants in which are primarily women. Quota sampling was used to recruit a racially and ethnically diverse sample and an effort was made to oversample individuals with less than a high school education. Potential participants were excluded if they were unable to read and understand English or Spanish (the two languages in which ASA24 is available with the U.S.); had dietary allergies, practices, or preferences that would interfere with the study protocol; were pregnant; or had previously had bariatric surgery. Approximately half (n=148) of the FEAST II sample completed ASA24 independently (independent condition) and the remainder (n=154) completed ASA24 in a small-group setting (assisted condition). This study was approved by the Institutional Review Board at Utah State University and the Westat Institutional Review Board.

For both studies, the sample size was based on detecting a difference in the proportion of foods truly consumed and reported between conditions. Participants were reimbursed for their travel and provided with modest remuneration for their time.

Data collection

At their first visit to the study center and after being provided with a brief introduction to the study and completing written informed consent, participants were invited to select and consume foods and beverages from a buffet for each of breakfast, lunch, and dinner.[11,12,30] A variety of foods and beverages were offered (Table 1, online only), including those contributing to a variety of HEI-2015 components. Items were served in their original or labelled containers. Each container was inconspicuously weighed prior to and after each participant served themselves and plate waste was weighed after each meal. Weights were taken with Ultra Ship 35 scales (My Weigh, Phoenix, AZ), which have a precise accuracy of 0.1 ounces (2.8 g) for items weighing up to 2 pounds (0.91 kg) and 0.2 ounces (5.7 g) for items weighing >2 pounds (0.91 kg). Each item was weighed independently by two technicians; if the two weights did not match to the gram, a third weight was taken and the mean of the two closest weights used. The weight consumed was calculated as the weight of the food taken minus the weight of the food left.

The following day, participants were asked to complete an unannounced recall for the prior day from midnight to midnight, using ASA24 independently but with access to a telephone helpline if needed (both studies), using ASA24 with assistance from a paraprofessional in a small group setting of 8-12 participants (FEAST II), or on the telephone with a trained interviewer using AMPM (FEAST I). ASA24 was developed by the National Cancer Institute to enable self-administered 24-hour dietary recalls and food records,[31] whereas AMPM was developed by the US Department of Agriculture to improve the accuracy of recalls in large-scale applications[5,33] and is used in NHANES.[34] Both recall systems use multiple passes to prompt accurate recall, with ASA24 using an adapted version of the AMPM's passes to allow self-administration.[31] FEAST I[11,30] used ASA24-2011, which incorporated an avatar that provided written and audio instructions to participants. FEAST II[12] used ASA24-2016, which offered a streamlined interface without an avatar.

After completing ASA24, FEAST I participants were asked to complete a brief self-administered questionnaire that queried demographic and health characteristics. FEAST II participants completed a similar brief self-administered questionnaire that additionally queried receipt of food assistance as well as where and how often they accessed the internet. Body mass index (BMI) was calculated based on self-reported height and weight (kg/m^2).[35]

Coding of observed and reported intake

Each food and beverage offered for consumption and reported was coded using the Food and Nutrient Database for Dietary Studies (FNDDS)[36] as well as the MyPyramid Equivalents Database (MPED) or its successor, the Food Patterns Equivalents Database (FPED).[37] The FNDDS enables estimation of energy and nutrient intakes, and the MPED/FPED disaggregate each food and beverage into ingredients that are assigned to guidance-based groupings, such as fruits, vegetables, and added sugars.[37] For FEAST I, FNDDS 4.1 (2007-2008) and the MPED version 2.0, supplemented with the USDA's Center for Nutrition Policy and Promotion Addendum,[38] were used. FEAST II made use of FNDDS 2011-2012 and the FPED, version 2.0.

Foods and beverages reported using ASA24 are automatically coded with linkage to the respective versions of FNDDS and MPED/FPED. Prior to analysis, corrections were applied to address known errors in the ASA24 database (https://epi.grants.cancer.gov/asa24/resources/issues.html). Prior analyses of these data have compared the foods and beverages truly consumed (observed) to those reported by participants.[11,12,30] Given the emphasis of the current analyses on overall dietary quality, all foods and beverages reported for all three eating occasions by participants were considered, whether or not they were matches for foods and beverages truly consumed at those eating occasions.

Healthy Eating Index-2015

The HEI-2015,[20,24] which quantifies alignment with the 2015-2020 DGA,[15] was used because it is the current iteration. The HEI-2015 comprises nine adequacy and four moderation components. The scoring algorithm operates on a density basis (e.g., amount per 1000 calories, ratio of fatty acids) and the HEI-2015 can thus be used to assess the quality of any mix of foods and drinks in terms of how calories are allocated. The maximum score of 100 points indicates perfect alignment with the DGA.

Statistical analysis

Analyses were conducted using SAS, version 9.4.[39] The population ratio approach was applied to arrive at HEI total and component scores. This method entails calculating total intakes of the dietary constituents among the group of persons of interest (i.e., intake is summed across the total sample), calculating the relevant ratio of the totals for each HEI component (i.e., total fruits per 1000 kcal across the total sample is derived), and then comparing the ratio with the scoring standards.[21] This approach has been shown to better reflect usual intake as compared to calculating ratios and scores at the level of each individual and averaging them to arrive at the mean for the group[40] and is recommended for comparing mean scores across groups.[21] Scores were estimated using observed and reported intake, with stratification by study and condition (ASA24 versus AMPM, ASA24 independent versus ASA24 assisted). In FEAST I, the data were also stratified by sex to improve comparability with the results of FEAST II, which included women only. A Monte Carlo approach was applied to estimate standard errors and differences in scores derived from observed and reported intake using macros available from the National Cancer Institute (https://epi.grants.cancer.gov/hei/sas-code.html). The macros were modified to account for the correlations between mean observed and mean reported intake measured on the same people on the same day (i.e., the observed and reported intakes were not treated as independent samples).

No statistical testing was employed in FEAST I due to the small sample size. For FEAST II, t-tests were used to determine if each difference was different from zero. A consistent analytic approach was applied to calculate component and total HEI scores by education and BMI within FEAST II. These two variables were selected *a priori* based on validation studies suggesting they are important correlates of reporting error.[8,9] For these stratified analyses, data for the independent and assisted groups within FEAST II were pooled because prior analyses showed similar differences between observed and reported intake between groups.[12] Pairwise t-tests were conducted to compare differences in scores derived from observed versus reported intake among the education and BMI groups, respectively.

Applying an adjustment for multiple comparisons would favor the hypothesis that HEI-2015 scores derived from observed and reported intake would be similar and therefore, no correction for multiple testing was applied. Differences were thus considered significant at $p<0.05$.

Results

Table 2 shows the characteristics of the two samples. The FEAST I sample primarily identified as white and most participants had completed college. Participants in FEAST II primarily identified as Hispanic/Latino and non-Hispanic Black, and a quarter to a third had completed college.

Tables 3 and 4 show HEI total and component scores for FEAST I and FEAST II, respectively. Among those completing ASA24 independently in either study, the absolute mean differences in total HEI-2015 scores derived from observed versus reported intake ranged from −1.3 to 5.8 points. Among men and women completing an interviewer-administered recall in FEAST I, the absolute mean differences were −1.1 and 2.3, respectively. The difference in the total score derived from observed versus reported intake for the assisted group in FEAST II was −2.5 (SE 0.87, $p<0.01$).

Among FEAST II participants regardless of recall condition, scores based on reported intake were significantly higher than those derived from observed intake for Total Vegetables, Seafood and Plant Proteins, and Refined Grains, and lower than scores based on observed intake for Saturated Fats. Scores derived from reported intake were significantly lower than those based on observed intake for Total Protein Foods and Added Sugars among those completing ASA24 independently. This blunted the difference between the total HEI score based on observed versus reported intake among this group to −1.3 points (SE 0.90; p=0.16).

Table 5 shows HEI total scores for FEAST II participants, stratified by education and BMI. Total HEI scores from observed intake were lower than scores derived from reported intake among those who had completed high school or less (−3.2, SE 1.1, p<0.01) and among those with BMI≥30 (−2.8, SE 1.1, p=0.01). Across all three education categories, scores derived from reported intake were statistically significantly higher than those derived from observed intake for Total Vegetables and Refined Grains (data not shown). This was also the case for Seafood and Plant Proteins among participants who had completed high school or less and those with some college, whereas scores based on reported intake were statistically significantly lower than those derived from observed intake for Saturated Fats among those with some college and for Saturated Fats and Added Sugars among those who had a college education or beyond. Across all three BMI categories, scores derived from reported intake were significantly higher than those based on observed intake for Refined Grains. This was also the case for Total Vegetables among those with BMI<25 and ≥30, Whole Grains among those with BMI 25≥BMI<30, and Seafood and Plant Proteins among those with BMI≥30. Among those with BMI<25, scores based on reported intake were lower than those based on observed intake for Saturated Fats and Added Sugars. Pairwise comparisons revealed few differences in the magnitude of the differences between component scores based on observed and reported intake across the education groups and BMI groups, respectively, and no significant differences for total HEI scores (data not shown).

Discussion

Characterizing measurement error in self-reported intake data can inform mitigation strategies and appropriate interpretation of results. Extensive efforts have been undertaken to assess the validity of the HEI,[22-29] but it is seldom possible to assess the accuracy of scores based on self-reported versus true intake. The present findings, informed primarily by results from the larger of the two studies, suggest that the magnitude of error in total HEI scores based on 24-hour dietary recalls completed by adults is generally small. A difference of 5 to 6 points in total HEI scores between independent groups might be considered meaningful based on an effect size of 0.5 applied to the observed standard deviation of the estimated distribution of usual HEI scores among U.S. adults.[21] The only difference between scores based on observed versus reported intake that exceeded 5 points was the 5.8 point discrepancy observed among the very small subsample of 21 women who completed ASA24 independently in FEAST I. Among other subgroups who completed ASA24 independently or with assistance or who completed interviewer-administered recalls, absolute mean differences in total HEI scores based on true and reported intake were between −2.5 and 2.3 points.

The pattern of results by education and BMI is consistent with hypotheses based on biomarker-based validation studies,[8,9] with higher total HEI-2015 scores based on reported versus true intake for subgroups with lower educational attainment and higher BMI. For the other education and BMI groups, scores derived from reported intake were also higher than those based on true intake, but these differences did not reach a p-value of <0.05. Indeed, in the larger subgroups afforded by FEAST II, total scores based on reported intake were consistently higher than those derived from observed intake, whereas this was not the case in FEAST I.

The findings highlight the need for care when interpreting differences in HEI scores among groups. Small or large differences may be artifacts of small sample sizes and/or random and/or systematic measurement error. When comparing differences among subgroups characterized by factors such as education or BMI, differential misreporting due to differences in capacity to accurately report intake or social desirability[41] and other potential biases should be borne in mind.

The components contributing to the differences in total scores varied somewhat by subgroup within FEAST II but consistently included Total Vegetables, Seafood and Plant Proteins, Refined Grains, and Saturated Fats. In earlier analyses, lower values for protein (grams) and higher values for vegetables (cup equivalents) were observed based on reported versus observed intake.[12] The HEI-2015 score for Total Protein Foods was similarly lower based on reported intake in the FEAST II independent condition, whereas the Total Vegetables and Seafood and Plant Proteins scores were higher based on reported intake in both conditions. Scores for moderation components were not consistently overestimated, suggesting no consistent differential underreporting of foods and beverages that might be perceived as less healthy than others. This is consistent with the earlier finding that rates of excluding sweets, desserts, and beverages from reporting were lower than the exclusion rate for fruits and vegetables, which were often offered as additions to main foods, such as salads and sandwiches.[12]

Several caveats should be borne in mind in interpreting these results. The samples were recruited from databases of research volunteers who received monetary compensation and participants may have been more highly motivated to accurately report their intake compared to participants in other studies. HEI scores were based on three meals offered and consumed within a controlled environment on a single day. Participants may have paid more attention to what they were consuming than usual due to the unfamiliar environment, potentially leading to more accurate reporting than might otherwise be the case. However, it is also possible consumption was reported with more error than would be the case if individuals had engaged in their usual eating patterns. Without knowing which of these two scenarios pertained to the individuals in the study, it is challenging to translate this study's findings directly to diverse populations in unconstrained eating environments. Furthermore, it is practically impossible to characterize true dietary patterns in such environments. While the small differences generally observed in this study may not pertain to all situations, given shifts in the field toward considering overall diet quality,[14] the findings are promising.

Errors in estimation of scores based on 24-hour dietary recalls may be driven by the exclusion of foods and beverages truly consumed, reporting of foods and beverages not truly consumed (i.e., intrusions), and inaccurate portion size estimation.[11,12,30] In initial data cleaning, eating occasions outside of the three meals eaten at the study center were excluded.[11,12] However, it is possible foods and beverages reported by participants as part of the study center meals but not observed were actually consumed before, after, or between meals, potentially resulting in misestimation of the magnitude of the difference between HEI-2015 scores.

The hypothesis testing procedures gave every chance for significant differences to be discovered, at the risk of some false positives. This was appropriate because it was hypothesized *a priori* that scores based on observed and true intake would be similar. Due to the small sample size, the depth of analysis of the FEAST I data was limited but these data were included to provide a sense of the magnitude of error based on a more diverse sample relative to the focus on women with low incomes in FEAST II, as well as insights into differences between interviewer-administered versus self-administered recalls. In FEAST II, 69 of 302 women completed ASA24 recalls in Spanish; for these recalls, a lower rate of reporting foods and beverages that were matches for those truly consumed was observed (65% compared to 73% for recalls completed in English).[12] Due to the small numbers, it is not possible to investigate the influence of language of completion on the accuracy of HEI scores. Finally, height and weight were self-reported, potentially resulting in some misclassification of BMI that may have blunted associations with HEI-2015 scores.

Conclusions

In summary, because the HEI is widely used in nutrition research, it is important to understand its measurement properties. These findings suggest HEI-2015 scores are generally well estimated when calculated using 24-hour dietary recall data. Analyses of data from additional feeding studies conducted in a variety of populations and settings would add to the confidence of these findings.

Funding/financial disclosures:

The data for the FEAST I study were collected by the US government via a contract with Westat (NO2-PC-64406, HHSN261200644006C). FEAST II was funded by a grant from the USDA National Institute of Food and Agriculture (2015-09151). The current analyses were funded by the National Cancer Institute.

References

1. Thompson FE, Kirkpatrick SI, Subar AF, Reedy J, Schap TE, Wilson MM, Krebs-Smith SM. The National Cancer Institute's Dietary Assessment Primer: A resource for diet research. J Acad Nutr Diet. 2015;115(12):1986–95. [PubMed: 26422452]
2. Kipnis V, Subar AF, Midthune D, Freedman LS, Ballard-Barbash R, Troiano RP, Bingham S, Schoeller DA, Schatzkin A, Carroll RJ. Structure of dietary measurement error: results of the OPEN biomarker study. Am J Epidemiol. 2003;158(1):14–6. [PubMed: 12835281]
3. Subar AF, Kipnis V, Troiano RP, Midthune D, Schoeller DA, Bingham S, Sharbaugh CO, Trabulsi J, Runswick S, Ballard-Barbash R, Sunshine J. Using intake biomarkers to evaluate the extent of dietary misreporting in a large sample of adults: The OPEN study. Am J Epidemiol. 2003;158(1):1–13. [PubMed: 12835280]
4. Schatzkin A, Kipnis V, Carroll RJ, Midthune D, Subar AF, Bingham S, Schoeller DA, Troiano RP, Freedman LS. A comparison of a food frequency questionnaire with a 24-hour recall for use in an epidemiological cohort study: results from the biomarker-based Observing Protein and Energy Nutrition (OPEN) study. Int J Epidemiol. 2003;32(6):1054–62. [PubMed: 14681273]
5. Moshfegh AJ, Rhodes DG, Baer DJ, Murayi T, Clemens JC, Rumpler WV, Paul DR, Sebastian RS, Kuczynski KJ, Ingwersen LA, Staples RC. The US Department of Agriculture Automated Multiple-

Pass Method reduces bias in the collection of energy intakes. Am J Clin Nutr. 2008;88(2):324–32. [PubMed: 18689367]

6. Neuhouser ML, Tinker L, Shaw PA, Schoeller D, Bingham SA, Horn LV, Beresford SA, Caan B, Thomson C, Satterfield S, Kuller L. Use of recovery biomarkers to calibrate nutrient consumption self-reports in the Women's Health Initiative. Am J Epidemiol. 2008;167(10):1247–59. [PubMed: 18344516]
7. Huang Y, Van Horn L, Tinker LF, Neuhouser ML, Carbone L, Mossavar-Rahmani Y, Thomas F, Prentice RL. Measurement error corrected sodium and potassium intake estimation using 24-hour urinary excretion. Hypertension. 2014;63(2):238–44. [PubMed: 24277763]
8. Freedman LS, Commins JM, Moler JE, Arab L, Baer DJ, Kipnis V, Midthune D, Moshfegh AJ, Neuhouser ML, Prentice RL, Schatzkin A. Pooled results from 5 validation studies of dietary self-report instruments using recovery biomarkers for energy and protein intake. Am J Epidemiol. 2014;180(2):172–88.. [PubMed: 24918187]
9. Freedman LS, Commins JM, Moler JE, Willett W, Tinker LF, Subar AF, Spiegelman D, Rhodes D, Potischman N, Neuhouser ML, Moshfegh AJ. Pooled results from 5 validation studies of dietary self-report instruments using recovery biomarkers for potassium and sodium intake. Am J Epidemiol. 2015;181(7):473–87. [PubMed: 25787264]
10. Wark PA, Hardie LJ, Frost GS, Alwan NA, Carter M, Elliott P, Ford HE, Hancock N, Morris MA, Mulla UZ, Noorwali EA. Validity of an online 24-h recall tool (myfood24) for dietary assessment in population studies: comparison with biomarkers and standard interviews. BMC Med. 2018;16(1):136. [PubMed: 30089491]
11. Kirkpatrick SI, Subar AF, Douglass D, Zimmerman TP, Thompson FE, Kahle LL, George SM, Dodd KW, Potischman N. Performance of the Automated Self-Administered 24-hour Recall relative to a measure of true intakes and to an interviewer-administered 24-h recall. Am J Clin Nutr. 2014;100(1):233–40. [PubMed: 24787491]
12. Kirkpatrick SI, Guenther PM, Douglass D, Zimmerman T, Kahle LL, Atoloye A, Marcinow M, Savoie-Roskos MR, Dodd KW, Durward C. The provision of assistance does not substantially impact the accuracy of 24-hour dietary recalls completed using the Automated Self-Administered 24-H Dietary Assessment Tool among women with low incomes. J Nutr. 2019;149(1):114–22. [PubMed: 30602015]
13. Brassard D, Lemieux S, Charest A, Lapointe A, Couture P, Labonté MÈ, Lamarche B. Comparing interviewer-administered and web-based food frequency questionnaires to predict energy requirements in adults. Nutrients. 2018;10(9):1292.
14. Reedy J, Subar A, George S, Krebs-Smith S. Extending Methods in Dietary Patterns Research. Nutrients. 2018;10(5):571.
15. US Department of Health and Human Services and US Department of Agriculture. 2015-2020 Dietary Guidelines for Americans. 8th edition. Washington, DC. 2015.
16. Krebs-Smith SM, Subar AF, Reedy J. Examining dietary patterns in relation to chronic disease: Matching measures and methods to questions of interest. Circulation. 2015;132(9):790–3. [PubMed: 26260734]
17. Ocké MC. Evaluation of methodologies for assessing the overall diet: Dietary quality scores and dietary pattern analysis. Proc Nutr Soc. 2013;72(2):191–9. [PubMed: 23360896]
18. Guenther PM, Reedy J, Krebs-Smith SM. Development of the Healthy Eating Index-2005. J Am Diet Assoc. Elsevier; 2008;108(11):1896–901. [PubMed: 18954580]
19. Guenther PM, Casavale KO, Reedy J, Kirkpatrick SI, Hiza HA, Kuczynski KJ, Kahle LL, Krebs-Smith SM. Update of the Healthy Eating Index: HEI-2010. J Acad Nutr Diet. 2013;113(4):569–80. [PubMed: 23415502]
20. Krebs-Smith SM, Pannucci TR, Subar AF, Kirkpatrick SI, Lerman J, Tooze JA, Wilson MM, Reedy J. Update of the Healthy Eating Index: HEI-2015. J Acad Nutr Diet. 2018;118(9):1591–602. [PubMed: 30146071]
21. Kirkpatrick SI, Reedy J, Krebs-Smith SM, Pannucci TE, Subar AF, Wilson MM, Lerman JL, Tooze JA. Applications of the Healthy Eating Index for surveillance, epidemiology, and intervention research: Considerations and caveats. J Acad Nutr Diet. 2018;118(9):1603–21. [PubMed: 30146072]

22. Guenther PM, Reedy J, Krebs-Smith SM, Reeve BB. Evaluation of the Healthy Eating Index-2005. J Am Diet Assoc. 2008;108(11):1854–64. [PubMed: 18954575]
23. Guenther PM, Kirkpatrick SI, Reedy J, Krebs-Smith SM, Buckman DW, Dodd KW, Casavale KO, Carroll RJ. The Healthy Eating Index-2010 is a valid and reliable measure of diet quality according to the 2010 Dietary Guidelines for Americans. J Nutr. 2014;144(3):399–407. [PubMed: 24453128]
24. Reedy J, Lerman J, Tooze JA, Subar AF, Pannucci TR, Kirkpatrick SI, Krebs-Smith SM. Evaluation of the Healthy Eating Index-2015. J Acad Nutr Diet. 2018;118(9):1622–33. [PubMed: 30146073]
25. Liese AD, Krebs-Smith SM, Subar AF, George SM, Harmon BE, Neuhouser ML, Boushey CJ, Schap TE, Reedy J. The Dietary Patterns Methods Project: Synthesis of findings across cohorts and relevance to dietary guidance. J Nutr. 2015;145(3):393–402. [PubMed: 25733454]
26. Harmon BE, Boushey CJ, Shvetsov YB, Ettienne R, Reedy J, Wilkens LR, Le Marchand L, Henderson BE, Kolonel LN. Associations of key diet-quality indexes with mortality in the Multiethnic Cohort: the Dietary Patterns Methods Project. Am J Clin Nutr. 2015;101(3):587–97. [PubMed: 25733644]
27. George SM, Ballard-Barbash R, Manson JE, Reedy J, Shikany JM, Subar AF, Tinker LF, Vitolins M, Neuhouser ML. Comparing indices of diet quality with chronic disease mortality risk in postmenopausal women in the Women's Health Initiative Observational Study: evidence to inform national dietary guidance. Am J Epidemiol. 2014;180(6):616–25. [PubMed: 25035143]
28. Reedy J, Krebs-Smith SM, Miller PE, Liese AD, Kahle LL, Park Y, Subar AF. Higher diet quality Is associated with decreased risk of all-cause, cardiovascular disease, and cancer mortality among older adults. J Nutr. 2014;144(6):881–9. [PubMed: 24572039]
29. Morze J, Danielewicz A, Hoffmann G, Schwingshackl L. Diet Quality as Assessed by the Healthy Eating Index, Alternate Healthy Eating Index, Dietary Approaches to Stop Hypertension Score, and Health Outcomes: A Second Update of a Systematic Review and Meta-Analysis of Cohort Studies. J Acad Nutr Diet. 2020.
30. Kirkpatrick SI, Potischman N, Dodd KW, Douglass D, Zimmerman TP, Kahle LL, Thompson FE, George SM, Subar AF. The use of digital images in 24-hour recalls may lead to less misestimation of portion size compared with traditional interviewer-administered recalls. J Nutr. 2016;146(12):2567–73. [PubMed: 27807039]
31. Subar AF, Kirkpatrick SI, Mittl B, Zimmerman TP, Thompson FE, Bingley C, Willis G, Islam NG, Baranowski T, McNutt S, Potischman N. The Automated Self-Administered 24-hour dietary recall (ASA24): a resource for researchers, clinicians, and educators from the National Cancer Institute. J Acad Nutr Diet. 2012;112(8):1134–7. [PubMed: 22704899]
32. United States Department of Agriculture Food and Nutrition Service. Am I Eligible for SNAP? https://www.fns.usda.gov/snap/eligibility#What are the SNAP income limits. Accessed May 15, 2020.
33. Blanton CA, Moshfegh AJ, Baer DJ, Kretsch MJ. The USDA Automated Multiple-Pass Method accurately estimates group total energy and nutrient intake. J Nutr. 2006;136(10):2594–9. [PubMed: 16988132]
34. Ahluwalia N, Dwyer J, Terry A, Moshfegh A, Johnson C. Update on NHANES dietary data: focus on collection, release, analytical considerations, and uses to inform public policy. Adv Nutr An Int Rev J. 2016;7(1):121–34.
35. Centers for Disease Control and Prevention. Body Mass Index (BMI). https://www.cdc.gov/healthyweight/assessing/bmi/index.html. Accessed May 15, 2020.
36. US Department of Agriculture Agricultural Research Service. Food and Nutrient Database for Dietary Surveys. https://www.ars.usda.gov/northeast-area/beltsville-md-bhnrc/beltsville-human-nutrition-research-center/food-surveys-research-group/docs/fndds/. Accessed May 15, 2020.
37. U.S. Department of Agriculture Agricultural Research Service. Food Patterns Equivalents Database. https://www.ars.usda.gov/northeast-area/beltsville-md-bhnrc/beltsville-human-nutrition-research-center/food-surveys-research-group/docs/fped-databases/. Accessed May 15, 2020.
38. Koegel KL, Kuczynski KJ, Britten P. Addendum to the MyPyramid Equivalents Database 2.0. Procedia Food Sci. 2013;2:75–80.

39. SAS, Version 9.4. SAS Institute, Cary, NC.
40. Freedman LS, Guenther PM, Krebs-Smith SM, Kott PS. A population's mean Healthy Eating Index-2005 scores are best estimated by the score of the population ratio when one 24-hour recall is available. J Nutr. 2008;138(9):1725–9. [PubMed: 18716176]
41. Hebert JR, Clemow L, Pbert L, Ockene IS, Ockene JK. Social desirability bias in dietary self-report may compromise the validity of dietary intake measures. Int J Epidemiol. 1995;24(2):389–98. [PubMed: 7635601]

Research Snapshot

Research Question:

What is the concordance between Healthy Eating Index-2015 (HEI-2015) scores based on observed intake versus intake reported using online and interviewer-administered 24-hour dietary recalls among men and women, overall and with stratification by education and body mass index?

Key Findings:

The findings suggest HEI-2015 scores are generally well estimated based on 24-hour dietary recall data.

Table 1.

Foods and beverages offered in the FEAST[a] I (2012) and FEAST[a] II (2016) studies, carried out in Washington, DC area

Meal	Foods	Beverages
Breakfast	Cold cereal (3 varieties)	Coffee (with cream)
	Oatmeal	Tea
	Bagels (4 varieties)	Orange juice
	Cream cheese	Milk
	Margarine	
	Jelly	
	Fruit salad	
	Sugar	
	Sugar substitute (3 varieties)	
Lunch	Pesto pasta salad	Bottled water
	Tuna sandwich (with lettuce, tomato)	Tea
	Turkey sandwich (with cheese, lettuce, tomato, mayonnaise, mustard)	Soda (3 varieties)
	Green salad (with red and green peppers, tomato, cucumber)	
	Grated cheese Salad dressing (3 varieties)	
	Apples	
	Bananas	
	Potato chips	
	Brownies	
	Sugar	
	Sugar substitute (3 varieties)	
Dinner	Vegetarian lasagna	Bottled water
	Roasted chicken breast and leg	Coffee
	Rice pilaf	Tea
	Garlic bread	Soda (3 varieties)
	Cooked broccoli	Milk
	Cooked carrots	
	Apple pie	
	Chocolate cake	
	Sugar	
	Sugar substitute (3 varieties)	

[a]FEAST, Food and Eating Assessment Study.

Table 2.

Demographic characteristics of participants in the FEAST I[a] (2012, n=81) and FEAST II[a] (2016, n=302) studies carried out in Washington, DC area

	FEAST I ASA24[b]		FEAST I AMPM[c]		FEAST II ASA24[b] independent	FEAST II ASA24[b] assisted
	Men n=19	Women n=21	Men n=20	Women n=21	Women n=148	Women n=154
	n (%)[d]					
Age (years)						
18-34	6 (32)	5 (24)	5 (25)	8 (38)	49 (33)	51 (33)
35-54	6 (32)	8 (38)	8 (40)	5 (24)	70 (47)	69 (45)
55-82	7 (37)	8 (38)	7 (35)	8 (38)	29 (20)	34 (22)
Race/ethnic identity						
White [e]	13 (68)	14 (67)	9 (45)	5 (24)	18 (12)	21 (14)
Black [e]	3 (32)	7 (33)	6 (30)	13 (62)	44 (30)	59 (38)
Hispanic/Latino [e]	--	--	--	--	72 (49)	62 (40)
Other racial/ethnic identity	3 (16)	0	5 (25)	3 (14)	14 (9)	12 (8)
Education						
Some or completed high school or GED [f]	1 (5)	2 (10)	4 (20)	3 (14)	41 (28)	48 (31)
Completed some college	3 (16)	3 (14)	4 (20)	9 (43)	69 (47)	54 (35)
Completed college	14 (74)	15 (71)	12 (60)	9 (43)	37 (25)	51 (33)
Body mass index (kg/m^2)						
<25	3 (16)	6 (29)	5 (25)	7 (33)	43 (29)	58 (38)
25≥29.9	7 (37)	6 (29)	9 (45)	6 (29)	33 (22)	38 (25)
≥30	7 (37)	9 (43)	5 (25)	8 (38)	63 (43)	55 (36)

[a]FEAST, Food and Eating Assessment Study.

[b]ASA24, Automated Self-Administered 24-hour Dietary Assessment Tool.

[c]AMPM, Automated Multiple-Pass Method.

[d]Proportions for education and body mass index may not add up to 100 due to missing information for some participants on the demographic and health behavior questionnaires.

[e]For FEAST II, White represents non-Hispanic White and Black represents non-Hispanic Black. This level of differentiation is not available for FEAST I. For FEAST I, Hispanic/Latino identity is included in Other racial/ethnic identity due to small cell sizes.

[f]General Educational Development.

Table 3.

Healthy Eating Index-2015 total and component scores based on observed and reported intake, by 24-hour recall condition, among men and women in FEAST[a] I (2012, n=81) carried out in Washington, DC area

Component (maximum score)	FEAST Independent completion of ASA24[b]				FEAST Interviewer-administered using AMPM[c]			
	Men n=19		Women n=21		Men n=20		Women n=21	
	Observed	Reported	Observed	Reported	Observed	Reported	Observed	Reported
	Mean[d] (95% CI)							
Total Fruits (5)	4.1 (2.9, 5.0)	4.7 (3.4, 5.0)	4.1 (3.2, 5.0)	4.2 (3.0, 5.0)	4.6 (3.7, 5.0)	4.3 (3.1, 5.0)	4.5 (3.2, 5.0)	4.0 (3.0, 5.0)
Whole Fruits (5)	5.0 (5.0, 5.0)	5.0 (4.4, 5.0)	5.0 (5.0, 5.0)	5.0 (4.3, 5.0)	5.0 (5.0, 5.0)	5.0 (4.4, 5.0)	5.0 (5.0, 5.0)	4.9 (3.9, 5.0)
Total Vegetables (5)	3.7 (3.1, 4.3)	3.8 (2.9, 4.8)	4.5 (3.8, 5.0)	4.0 (3.1, 5.0)	4.0 (3.3, 4.7)	4.5 (3.8, 5.0)	3.9 (3.0, 4.8)	4.5 (3.5, 5.0)
Greens and Beans (5)	4.8 (3.7, 5.0)	4.5 (1.9, 5.0)	4.8 (4.1, 5.0)	4.5 (3.0, 5.0)	5.0 (4.6, 5.0)	4.9 (3.9, 5.0)	5.0 (4.4, 5.0)	4.6 (3.2, 5.0)
Whole Grains (10)	2.9 (2.1, 3.7)	3.7 (1.8, 5.7)	2.6 (1.9, 3.3)	4.6 (2.6, 6.6)	3.5 (2.8, 4.2)	4.9 (3.4, 6.4)	3.4 (2.5, 4.3)	4.5 (3.0, 6.1)
Dairy (10)	4.8 (3.5, 6.2)	5.3 (4.0, 6.6)	5.3 (4.3, 6.5)	4.7 (3.5, 6.1)	4.8 (3.6, 6.0)	4.0 (3.1, 5.1)	4.2 (3.3, 5.1)	3.4 (2.3, 4.6)
Total Protein Foods (5)	4.8 (4.0, 5.0)	4.5 (3.7, 5.0)	4.7 (3.8, 5.0)	4.5 (3.7, 5.0)	4.9 (4.1, 5.0)	4.5 (3.8, 5.0)	4.8 (4.2, 5.0)	4.4 (3.5, 5.0)
Seafood and Plant Proteins (5)	2.8 (2.0, 3.7)	3.0 (1.5, 4.6)	3.4 (2.8, 4.1)	3.6 (2.2, 5.0)	3.2 (2.5, 4.0)	4.3 (2.9, 5.0)	3.1 (2.3, 3.9)	3.7 (1.9, 5.0)
Fatty Acids (10)	6.5 (4.8, 8.5)	5.4 (3.9, 7.1)	7.5 (5.6, 9.5)	4.6 (3.2, 6.2)	6.3 (5.6, 7.1)	6.6 (5.0, 8.6)	8.1 (6.7, 9.6)	7.7 (6.1, 9.3)
Refined Grains (10)	3.3 (1.4, 5.1)	2.7 (0.6, 4.9)	2.8 (1.3, 4.4)	3.2 (0.7, 5.6)	3.0 (1.5, 4.6)	4.2 (2.6, 5.9)	3.5 (2.3, 4.7)	3.6 (2.4, 4.8)
Sodium (10)	6.2 (5.0, 7.2)	4.1 (3.3, 4.9)	5.7 (4.8, 6.5)	2.9 (0.4, 5.0)	5.4 (4.4, 6.3)	3.9 (2.9, 4.8)	6.0 (4.9, 7.0)	3.9 (2.5, 5.2)
Added Sugars (10)	6.0 (3.4, 8.9)	6.1 (4.2, 8.1)	7.6 (6.6, 8.6)	6.6 (5.1, 8.3)	6.8 (5.8, 7.8)	5.9 (4.3, 7.6)	5.4 (3.7, 7.3)	4.6 (2.8, 6.7)
Saturated Fats (10)	7.0 (5.7, 8.3)	7.6 (6.2, 9.1)	6.8 (5.7, 7.8)	6.6 (5.7, 7.4)	7.0 (5.9, 8.2)	7.5 (6.1, 9.1)	8.1 (7.3, 9.0)	8.7 (8.0, 9.4)
Total (100)	61.8 (56.1, 67.5)	60.4 (55.3, 65.1)	64.7 (60.5, 69.1)	58.9 (52.5, 64.9)	63.2 (58.6, 68.0)	64.3 (57.7, 71.3)	64.8 (59.6, 70.2)	62.5 (56.5, 67.6)

[a] FEAST, Food and Eating Assessment Study.

[b] ASA24, Automated Self-Administered 24-hour Dietary Assessment Tool.

[c] AMPM, Automated Multiple-Pass Method.

[d] Healthy Eating Index-2015 scores were calculated using the population ratio approach.

Author Manuscript
Author Manuscript
Author Manuscript

Table 4.

Healthy Eating Index-2015 total and component scores based on observed and reported intake, by 24-hour recall condition, among women in FEAST[a] II (2016, n=302), carried out in Washington, DC area

Component (maximum score)	Completed ASA24[b] independently n=148 women				Completed ASA24[b] with assistance in a small group setting facilitated by a paraprofessional n=154 women			
	Observed	Reported	Difference (SE)[d]	P-value[d]	Observed	Reported	Difference (SE)[d]	P-value[d]
	Mean[c] (95% CI)				Mean[c] (95% CI)			
Total Fruits (5)	4.9 (4.6, 5.0)	4.9 (4.4, 5.0)	0.04 (0.13)	0.74	5.0 (5.0, 5.0)	5.0 (5.0, 5.0)	0.00 (0.02)	0.91
Whole Fruits (5)	5.0 (5.0, 5.0)	5.0 (5.0, 5.0)	0.00 (0.00)	.	5.0 (5.0, 5.0)	5.0 (5.0, 5.0)	0.00 (0.00)	.
Total Vegetables (5)	4.1 (3.9, 4.4)	4.7 (4.3, 5.0)	−0.54 (0.16)	<0.01	4.1 (3.8, 4.3)	4.7 (4.3, 5.0)	−0.69 (0.16)	<0.01
Greens and Beans (5)	5.0 (5.0, 5.0)	5.0 (5.0, 5.0)	0.00 (0.00)	.	5.0 (5.0, 5.0)	5.0 (5.0, 5.0)	−0.00 (0.01)	0.95
Whole Grains (10)	2.5 (2.3, 2.7)	2.5 (2.1, 3.0)	−0.04 (0.21)	0.86	2.7 (2.4, 3.0)	3.1 (2.6, 3.6)	−0.35 (0.26)	0.17
Dairy (10)	4.6 (4.4, 4.9)	4.6 (4.1, 5.1)	0.00 (0.21)	0.99	4.7 (4.3, 5.0)	4.8 (4.3, 5.3)	−0.17 (0.21)	0.44
Total Protein Foods (5)	5.0 (4.8, 5.0)	4.6 (4.2, 5.0)	0.38 (0.17)	0.03	5.0 (5.0, 5.0)	5.0 (4.7, 5.0)	0.03 (0.07)	0.70
Seafood and Plant Proteins (5)	2.7 (2.4, 2.9)	3.2 (2.6, 3.9)	−0.57 (0.27)	0.04	2.6 (2.3, 2.8)	3.2 (2.6, 3.8)	−0.58 (0.26)	0.03
Fatty Acids (10)	7.4 (6.9, 7.9)	7.4 (6.6, 8.2)	0.00 (0.43)	0.99	7.6 (7.1, 8.1)	7.7 (6.9, 8.6)	−0.13 (0.39)	0.75
Refined Grains (10)	2.5 (1.9, 3.1)	4.1 (3.5, 4.8)	−1.6 (0.31)	<0.01	3.7 (3.2, 4.2)	5.1 (4.4, 5.7)	−1.4 (0.29)	<0.01
Sodium (10)	4.9 (4.6, 5.2)	5.2 (4.6, 5.7)	−0.26 (0.24)	0.29	4.5 (4.1, 4.9)	4.6 (3.9, 5.2)	−0.11 (0.32)	0.72
Added Sugars (10)	6.6 (6.2, 7.0)	6.0 (5.4, 6.5)	0.65 (0.23)	<0.01	6.9 (6.5, 7.3)	6.6 (6.1, 7.1)	0.32 (0.21)	0.14
Saturated Fats (10)	7.5 (7.1, 7.8)	6.8 (6.3, 7.3)	0.68 (0.25)	<0.01	7.5 (7.2, 7.9)	7.1 (6.6, 7.6)	0.49 (0.24)	0.04
Total (100)	62.7 (61.4, 63.9)	64.0 (61.8, 66.1)	−1.3 (0.90)	0.16	64.2 (63.0, 65.5)	66.8 (64.8, 68.8)	−2.5 (0.87)	<0.01

[a] FEAST, Food and Eating Assessment Study.

[b] ASA24, Automated Self-Administered 24-hour Dietary Assessment Tool.

[c] HEI-2015 scores were calculated using the population ratio method.

[d] Standard errors and differences in scores derived from true and reported intake were constructed using a Monte Carlo approach using macros available from the National Cancer Institute (https://epi.grants.cancer.gov/hei/sas-code.html). T-tests were used to determine if each difference was different from zero.

Table 5.

Healthy Eating Index-2015 total scores based on observed and reported intake, by education and body mass index, among women in FEAST[a] II (2016, n=302)[b], carried out in Washington, DC area

Education	Observed	Reported	Difference (SE)[d]	P-value[d]
	Mean (95% CI)[c]			
Some or completed high school or GED (n=89)	**62.6 (60.9, 64.3)**	**65.8 (63.5, 68.2)**	**−3.2 (1.1)**	**<0.01**
Completed some college (n=123)	64.0 (62.6, 65.4)	65.3 (62.9, 67.7)	−1.3 (0.97)	0.18
Completed college (n=88)	63.4 (61.9, 65.0)	64.6 (62.1, 67.3)	−1.2 (1.1)	0.29
BMI (kg/m^2)				
<25 (n=101)	63.7 (62.2, 65.4)	65.3 (62.7, 68.0)	−1.6 (1.1)	0.13
25≥29.9 (n=71)	63.9 (62.2, 65.6)	65.5 (62.7, 68.2)	−1.6 (1.1)	0.15
≥30 (n=118)	**62.5 (61.0, 63.9)**	**65.3 (62.9, 67.7)**	**−2.8 (1.1)**	**0.01**

[a]FEAST, Food and Eating Assessment Study.

[b]FEAST II participants who completed Automated Self-Administered 24-hour Dietary Assessment Tool (ASA24) recalls in the independent and assisted conditions were pooled into one group. Education information was missing for 2 participants and BMI was missing for 12.

[c]Healthy Eating Index-2015 scores were calculated using the population ratio method.

[d]Standard errors and differences in scores derived from true and reported intake were constructed using a Monte Carlo approach based on macros available from the National Cancer Institute (https://epi.grants.cancer.gov/hei/sas-code.html). T-tests were used to determine if each difference was different from zero.