# Quality of Dietary Intake in Children With Developmental Disabilities: A Pilot Study

Andrea Moosreiner, MPH, RD, CD; Michele Polfuss, PhD, RN, CPNP-AC/PC; Bethany Forseth, PhD, MS


## ABSTRACT

**Background:** Children with developmental disabilities have a high prevalence of overweight and obesity. The role and contribution of their diet to weight status is poorly understood.

**Objectives:** This pilot study describes the dietary quality of children with spina bifida and Down syndrome compared with typically developing peers.

**Methods:** Dietary intakes of 8 children with spina bifida or Down syndrome and 4 children without developmental disabilities, aged 8 to 18 years, were collected using six 24-hour dietary recalls through Facetime. Dietary quality was assessed by application of the Healthy Eating Index (HEI).

**Results:** Children with spina bifida and Down syndrome had higher HEI scores when compared to typically developing peers (48.3, 52.9, and 46.2, respectively) and vegetable consumption (1.9, 2.6, and 1.4, respectively). All groups had undesirable intakes of saturated fat, added sugar, and sodium. Within this small sample, children with spina bifida and Down Syndrome had similar diet quality to their typically developing peers.

**Conclusions:** Further investigation in a larger sample is recommended to support the development of methods to optimize weight management in children with developmental disabilities.


## INTRODUCTION

Obesity is an epidemiologic issue that results in increased health care costs, morbidity, and mortality.[1] Obesity is multifactorial in its origin, but common areas of focus in its etiology are diet (energy intake) and activity (energy expenditure). A large subset of research has focused on understanding and preventing pediatric obesity as the next generation comes of age in this obesogenic environment. Several groups of children encounter greater challenges and subsequent inequalities in obesity prevalence, including children with spina bifida and Down syndrome.[2-4]

Spina bifida is a neural tube defect where a portion of the spinal cord does not close properly during gestation.[5] Depending on where the spinal cord is affected, orthopedic, bowel, and bladder abnormalities and lower extremity paralysis can occur.[5] Down syndrome is a chromosomal condition associated with intellectual disabilities and hypotonia.[6] Research focused on obesity in children with spina bifida and Down syndrome has been limited in comparison to typically developing peers. Published reports have identified several determinants of weight status in both cohorts. Weight status in children with spina bifida has been associated with a decreased energy expenditure at the metabolic level and related characteristics (limited ambulation, decreased muscle mass, and excess adiposity in lower extremities),[7,8] along with dietary changes.[9] Similarly, in children with Down syndrome, decreased resting energy expenditure, altered lipid metabolism, increased leptin, comorbidities, and unfavorable diets have been associated with weight status.[7,10,11] However, studies on energy or nutrient intake for individuals with these diagnoses have focused primarily on dietary assessment methods, energy expenditure, and body composition[12,13] and have not examined a relationship between dietary quality and weight status.[14]

For all populations, dietary quality is a contributing factor

• • •

**Author Affiliations:** Clinical and Translational Science Institute of Southeastern Wisconsin, Medical College of Wisconsin (MCW), Milwaukee, Wisconsin (Moosreiner); University of Wisconsin – Milwaukee, College of Nursing, Milwaukee, Wisconsin (Polfuss, Forseth); Children's Wisconsin, Department of Nursing Research, Milwaukee, Wisconsin (Polfuss).

**Corresponding Author:** Andrea Moosreiner, MPH, RD, CD, Bionutrition Program Manager, Clinical and Translational Science Institute of Southeastern Wisconsin, Medical College of Wisconsin, 8701 Watertown Plank Rd, Milwaukee, WI 53226; phone 414.805.7306; email amoosreiner@mcw.edu; ORCID ID 0000-0003-0629-1702.

in the development of several chronic conditions (eg, cardiovascular disease, obesity, cancer, and diabetes).[15] Examples of poor dietary quality can include a decreased consumption of fruit, vegetable, and whole-grain foods and an increased consumption of calorically dense snack foods.[16] Nutritional habits are often formed early in life and can continue into adulthood.[17] Diet quality and the amount of energy intake is particularly critical during childhood, as it can have lasting effects on the balance of energy, development of overweight and obesity, and risk of comorbidities.

Previous studies have assessed dietary quality in American children and adolescents using nutrition data from the National Health and Nutrition Examination Survey (NHANES) and by applying data to the Healthy Eating Index (HEI).[18] The HEI measures diet quality by assessing food group intake in comparison to the Dietary Guidelines for Americans (DGA), which describes nutritionally adequate food group servings based on caloric intake.[19] Children with developmental disabilities are not included in the NHANES data, leaving the dietary quality of this at-risk population unexamined. This pilot study aimed to use the HEI, a dietary assessment method previously employed with typically developing children, to describe dietary quality in a small sample of children and adolescents with spina bifida and Down syndrome.

## METHODS

### Study Design and Participants

This descriptive, cross-sectional analysis is part of a larger pilot study measuring energy expenditure in children (age 4-18 years) with and without developmental disabilities.[7] Participants included a subset (n=12) of children aged 8 to 18 years diagnosed with spina bifida, Down syndrome, or no developmental disability. Participants were asked to attend a clinic visit and participate in 2 weeks of testing for data collection. Before starting this portion of the study, approval from the Institutional Review Board and written consent and assent from the parent and child were obtained.

### Measures

*Anthropometrics*

Weight and height were obtained from each participant during the original data collection.[7] Based on the participants' ability to stand independently, arm span was used as a surrogate measure for standing height. Full details on these measures were reported previously.[7]

*Dietary Intake and Assessment*

Each participant completed 6 multiple-pass 24-hour dietary recalls collected by a registered dietitian via Facetime. Data collection occurred during late summer and fall seasons, and participants were instructed to eat as usual. Measuring cups and spoons, a deck of cards, and 2-dimensional portion size tools were provided to assist with estimating portion sizes during the recalls. Participants sought input from a proxy (eg, parent) if they were unable to recall eating events or details of foods and beverages consumed. All dietary recalls were recorded and entered into Nutrition Data Systems for Research (NDSR), Nutrition Coordinating Center, University of Minnesota, software version 2016.

*Dietary Quality - HEI Scores*

The HEI-2010 scores were used to measure dietary quality. HEI-2010 includes 12 components that are summed to a maximum score of 100 points. Higher scores equate to a higher quality of diet. The components capture food groups and nutrients that are encouraged for adequate nutrient intake (whole fruits, total vegetables, greens and beans, whole grains, dairy, total protein from meat, seafood and plant proteins, and fatty acids) as well as foods and nutrients that should be consumed in moderation (refined grains, sodium, and empty calories) within the DGA 2010.[19]

### Analysis

Descriptive statistics were used to assess child anthropometrics and family demographics. Caloric, nutrient, and food group intake data were analyzed using the NDSR. Food group serving sizes are based on the recommendations of the DGA 2010. Average values from six 24-hour dietary recalls were used for nutritional descriptive analyses. The nutritional data did not have a normal distribution; therefore, median values were used when reporting these data.

## RESULTS

This analysis includes 6 male (50%) and 6 female (50%) participants age 8-18 years, with a mean age of 13.2 (±3.4). Of the 12 participants, 4 were diagnosed with Down syndrome, 4 with spina bifida, and 4 without a developmental disability. Most participants reported their race as Caucasian (83%), followed by Asian (8%) and other (8%). The majority of parents were married (n = 11, 92%), with 1 family of divorced parents (8%); combined family income varied, with 7 families (58%) reporting their income between $75,000 and $100,000 followed by 2 families (17%) reporting combined income of $30,001 to  50,000.

Using the Centers for Disease Control and Prevention's Body Mass Index (BMI) percentile charts for boys and girls aged 2 to 20 years, 2 children with Down syndrome were categorized as normal weight (5% to <85%), 1 was categorized as overweight (85% to <95%), and 1 as obese (≥95%). Two children with spina bifida were categorized with a normal BMI (5% to <85%) and 2 as obese (≥95.1%). Three controls were classified as normal weight and 1 as overweight.

Six 24-hour dietary recalls were collected—2 weekend and 4 weekday days—and analyzed from each of the 12 participants. All recalls were considered complete (ie, multiple meals and snacks were reported for each), resulting in 24 recalls per group and 72 recalls total. From the dietary recalls, average values for each participant were obtained; group median values of dietary components are listed in Tables 1 and 2.

Energy intake was highest in children with Down syndrome. Consumption of vegetable, greens, and bean servings were higher among children with spina bifida and Down syndrome than children without developmental disabilities (1.9, 2.6, and 1.4, respectively). Whole fruit intake was similar across all cohorts, with the group diagnosed with Down syndrome having the highest intake of total fruit servings. The group with Down syndrome also had the highest seafood and plant-based protein servings when compared to children diagnosed with spina bifida and control group (1.2, 0.7, and 0.4, respectively). Children with spina bifida and Down Syndrome had higher intakes of lean meat servings when compared to those without developmental disabilities (2.9, 2.8, and 1.6, respectively). Sweetened beverage intake of children with Down syndrome was collectively higher than both the spina bifida and control group (1.5, 0.0, and 0.3, respectively). Children without developmental disabilities had a lower intake of starchy vegetable servings and a higher intake of unsweetened water. All groups had high intakes of sodium, added sugar, saturated fat, and refined grain servings.

**Table 1.** Dietary Nutrient Intake by Diagnosis Group

| Dietary Nutrient | Down Syndrome n = 4 | Spina Bifida n = 4 | Control n = 4 | All n = 4 |
|---|---|---|---|---|
| Calories (kcals) | 2322.2 (1800, 2710) | 1640.5 (1529, 3208) | 1865 (1051, 1902) | 1865.5 (1051, 3208) |
| Fat (g) | 100.3 (73.4, 114.8) | 62.9 (51.9, 143.1) | 65.6 (54.8, 70.0) | 70.9 (51.9, 143.1) |
| Carbohydrate (g) | 268.0 (224.1, 303.3) | 213.6 (194.4, 353.7) | 261.7 (90.5, 275.8) | 256.7 (90.5, 353.7) |
| Protein (g) | 93.2 (70.5, 120.0) | 67.6 (60.4, 135.9) | 56.0 (53.1, 69.5) | 70.0 (53.1, 135.9) |
| Saturated fatty acids (g) | 34.3 (28.1, 40.4) | 26.7 (17.8, 51.0) | 23.1 (20.0, 26.1) | 27.1 (17.8, 51.0) |
| Dietary fiber (g) | 15.3 (13.5, 17.1) | 13.3 (8.8, 25.4) | 11.6 (7.1, 15.2) | 14.4 (7.1, 25.4) |
| Sodium (mg) | 3870 (2281, 4886) | 3077 (2619, 5615) | 2549 (1577, 2710) | 2703 (1577, 5615) |
| % Fat calories | 37.4% (35.7, 39.3) | 33.1% (28.2, 38.2) | 33.0% (30.1, 45.8) | 35.8% (28.2, 45.8) |
| % Carbohydrates kcals | 44.8% (44.1, 48.2) | 49.8% (43.9, 55.6) | 52.9% (31.7, 58.1) | 48.4% (31.7, 58.1) |
| % Protein calories | 16.8% (16.2, 18.5) | 17.0% (15.7, 18.9) | 14.3% (11.2, 22.5) | 16.2% (11.2, 22.5) |
| % Sat fat calories | 13.3% (12.8, 14.5) | 12.8% (9.8, 16.0) | 12.4% (10.1, 16.9) | 13.2% (9.8, 16.9) |
| Added sugars (g) | 68.6 (58.5, 95.6) | 51.8 (32.0, 54.5) | 60.7 (26.2, 116.4) | 58.8 (26.2, 116.4) |

Median values (minimum, maximum).

**Table 2.** Healthy Eating Index (HEI) Score and Total Food Serving Intakes

| HEI Score and Food Servings | Down Syndrome n = 4 | Spina Bifida n = 4 | Control n = 4 | All n = 12 |
|---|---|---|---|---|
| HEI-2010 | 52.9 (47.7, 59.6) | 48.3 (33.4, 54.1) | 46.2 (41.2, 59.6) | 51.1 (33.4, 59.6) |
| Total fruit | 1.5 (0.8, 4.4) | 1.1 (0.0, 2.2) | 1.1 (0.5, 2.5) | 0.8 (0.0, 2.4) |
| Whole fruit | 0.8 (0.3, 2.4) | 0.9 (0.0, 2.2) | 0.8 (0.5, 2.0) | 1.4 (0.0, 4.4) |
| Total vegetable | 2.6 (2.1, 3.4) | 1.9 (0.7, 5.7) | 1.4 (0.5, 2.7) | 2.3 (0.5, 5.7) |
| Starchy vegetable | 1.2 (0.9, 2.0) | 0.8 (0.4, 0.9) | 0.5 (0.2, 0.8) | 0.8 (0.4, 2.0) |
| Greens and beans | 0.9 (.07, 1.1) | 0.4 (0.0, 0.4) | 0.2 (0.0, 0.5) | 0.4 (0.0, 1.1) |
| Total grain | 6.1 (3.7, 8.1) | 7.1 (4.6, 10.9) | 5.3 (4.2, 6.3) | 6.0 (3.7, 10.9) |
| Whole grain | 0.1 (0.0, 2.1) | 0.6 (0.3, 0.8) | 0.4 (0.0, 1.9) | 0.4 (0.0, 2.1) |
| Refined grain | 5.0 (3.5, 7.2) | 5.0 (4.3, 9.2) | 4.4 (3.9, 5.1) | 4.5 (3.5, 9.2) |
| Total protein food | 7.7 (6.3, 8.9) | 3.4 (1.8, 9.2) | 3.8 (3.0, 4.6) | 4.4 (1.8, 9.2) |
| Lean meat | 2.8 (0.9, 4.9) | 2.9 (0.0, 5.3) | 1.6 (0.4, 2.6) | 2.3 (0.0, 5.3) |
| Nonlean meats | 5.4 (4.9, 6.5) | 1.6 (1.0, 5.1) | 2.5 (0.7, 4.2) | 3.7 (1.0, 6.5) |
| protein | 1.2 (0.0, 2.0) | 0.7 (0.0, 1.4) | 0.4 (0.3, 1.1) | 0.6 (0.0, 2.0) |
| Total dairy | 3.3 (2.1, 6.0) | 4.4 (1.4, 5.0) | 2.0 (1.0, 4.0) | 3.4 (1.0, 6.0) |
| Full fat dairy | 0.3 (0.0, 0.8) | 1.0 (0.2, 2.3) | 0.5 (0.0, 0.8) | 0.5 (0.0, 1.5) |
| Reduced-fat dairy | 1.6 (1.0, 2.9) | 0.4 (0.0, 0.8) | 0.4 (0.2, 1.1) | 0.7 (0.0, 2.9) |
| Low fat or fat-free dairy | 0.5 (0.0, 2.4) | 1.5 (1.0, 2.4) | 0.0 (0.0, 1.7) | 0.9 (0.0, 2.4) |
| Total fat | 4.3 (3.2, 4.7) | 3.4 (2.4, 10.6) | 1.6 (0.3, 4.2) | 3.5 (0.3, 10.6) |
| Total beverage | 2.3 (0.5, 3.6) | 1.6 (0.2, 3.5) | 4.1 (2.3, 10.3) | 3.0 (0.3, 10.3) |
| Sweetened milk | 0.8 (0.0, 1.9) | 0.0 (0.0, 0.8) | 0.0 (0.0 ,0.0) | 0.0 (0.0, 1.9) |
| Sweetened soft drinks | 0.5 (0.0, 1.4) | 0.0 (0.0, 0.3) | 0.3 (0.0, 0.5) | 0.1 (0.0, 1.4) |
| Sweetened fruit drinks | 0.2 (0.0, 1.0) | 0.0 (0.0, 0.3) | 0.3 (0.0, 2.3) | 0.1 (0.0, 2.3) |
| Unsweetened water | 0.9 (0.0, 2.6) | 1.6 (0.2, 2.5) | 2.4 (1.3, 10.3) | 1.8 (0.0, 10.3) |
| Empty calorie intake (% calories) | 28% (24.9, 29.7) | 24% (21.4, 27.4) | 29% (24.0, 37.2) | 27% (21.4, 37.2) |

Median values (minimum, maximum).
Serving sizes were assigned to each Nutrition Data Systems for Research food based on the recommendations made by the Dietary Guidelines for Americans 2010.

## DISCUSSION

When comparing dietary intake to the DGA 2010 in this sample of children with spina bifida and Down syndrome, quality of diets was similar compared to children without developmental disabilities. For a few healthy nutrients and food groups, the quality of intake was better in children with spina bifida or Down syndrome, as evidenced by the sample reporting higher HEI scores. However, the Down syndrome cohort reported higher calorie intake and total fruit (including calorically dense sweetened juice drinks), suggesting total caloric intake may be more contributory to weight status than diet quality alone. Due to the pilot nature of the study and sample size, statistical analysis of the difference could not be performed to assess for significance.

The average HEI score for typically developing children (2-17 years of age) from the 2015-2016 NHANES data set, using the HEI-2015 scoring system, is 53.9.[20] However, the HEI-2015 scoring system is slightly different than the HEI-2010 used in this study. HEI-2015 replaced the "empty calories" component with added sugar and saturated fat components.[21] To date, the last NHANES' HEI score published for children using the HEI-2010 scoring system used data collected in 2011-2012 and reported an average HEI score of 55.07.[20] The HEI scores presented in this study from all groups are below these national averages. The lower HEI scores in the spina bifida and Down syndrome groups of the present study were also observed in an adult population with intellectual and developmental disabilities, reporting an average HEI of 46.7, which is lower than the national average of 58.3 for healthy adults.[14]

Due to the range of age and unknown activity levels within our sample, the DGA daily serving recommendations for each food group could not be applied to see if each participant group was meeting daily food group serving recommendations. Although, when applying the DGA's nutrient intake recommendations for added sugar and saturated fat intake, all groups exceeded the recommendations. All groups also exceeded the Tolerable Upper Intake Level for sodium. These nutrient findings correspond with limited reports from other dietary assessment studies conducted within developmentally disabled populations[14,22,23] and reflect the dietary intakes of all Americans.[24]

The method of using Facetime to collect the dietary 24-hour recalls increased reliability. Being able to visually see an individual's face—especially children's faces—helped identify visual cues about their ability and willingness to recall all items. It was also beneficial to have parents and family members present during the Facetime recalls to aid with prompting forgotten foods and give detail on brands, types, and amounts of foods. This methodology provided a more comprehensive approach and potentially increased the accuracy of the child's dietary intake.

In this pilot study of children with spina bifida and Down syndrome, findings suggest that diet quality may not have as significant of a role in weight status as a lower energy expenditure when compared to typically developing counterparts. These findings could be due to the small sample size, as well as other unknown determinants. Obesity is multifactorial in its origin, and other factors need to be considered. It is documented that spina bifida and Down syndrome cohorts are known to have a lower energy expenditure, which has an instrumental role in an individual's weight status, and it would be reasonable to assume that it may be exacerbated when other factors are present.[7] A primary example includes socioeconomic status, which has been associated with food choices, weight status, and energy intake.[25] While family income was obtained for participants, the influence was not examined due to the small sample size. Future studies are recommended to include socioeconomic status and dietary quality in a larger sample to determine combined influences on weight status.

Future studies would benefit from recruiting a larger sample of 1 cohort and measure spectrums within to strengthen statistical analyses and accurately generalize data. Limiting age range or stratifying age groups per DGA food group serving recommendations will also strengthen statistical analyses. Collecting physical activity and energy expenditure measurements will help determine calorie requirements and if there is a deficit or surplus of daily energy. Additionally, understanding socioeconomic status and food-related habits of family members may be useful.

A strength of this study is that this is one of the first to examine diet quality in children with intellectual and developmental disabilities using reliable methods. While there are no common therapies for preventing high BMIs in lower energy expenditure phenotypes, further exploring the relationship between weight status and energy expenditure, along with caloric and nutrient intakes, may discern effective interventions to combat the obesity prevalence in children with developmental disabilities.

## CONCLUSION

The use of this study's dietary assessment method and application of the HEI provides a guide to better understand dietary quality in children with developmental disabilities. Understanding the nutritional quality of these children is understudied and yet critical for developing achievable interventions and providing education to families on the development of healthy habits related to food. This study's findings only begin to identify what is known and not known about the diet quality and habits of children with developmental disabilities and their families.

**Funding/Support:** This work was supported by the National Institutes of Nursing Research (NINR) of the National Institutes of Health (NIH) under Award Number P20NR015339 and the Clinical and Translational Science Institute of Southeastern Wisconsin through the Advancing a Healthier Wisconsin Endowment of the Medical College of Wisconsin under the award 8UL1TR000055.

**Financial Disclosures:** None declared.

## REFERENCES

**1.** Abdelaal M, le Roux CW, Docherty NG. Morbidity and mortality associated with obesity. *Ann Transl Med*. 2017;5(7):161. doi:10.21037/atm.2017.03.107

**2.** Bandini LG, Curtin C, Hamad C, Tybor DJ, Must AV. Prevalence of overweight in children with developmental disorders in the continuous National Health and Nutrition Examination Survey (NHANES) 1999-2002. *J Pediatr.* 2005;146(6):738-743. doi:10.1016/j.jpeds.2005.01.049

**3.** Murray J, Ryan-Krause P. Obesity in children with Down syndrome: background and recommendations for management. *Pediatr Nurs*. 2010;36(6):314-319.

**4.** Dosa NP, Foley JT, Eckrich M, Woodall-Ruff D, Liptak GS. Obesity across the lifespan among persons with spina bifida. *Disabil Rehabil.* 2009;31(11):914-920. doi:10.1080/09638280802356476

**5.** What is spina bifida? Centers for Disease Control and Prevention. Updated September 2019. Accessed October 7, 2019. https://www.cdc.gov/ncbddd/spinabifida/facts.html

**6.** About Down syndrome. National Institutes of Health. Updated June 2018. Accessed October 7, 2019. https://www.nih.gov/include-project/about-down-syndrome

**7.** Polfuss M, Sawin KJ, Papanek PE, et al. Total energy expenditure and body composition of children with developmental disabilities. *Disabil Health J.* 2018;11(3):442-446. doi:10.1016/j.dhjo.2017.12.009

**8.** Rimmer JH, Rowland JL, Yamaki K. Obesity and secondary conditions in adolescents with disabilities: addressing the needs of an underserved population. *J Adolesc Health*. 2007;41(3):224-229. doi:10.1016/j.jadohealth.2007.05.005

**9.** Rendeli C, Kuczynska E, Giuliano AC, Chiaretti A, Ausili E. Dietary approach to prevent obesity risk in spina bifida patients. *Childs Nerv Syst.* 2020;36(7):1515-1520. doi:10.1007/s00381-019-04471-y

**10.** Luke A, Roizen NJ, Sutton M, Schoeller DA. Energy expenditure in children with Down syndrome: correcting metabolic rate for movement. *J Pediatr.* 1994;125(5 Pt 1):829-838. doi:10.1016/s0022-3476(94)70087-7

**11.** Bertapelli F, Pitetti K, Agiovasitis S, Guerra-Junior G. Overweight and obesity in children and adolescents with Down syndrome—prevalence, determinants, consequences, and interventions: a literature review. *Res Dev Disabil.* 2016;57:181-192. doi:10.1016/j.ridd.2016.06.018

**12.** Polfuss M, Moosreiner A, Boushey CJ, Delp EJ, Zhu F. Technology-based dietary assessment in youth with and without developmental disabilities. *Nutrients*. 2018;10(10);1482. doi:10.3390/nu10101482

**13.** Bathgate KE, Sherriff JL, Leonard H, et al. Feasibility of assessing diet with a mobile food record for adolescents and young adults with down syndrome. *Nutrients*. 2017;9(3):273. doi:10.3390/nu9030273

**14.** Ptomey L, Goetz J, Lee J, Donnelly J, Sullivan D. Diet quality of overweight and obese adults with intellectual and developmental disabilities as measured by the Healthy Eating Index-2005. *J Dev Phys Disabil*. 2013;25(6):625-636. doi:10.1007/s10882-013-9339-z

**15.** Willett W, Koplan J, Nugent R, Dusenbury C, Puska P, Gaziano T. Prevention of chronic disease by means of diet and lifestyle changes. In: Jamison DT BJ, Measham AR, et al, eds. *Disease Control Priorities in Developing Countries.* 2nd ed. Oxford University Press; 2006: chap 44. Accessed October 2, 2019. https://www.ncbi.nlm.nih.gov/books/NBK11795/

**16.** Roblin L. Childhood obesity: food, nutrient, and eating-habit trends and influences. *Appl Physiol Nutr Metab.* 2007;32(4):635-645. doi:10.1139/H07-046

**17.** Movassagh EZ, Baxter-Jones ADG, Kontulainen S, Whiting SJ, Vatanparast H. Tracking dietary patterns over 20 years from childhood through adolescence into young adulthood: the Saskatchewan Pediatric Bone Mineral Accrual Study. *Nutrients*. 2017;9(9):990. doi:10.3390/nu9090990

**18.** Gu X, Tucker KL. Dietary quality of the US child and adolescent population: trends from 1999 to 2012 and associations with the use of federal nutrition assistance programs. *Am J Clin Nutr.* 2017;105(1):194-202. doi:10.3945/ajcn.116.135095

**19.** Healthy Eating Index. Food and Nutrition Service, US Department of Agriculture. Updated January 31, 2019. Accessed October 3, 2019. https://www.fns.usda.gov/resource/healthy-eating-index-hei

**20.** HEI scores for Americans. Food and Nutrition Services, US Department of Agriculture. Updated January 31, 2019. Accessed October 2, 2019. https://www.fns.usda.gov/hei-scores-americans

**21.** Comparing the HEI-2015, HEI–2010 & HEI–2005. Division of Cancer Control & Population Sciences, National Cancer Institute. Updated April 15, 2019. Accessed October 3, 2019. https://epi.grants.cancer.gov/hei/comparing.html

**22.** Bertoli S, Battezzati A, Merati G, et al. Nutritional status and dietary patterns in disabled people. *Nutr Metab Cardiovasc Dis.* 2006;16(2):100-112. doi:10.1016/j.numecd.2005.05.007

**23.** Braunschweig CL, Gomez S, Sheean P, Tomey KM, Rimmer J, Heller T. Nutritional status and risk factors for chronic disease in urban-dwelling adults with Down syndrome. *Am J Ment Retard.* 2004;109(2):186-193. doi:10.1352/0895-8017(2004)109<186:NSARFF>2.0.CO;2

**24.** Shan Z, Rehm CD, Rogers G, et al. Trends in dietary carbohydrate, protein, and fat intake and diet quality among US adults, 1999-2016. *JAMA*. 2019;322(12):1178-1187. doi:10.1001/jama.2019.13771

**25.** Ogden C, Fakhouri TH, Carroll MD, et al. Prevalence of obesity among adults, by household income and education – United States, 2011-2014. *MMWR Morb Mortal Wkly Rep*. 2017;66(50):1369-1373. doi:10.15585/mmwr.mm6650a1

advancing the art & science of medicine in the midwest

# WMJ

*WMJ* (ISSN 1098-1861) is published through a collaboration between The Medical College of Wisconsin and The University of Wisconsin School of Medicine and Public Health. The mission of *WMJ* is to provide an opportunity to publish original research, case reports, review articles, and essays about current medical and public health issues.



**Visit www.wmjonline.org to learn more.**