Preventive Medicine 77 (2015) 23–27

Contents lists available at ScienceDirect

Preventive Medicine

journal homepage: www.elsevier.com/locate/ypmed

Healthy eating index and metabolically healthy obesity in U.S. adolescents and adults

Sarah M. Camhi [a,*], E. Whitney Evans [b], Laura L. Hayman [c], Alice H. Lichtenstein [d], Aviva Must [e]

[a] Exercise and Health Sciences Department, University of Massachusetts, Boston, MA, USA
[b] Weight Control and Diabetes Research Center, Brown Medical School/Miriam Hospital, Providence, RI, USA
[c] Office of the Vice-Provost for Research, University of Massachusetts, Boston, MA, USA
[d] JM USDA Human Nutrition Research Center on Aging, Tufts University, Boston, MA, USA
[e] Department of Public Health Community Medicine, Tufts University School of Medicine, Boston, MA, USA

ARTICLE INFO

Available online 1 May 2015

Keywords:
Diet
Metabolically healthy obese (MHO)
Obesity
HEI-2005

ABSTRACT

Objective. To determine whether dietary quality differs between metabolically-healthy-obese (MHO) and metabolically-abnormal-obesity (MAO) in a nationally representative sample.

Methods. National Health and Nutrition Examination Survey (NHANES) data (2007–2008; 2009–2010) were used to identify obese adolescents (≥95th body mass index (BMI) %tile) and adults (≥30 kg/m^2). MHO was defined as <2 abnormal cardiometabolic risk factors (elevated blood pressure, triglycerides, glucose, low high density lipoprotein cholesterol (HDL-C); or on medications). Healthy Eating Index 2005 (HEI-2005) scores were calculated from 24-hour recall data. General linear regression models determined whether HEI-2005 scores differed between MHO and MAO after controlling for age, race, gender, NHANES wave, BMI, physical activity and health status by age group (12–18; 19–44; 45–85 years).

Results. Compared with MAO, MHO adolescents (n = 133) had higher total HEI-2005 score, higher milk scores, and higher scores from calories from solid fats, alcohol beverages and added sugars. MHO women 19–44 years (n = 240) had higher total HEI-2005, higher whole fruit, higher whole grain and higher meat and bean scores compared with MAO. No significant differences were observed between MHO and MAO for HEI-2005 total scores in men 19–44 years, or adults 45–85 years.

Conclusion. MHO adolescents and women 19–44 years have better dietary compliance to the U.S. guidelines when compared with MAO, suggesting potential intervention targets to improve cardiometabolic risk within obesity.

Introduction

Obesity has been increasing in U.S. adolescents and adults for the past 30 years (Flegal et al., 2012; Ogden et al., 2012). Obese individuals are more likely to have multiple abnormal cardiovascular risk factors present (Park et al., 2003), however, not all obese individuals exhibit this cardiometabolic phenotype (Karelis et al., 2004; Sims, 2001). Evidence shows that metabolically healthy obese (MHO) individuals have slower atherosclerotic lesion progression (Khan et al., 2011; Marini et al., 2007) and lower incidence of cardiovascular disease and type II diabetes when compared to their metabolically abnormal obese (MAO) counterparts (Meigs et al., 2006). What accounts for the metabolic differences observed between MHO and MAO individuals is relatively unknown; however, research suggests that inflammation (Phillips and Perry, 2013), genetics (Schwenk et al., 2013), and lifestyle (Phillips and Perry, 2013) may all contribute to metabolic health.

Recommendations for clinical care of MHO encourage eating a balanced diet (Sims, 2001), however, there is a lack of specific evidence on which aspects of dietary intake should be encouraged or emphasized. Research comparing diets of MHO and MAO suggests no differences (Gilardini et al., 2011; Hankinson et al., 2013; Lee, 2009; Shin et al., 2006), however these studies were conducted with women only (Shin et al., 2006), specific age groups (Hankinson et al., 2013) or with non-U.S. groups (Lee, 2009; Shin et al., 2006), which limits their generalizability. This research has also been restricted to the evaluation of macronutrient and micronutrient composition in adolescents (Gilardini et al., 2011) or adults (Lee, 2009), or to single foods, such as alcohol intake (Gutierrez-Repiso et al., 2014; Lee, 2009; Velho et al., 2010; Wildman et al., 2008), limiting our ability to understand how nutrients and foods may work in synergy (Jacobs and Steffen, 2003).

* Corresponding author at: Exercise and Health Sciences Department, College of Nursing and Health Sciences, University of Massachusetts, Boston, 100 Morrissey Blvd, Boston, MA 02125, USA. Fax: +1 617 287 7527.
E-mail address: sarah.camhi@umb.edu (S.M. Camhi).

http://dx.doi.org/10.1016/j.ypmed.2015.04.023
0091-7435/

Examining dietary intake quality, instead of quantity, allows for a more comprehensive examination of a person's dietary intake that reflects a balance, quantity and combination of foods and beverages. Nutritional quality scores have shown associations with risk of chronic disease and mortality (Chiuve et al., 2011), and some recent evidence from an Irish cohort study to suggest that higher dietary quality and food pyramid compliance is associated with better metabolic health in obese adults (Phillips et al., 2013). The Healthy Eating Index (HEI) was developed to assess diet quality in relation to our U.S. National Dietary Guidelines (2005) and takes into account the quality of the combination of foods eaten (Guenther et al., 2007). Thus, the purpose of the current analysis was to determine whether diet quality, measured by total and component Healthy Eating Index 2005 (HEI-2005), differs between MHO and MAO in a nationally representative U.S. sample of adolescents and adults.

Methods

Data from two National Health and Nutrition Examination Surveys (NHANES 2007–2008; 2009–2010) were used for adolescents 12–18 years, and adults 19–85 years. Socio-demographic information such as race/ethnicity and age was self-reported.

Height and weight were measured with standardized procedures, as previously described (NHANES Questionnaires, Datasets and Related Documentation, 2012). Body mass index (BMI; kg/m^2) was calculated from measured height and weight. For adolescents (12–18 years), obesity was operationalized by age- and sex-specific CDC BMI percentile ≥95th percentile (Kuczmarski et al., 2000), for adults ≥30 kg/m^2 (Clinical guidelines on the identification et al., and Treatment of Overweight in Adults. 1998).

Blood pressure was measured after a 5-minute rest using standardized procedures obtaining a maximum of four readings (NHANES Questionnaires, Datasets and Related Documentation, 2012). Readings 2–4 when available, were averaged and used in this analysis. Blood was drawn after a 10-hour fast, in the left arm, at the antecubital vein. All laboratory procedures for the assessment of cardiovascular risk factor levels were standardized (NHANES Questionnaires, Datasets and Related Documentation, 2012).

Dietary intake was measured via one, in-person 24 hour recall collected using the USDA's Automated Multiple Pass Method. HEI-2005 scores were calculated using the Center for Nutrition Policy and Promotion and National Cancer Institute HEI SAS code. The food group standards are based on the recommendations found in MyPyramid (Britten et al., 2006). The standards are expressed as a percent of calories, or per 1000 calories, and scores for individual components are given for total fruit (maximum 5 points), whole fruit (maximum 5 points), total vegetables (maximum 5 points), dark green and orange vegetables (maximum 5 points), other vegetables and legumes (maximum 5 points), total grains (maximum 5 points), whole grains (maximum 5 points), milk (maximum 10 points), meat and beans (maximum 10 points), oils (maximum 10 points), saturated fat (maximum 10 points), and calories from solid fats, alcoholic beverages (SoFAAS; maximum 20 points). The maximum total HEI-2005 score is 100, and higher total and component HEI-2005 scores indicate better compliance with the Dietary Guidelines for Americans. Sodium, oil and SoFAAS are reverse coded to also reflect that a higher score correlates with reduced consumption of these particular foods and nutrients. The HEI-2005 has been shown to be a valid and reliable tool for assessing dietary intake (Guenther et al., 2007, 2008).

Recreational physical activity participation was categorized at two intensities, moderate (moderate effort and small increases in breathing or heart rate) and vigorous (hard effort with large increases in breathing or heart rate) that lasted ≥10 min continuously. Days of participation and minutes per day were multiplied separately for each intensity, and then summed to create moderate to vigorous physical activity (MVPA; minutes/week).

Self reported health status was measured in adults ages 18–85 via a single question, "Would you say your health in general is excellent, very good, good, fair or poor?" Given the cross sectional nature of NHANES data and the potential for reverse causality (i.e., a health event causing individuals to change diet and subsequently improve their metabolic health), we controlled for self-reported health status in the models estimating the relationship between metabolic health and diet quality in adults 19–44 years and adults 45–85 years.

MHO was defined as an obese adolescent or adult with ≤2 abnormal risk factors for blood pressure, triglycerides, HDL-C and fasting glucose (Camhi and Katzmarzyk, 2011; Camhi et al., 2013). Specific thresholds for each risk factor for adolescents and adults are presented in Table 1.

Table 1
Definitions for metabolically healthy obese (MHO) and metabolically abnormal obesity (MAO) in adolescents and adults.

	MHO	MAO
BMI	Adolescents: ≥95th %tile; adults: >30 (kg/m^2)	Adolescents: ≥95th %tile; adults: >30 (kg/m^2)
Cardiometabolic risk	<2 abnormal risk factors	≥2 abnormal risk factors
Abnormal cardiometabolic risk factors	Adolescents	Adults
Blood pressure (mm Hg)[a]	≥90th %tile for age, gender, and height[a]	≥130/85[a]
Triglycerides (mg/dL)	≥150[a]	≥150[a]
HDL-C (mg/dL)	<40 boys, <50 girls[a]	Men <40, women <50[a]
Fasting glucose (mg/dL)	≥100[a]	≥100[a]

[a] OR on relevant medications.

Statistical analysis

Participants were included in the present analysis if they were not pregnant (n = 1 19–44 years) or diabetic (n = 1, 12–18 years; n = 24, 19–44 years; n = 291, 45–85 years), had complete data on variables of interest (n = 8, 12–18 years; n = 78, 19–44 years; n = 68, 45–85 years), and ≥10 h fasted for blood draw (n = 33, 12–18 years; n = 115, 19–44 years; n = 143, 45–85 years). T-tests were used to examine differences in means for continuous demographic variables for continuous variables and chi-square tests were used to compare percentages of categorical variables between MHO and MAO. General linear regression models were used to determine whether total and component HEI-2005 scores differed between MHO and MAO after controlling for age, race, gender, self-reported health status, NHANES wave, BMI and moderate to vigorous physical activity by age groups (12–18 years n = 133, 19–44 years n = 451; 45–85 years n = 651). Additionally, because the relationship between metabolic health and diet quality may differ by gender, we tested for effect modification by gender by testing the statistical significance of an interaction term in each age group. Where the interaction term was statistically significant for total HEI-2005 scores, we also tested its significance for each component score and report results stratified by gender. All analyses used sample fasting weights for NHANES to reflect the complex sampling survey design.

Results

Approximately 72%, 47% and 23% of participants were classified as MHO in adolescents 12–18 years, adults 19–44 years and adults 45–85 years, respectively. Subjects identified as MHO were significantly younger within adult age groups (adults 19–44 years and adult 45–85 years), had lower BMI values (adolescents and adults 19–44 years), and had a lower prevalence of males (adult 19–44 years) and white race/ethnicity (adult 19–44 years). MHO individuals also had consistently lower triglycerides, systolic blood pressure and glucose values, and lower HDL levels in all age groups (Table 2).

In adolescents, there was no evidence of effect modification by gender in the relationship between metabolic health and dietary quality. As shown in Table 3a, after adjustment for age, race, gender, NHANES wave, BMI and MVPA, adolescents with a MHO profile had better quality diets, as indicated by a higher total HEI-2005 score as compared with MAO (MHO vs. MAO, mean ± SE; p-value for difference: 55.2 ± 1.2 vs. 47.8 ± 2.6; p = 0.005). This difference is likely due to the finding that adolescents with a MHO profile had higher milk scores (5.2 ± 0.4 vs. 3.5 ± 0.7; p = 0.03), and higher scores (reduced consumption) from calories from solid fats, alcoholic beverages, and added sugars (SoFAAS) (15.5 ± 0.7 vs. 11.6 ± 1.0, p = 0.007) (Table 3a).

In adults 19–44 years, effect modification by gender was present in the relationship between metabolic health and total HEI-2005 scores. Accordingly, the results for total and component HEI-2005 scores have been stratified by gender (Table 3b). Specifically, women with a MHO profile