Nursing & Health Sciences

Nursing and Health Sciences (2015), **17**, 467–475

Research Article

Lifestyle habits and obesity progression in overweight and obese American young adults: Lessons for promoting cardiometabolic health

EunSeok Cha, PhD, MPH, MSN, CDE, RN,[1] Margeaux K. Akazawa, MPH,[2] Kevin H. Kim, PhD,[3] Colleen R. Dawkins, MSN, FNP-BC, RD,[1] Hannah M. Lerner, BS,[4] Guillermo Umpierrez, MD, FACP, FACE[5] and Sandra B. Dunbar, PhD, FAAN, FAHA, RN[1]

[1]*Nell Hodgson Woodruff School of Nursing,* [2]*Rollins School of Public Health,* [5]*School of Medicine, Emory University, Atlanta, Georgia,* [3]*Posthumous, University of Pittsburgh, School of Education, Pittsburgh, Pennsylvania, and* [4]*Gillings School of Global Public Health, University of North Carolina, Chapel Hill, North Carolina, USA*

Abstract Obesity among young adults is a growing problem in the United States and is related to unhealthy lifestyle habits, such as high caloric intake and inadequate exercise. Accurate assessment of lifestyle habits across obesity stages is important for informing age-specific intervention strategies to prevent and reduce obesity progression. Using a modified version of the Edmonton Obesity Staging System (mEOSS), a new scale for defining obesity risk and predicting obesity morbidity and mortality, this cross-sectional study assessed the prevalence of overweight/obese conditions in 105 young adults and compared their lifestyle habits across the mEOSS stages. Descriptive statistics, chi-square tests, and one-way analyses of variance were performed. Eighty percent of participants (n = 83) fell into the mEOSS-2 group and had obesity-related chronic disorders, such as diabetes, hypertension, and/or dyslipidemia. There were significant differences in dietary quality and patterns across the mEOSS stages. Findings highlighted the significance of prevention and early treatment for overweight and obese young adults to prevent and cease obesity progression.

Key words cardiometabolic health, lifestyle habits, obesity progression, young adults, health promotion.

INTRODUCTION

Currently, 69.2% of Americans are overweight or obese (Center for Disease Control and Prevention, n.d.). Alarmingly, obesity prevalence, particularly among young adults, continues to grow rapidly (Flegal *et al*., 2010; Ogden *et al*., 2012). Obese individuals are especially vulnerable to chronic diseases, such as type 2 diabetes (T2D) and cardiovascular diseases (CVDs) (Devereux & Alderman, 1993; Grundy *et al*., 2005; Kramer *et al*., 2013). However, some researchers argue that the traditional measure of using body mass index (BMI) is not an accurate gauge of obesity related morbidity or mortality risk (Hu, 2007; Padwal *et al*., 2011) because more than two-thirds of Americans are overweight and obese (Center for Disease Control and Prevention, n.d.), and only a subgroup of these individuals actually develop a chronic disease (Brochu *et al*., 2001). These researchers suggest the existence of a phenomena known as "healthy obesity:" individuals who are obese by BMI definition, but have no metabolic aberrations (Kramer *et al*., 2013).

Healthy eating and adequate physical activity may contribute to "healthy obesity" as preventive factors to delay and prevent obesity and chronic disease progression (Brochu *et al*., 2001; McCullough *et al*., 2002). the Edmonton Obesity Staging System (EOSS) is a new approach to define overweight and obesity, based on comorbidities and functional status (Sharma & Kushner, 2009; Kuk *et al*., 2011; Padwal *et al*., 2011). Because of the growing prevalence of obesity in young adults aged 18–29 (Ogden *et al*., 2012), there is a strong need to develop lifestyle interventions that are tailored to meet young adults' education needs and address their current health conditions. This age group, however, is understudied. To provide effective counseling to prevent and delay obesity progression, researchers and clinicians need to be informed about patterns of age-related risk behaviors associated with obesity progression in young adults.

LITERATURE REVIEW

The EOSS is a new scaling tool to measure obesity progression (Sharma & Kushner, 2009; Kuk *et al*., 2011; Padwal *et al*.,

Correspondence address: EunSeok Cha, Nell Hodgson Woodruff School of Nursing, Emory University, 1520 Clifton Road NE, Atlanta, GA 30322-4201, USA. Email: echa5@emory.edu

Received 12 June 2014; revision received 13 February 2015; accepted 17 February 2015 [Correction added on 23 June, 2015, after first online publication: The affiliation of the corresponding author, EunSeok Cha, has been corrected to 'Nell Hodgson Woodruff School of Nursing, Emory University, Atlanta, Georgia, USA'.]

© 2015 Wiley Publishing Asia Pty Ltd.

doi: 10.1111/nhs.12218

2011) and consists of five stages (stage 0–4); stage 0 refers to "healthy obesity," that is, no metabolic abnormality. When individuals have preclinical conditions (e.g. prediabetes), they fall into EOSS-1. When individuals have co-morbidities, such as T2D, hypertension, or dyslipidemia, they are categorized as EOSS-2 (Padwal *et al*., 2011). People in EOSS-0 to EOSS-2 experience no or minimal physical and functional limitations as a result of their obesity. Additionally, individuals in these stages have no obesity-related problems maintaining a normal routine (Kuk *et al*., 2011; Padwal *et al*., 2011). When obese individuals have end-organ damage (e.g. myocardial infarction, heart failure, stroke), they are classified as EOSS-3; when they have severe or potentially end-stage disabilities along with severe physiological/psychological limitations, they are classified as EOSS-4 (Kuk *et al*., 2011; Padwal *et al*., 2011). Because the EOSS more accurately predicts how obesity relates to mortality risk, researchers and clinicians should consider using this nuanced scale to assess obesity progression in order to design effective treatment and counseling (Sharma & Kushner, 2009; Kuk *et al*., 2011; Padwal *et al*., 2011).

The growing prevalence of obesity among young adults may be tied to their unhealthy lifestyle habits, including unhealthy eating and inadequate physical activity (Nelson *et al*., 2008; Unwin *et al*., 2013). Young adults often consume calorie dense foods, such as fast food, late night meals, and sugar sweetened beverages (SSBs) (Nelson *et al*., 2008; Bleich *et al*., 2011), and their exercise is inadequate to prevent unintended weight gain (Tudor-Locke *et al*., 2011; Cha *et al*., 2013; Centers for Disease Control and Prevention, 2014). Although more young adults reported achieving the recommended exercise rate (150 min per week in moderate-intensity aerobic exercise, equivalent to eight Metabolic Equivalent of Task [MET]-hour/week) than older adults (Health gov, 2008), their basal physical activity (daily routine activity) was lower than mature adults (Tudor-Locke *et al*., 2011; Cha *et al*., 2013). That is, many young adults who report meeting an exercise goal (≥ 8 MET-hour/week) may not reach a "daily activity goal" (i.e. 9000–11 000 steps per day, which is equivalent to 23 MET-hour/week) (Tudor-Locke *et al*., 2011). Their exercise is inadequate to ensure normal weight maintenance or weight loss. A lifestyle intervention for young adults needs to target age-related risk behaviors based on the assessment of their current behaviors.

PURPOSE

This study assessed young adults' lifestyles across EOSS stages to provide practical information for researchers and clinicians to tailor lifestyle interventions for overweight and obese young adults that are specific to their age, dietary and physical activity patterns, and obesity stage. This study examined the prevalence of overweight/obese young adults in each stage of the modified EOSS (mEOSS) and lifestyle factors (dietary habits, nutritional quality, and physical activity) that influence obesity progression. Specifically, we: (i) examined the prevalence of overweight/obese young adults in each stage of the mEOSS; and (ii) compared the dietary habits, nutrition quality, and physical activity between the stages to define age-specific nutrition and exercise areas targeted to stop obesity progression.

METHODS

Design

This was an ancillary study to the Diabetes Prevention Program for Young Adults (DPP-Y) that assessed the need for an age specific diabetes prevention program for young adults (Cha *et al*., 2013). A cross-sectional, descriptive correlational study design was used.

Participants

Between 2011 and 2012, 106 young adults were recruited from the metro Atlanta area using recruitment flyers posted in eight participating college and university campus bulletin boards, four university student health centers, one diabetes clinic, e-mail invitations via a student email listserv (1 university), and peer and self-referral. Eligible participants were young adults aged 18–29 years, overweight/obese (BMI ≥ 25), and physically inactive (leisure time physical activity < 90 min/week in a usual week).

Ethical considerations

The institutional review boards of all participating institutions approved this study. Written informed consent from all study participants was obtained, and participants' data were de-identified prior to data analysis to protect participants' confidentiality.

Data collection

Participants completed a self-reported survey packet to assess socio-demographics, and dietary habits and quality. An interviewer administered the survey to assess physical activity.

Demographic information, such as age, ethnicity, years of education, and smoking habits, was assessed using the Socio-demographic Questionnaire (SDQ).

Trained research nurses in a university Clinical Research Unit collected anthropometric and metabolic data. Blood pressure was assessed to comply with American Heart Association (AHA) standard guidelines (Moser, 2005). Fasting blood glucose, HbA1C (A1C), lipids (total serum cholesterol, triglyceride, direct high-density lipoprotein cholesterol [HDL], and direct low-density lipoprotein cholesterol [LDL]) were assessed using an antecubital vein blood sample taken after at least 8h of fasting. After the blood was drawn, the samples were transported to a nationally accredited lab for data analysis using an enzymatic method.

Two methods were used to define overweight and obese conditions. First, BMI (Kg/m^2) was calculated using weight (Kg) and height (cm), measured by a trained research nurse. The mEOSS, which considers cardiometabolic risk and BMI together (Sharma & Kushner, 2009; Padwal *et al*., 2011), was then used to define the stages of overweight and obese

© 2015 Wiley Publishing Asia Pty Ltd.

Table 1. Classification and cut-off points for assigning modified EOSS

	mEOSS-0	mEOSS-1	mEOSS-2
Overall definition	No apparent metabolic risk factors	Present obesity-related subclinical risk factors (e.g. prediabetes/ pre-hypertension, borderline dyslipidemia)	Present established obesity-related chronic diseases (e.g. hypertension, T2D, dyslipidemia)
Metabolic risk factors			
Fasting glucose	< 100 mg/dL	100–125 mg/dL	≥ 126 mg/dL
†A1C (%)	< 5.7%	5.7–6.4%	≥ 6.5%
Blood pressure (mmHg)	< 130/85; if individual has diabetes	For individuals classified as having diabetes, SBP 125–129.9 or DBP 75–79.9. Otherwise, SBP 130–139.9 or DBP 85–89.9	If individual is taking antihypertensive drug; if individual has diabetes, 130/80; otherwise, ≥ 140/90
Total cholesterol (mg/dL)	< 200 mg/dL	200–239 mg/dL	≥ 240 mg/dL
LDL cholesterol (mg/dL)	< 130	130–159 mg/dL	≥ 160 mg/dL
†HDL cholesterol	≥ 40 mg/dL in men; ≥ 50 mg/dL in women		< 40 mg/dL in men; < 50 mg/dL in women
Triglyceride	< 150 mg/dL	150–199 mg/dL	≥ 200 mg/dL

†Metabolic risk cut-off points were adapted from the Edmonton Obesity Staging System (EOSS) and Adult Treatment Panel III. HbA1C was included as a metabolic risk factor because it has been an accepted diagnostic measure of prediabetes and type 2 diabetes (T2D) by the American Diabetes Association since 2010. DBP, diastolic blood pressure; HDL, high-density lipoprotein cholesterol; LDL, low-density lipoprotein cholesterol; mEOSS, modified EOSS; SBP, systolic blood pressure.

conditions after two small modifications by the authors. HbA1C was added to define hyperglycemic conditions (EOSS-1: prediabetes; EOSS-2: diabetes) because as of 2011, the American Diabetes Association includes HbA1C as a diagnostic measure of prediabetes and diabetes (American Diabetes Association, 2011; Grundy, 2012). The cut-off point of cholesterol guidelines using the Adult Treatment Panel (ATP) III was also modified (see Table 1) (Grundy *et al*., 2005; Padwal *et al*., 2011; Grundy, 2012). Thus, a HDL of ≥ 50 mg/dL for women and a HDL of ≥ 40 mg/dL for men were used as the new cut-off points (10-year risk for CVD Framingham Point Score = 0) for EOSS-0 (Grundy *et al*., 2005; Grundy, 2012). Table 1 shows the cut-off points of each metabolic risk factor in accordance with the ATP III definition and mEOSS (Grundy *et al*., 2005; Padwal *et al*., 2011).

Dietary habits and quality were assessed with a self-reported 152-item Youth/Adolescent Food Frequency Questionnaire (YAQ) (Rockett *et al*., 1997). Based on participants' responses, dietary patterns (e.g. frequency of fried foods, skipping breakfast), nutrition components, sources of calorie intakes, and serving sizes were calculated by the Harvard University School of Public Health Nutrition Department. The Dietary Quality Index Revised score for young adults (DQIR-Y) (Newby *et al*., 2003; Cha *et al*., 2014), adjusted to reflect the most recent dietary guidelines for young adults aged 18–30 in the 2010 Dietary Guideline for Americans (U.S. Department of Agriculture and U.S. Department of Health & Human Services, 2010), was calculated to assess overall dietary quality. The detailed scoring guide of the DQIR-Y is presented in Table 2.

Physical activity was measured using the seven-item Modifiable Activity Questionnaire (MAQ), the primary physical activity measure used in the Diabetes Prevention Program (Kriska, 1997; Kriska *et al*., 2006). Trained research staff assessed leisure and occupational activity and inactivity in the past year to calculate the MET-hour per week (Kriska *et al*., 2006). Based on the MET-hour per week, the participants were divided into four groups: (i) physical activity group (≥ 23 MET-hour per week); (ii) physical inactivity group 1 (> 8 MET-hour per week and < 23 MET-hour per week); (iii) physical inactivity group 2 (> 0 MET-hour per week and < 8 MET-hour per week); and (iv) no activity group (MET-hour per week = 0) (Tudor-Locke *et al*., 2011).

Data analysis

Data analysis was conducted with SPSS 20.0 (IBM Corp., Armonk, NY, USA). Prior to data analysis, data patterns (missing data) were examined. One participant reported a very small calorie intake (326.70 Kcal per day). We included this participant because the overall findings did not change with/without this participant, and our primary goal was to examine dietary patterns and nutrient components rather than overall calorie intake in overweight and obese young adults. A participant who did not complete blood work was excluded. Thus, final data analyses were conducted with 105 participants. To answer our specific aims, descriptive statistics, a series of chi-square tests, and one-way analyses of variance were performed.

RESULTS

Sample characteristics

The majority of participants were female (78.1%) and non-Hispanic African-Americans (66.7%). Almost half of the participants (n = 48, 45.71%) met the BMI criteria for class II

© 2015 Wiley Publishing Asia Pty Ltd.

Table 2. Scoring guides of Dietary Quality Index Revised for young adults

Component	DQIR-Y Scoring†	Scoring guides‡	Possible ranges
Grains	7 servings	10:1 point less for each 10% less than intake required for full score	0–10
Vegetables	3 servings	Same as above	0–10
Fruit	2 servings	Same as above	0–10
Total fat	≤ 30% of total calories	≤ 30% = 10; 31–44% = 5; ≥ 45% = 0	0–10
Saturated fat	≤ 10% of total calories	≤ 10% = 10; 11–14% = 5; ≥ 15% = 0	0–10
Cholesterol	< 300 mg	< 300 mg = 10; 300–449 mg = 5; ≥ 450 mg = 0	0–10
Calcium	1000 mg	10:1 point less for each 10% less than intake required for full score	0–10
Iron	18 mg for women; 8 mg for men	10:1 point less for each 10% less than intake required for full score	0–10
Diet modification			
Added sugar	5–15% of total calories	≤ 5% = 2.5; 5.01%-10.0% = 1.5; 10.01%-15.0% = 1; > 15.0% of total calories = 0	0–2.50
Sodium	≤ 1500–2300 mg	≤ 1500 mg = 2.5; 1501–2300 mg = 1.5; ≥ 2301 mg = 0	0–2.50
Food group of diet diversity		Representative foods	
Grains	Non-whole grain breads	White bread, roll	0–2.50
	Quick breads	Muffin, English muffin, pancakes	
	Pasta	Lasagna, macaroni, spaghetti, pasta	
	Whole grain breads	Dark bread, graham crackers, wheat thins	
	Cereals	Cold cereal, hot cereal	
	Rice	Rice	
	Other grains	Corn bread, tortilla, kasha, popcorn	
Vegetables	Deep yellow or orange	Carrot, sweet potatoes	0–2.50
	Deep green	Broccoli, spinach, green/kale	
	Tomato product	Fresh tomato, tomato sauce	
	Potatoes	French fries, potatoes: baked, boiled, mashed	
	Beans	Tofu, beans	
	Starch	Corn, peas, or lima beans	
	Other	Beets (not greens), mixed vegetables, pepper	
Fruits	Citrus, berries, and melons	Cantaloupe, orange, strawberries	0–2.50
	Juices	Orange, apple	
	Other	Raisins, banana, apples, pears	
Meat & dairy	Beef/pork (red meat)	Beef, pork, organ meats, lunch meats	0–2.50
	Poultry	Chicken, turkey	
	Milk	Milk (skim, 1%, 2% & whole milk), chocolate milk	
	Cheese	Cheese, cream cheese, cottage cheese	
	Eggs and soup	Eggs	
	Fish	Tuna, fish stick, fresh fish, shrimp, lobster, scallops	
	Yogurt	Yogurt	
Total score			0–95.00

†Based on 1800–2200 Kcal for 2010 Dietary guideline for Americans aged 19–30 and mypyramid.gov. ‡Scoring by Newby *et al.* 2003; U. S. Department of Agriculture and U. S. Department of Health & Human Services, 2010.

obesity or higher (BMI ≥ 35). The mean age and years of education were 24.0 and 15.1 years, respectively. About 12% of the participants ($n = 13$) were born outside of the United States (US). Two-thirds of participants reported that they had never smoked ($n = 78$, 75.0%) (Table 3).

Obesity progression and cardiometabolic risk

About 80% of participants ($n = 83$) were categorized as mEOSS-2, presenting with obesity-related chronic disorders (hypertension, diabetes or dyslipidemia). However, none were aware of their conditions prior to their enrollment in the study. Metabolic aberration seemed to occur individually depending on predisposing conditions of young adults, rather than in a cluster of risk factors (i.e. metabolic syndrome). The highest prevalence of metabolic risk was visceral obesity (88.8%), followed by low HDL (76.2%), higher A1C (26.7%), and elevated blood pressure (25.7%) (See Table 4).

Lifestyle habits

Physical activity

The average self-reported physical activity was 16.3 MET-hour/week (median: 6.1 MET-hour per week). Two-thirds of young adults reported less than eight MET-hour per week and 14.3% of participants reported no physical activity during the past year (see Table 3).

© 2015 Wiley Publishing Asia Pty Ltd.

Table 3. Sample characteristics and physical activity by mEOSS stages (n = 105)

	Total Mean ± SD	mEOSS-0 (n = 9) Mean ± SD	mEOSS-1 (n = 13) Mean ± SD	mEOSS-2 (n = 83) Mean ± SD	P-value
Age	24.0 ± 3.5	23.1 ± 2.7	23.2 ± 4.5	24.3 ± 3.1	0.400
BMI	36.8 ± 8.1	34.8 ± 7.0	31.4 ± 3.3	37.68 ± 8.32	0.022
Years of education	15.1 ± 2.6	15.6 ± 2.0	14.4 ± 2.9	15.56 ± 2.72	0.972
Physical activity median (MET/h-week)	6.22	5.6	5.9	6.7	
	n (%)	n (%)	n (%)	n (%)	
Male versus female	23 (21.9) *vs* 82 (78.1)	0 (0.0) *vs* 9 (100.0)	4 (30.8) *vs* 9 (69.2)	19 (22.9) *vs* 64 (77.1)	0.198
African-Americans (AA) versus non-AA	70 (66.7) *vs* 35 (33.3)	6 (66.7) *vs* 3 (33.3)	8 (61.5) *vs* 5 (38.5)	56 (67.5) *vs* 27 (32.5)	0.930
†Smoking:					
Never smoked	78 (75.0)	5 (55.6)	11 (84.6)	62 (74.7)	0.266
Former smoker	15 (14.4)	3 (33.3)	1 (7.7)	11 (13.3)	
Currently smoker	11 (10.6)	1 (11.1)	0 (0.0)	10 (12.0)	
Physical activity n (%)					
No activity (MET/h = 0)	15 (14.3)	2 (22.2)	3 (23.1)	10 (12.0)	0.248
Physically inactive (0.1–7.9 MET/h-week)	47 (44.8)	4 (44.4)	5 (38.5)	38 (45.8)	
Physically inactive (8–22.9 MET/h-week)	17 (16.2)	0 (0.00)	4 (30.8)	13 (15.7)	
Physically active (23 ≥ MET/h-week)	26 (24.8)	3 (33.3)	1 (7.7)	22 (26.5)	

†Data for one participant was missing. BMI, body mass index; MET, metabolic equivalent of task; mEOSS, modified Edmonton Obesity Staging System; SD, standard deviation.

Table 4. Prevalence of metabolic risk across mEOSS stages

		Total (n = 105) n (%)	mEOSS-0 (n = 9) n (%)	mEOSS-1 (n = 13) n (%)	mEOSS-2 (n = 83) n (%)
Obesity	(BMI ≥ 30)	83 (79.1)	6 (66.7)	9 (69.2)	68 (80.0)
BMI ranges		26.2–58.6	27.4–46.1	26.9–40.5	26.2–58.6
Waist circumference	Men ≥ 102 cm; women ≥ 88 cm	85 (81.0)	8 (88.9)	6 (46.2)	71 (85.5)
Fasting glucose	100–125	7 (6.7)	0 (0.0)	1 (7.7)	6 (7.2)
	≥ 126 mg/dL	1 (1.0)	0 (0.0)	0	1 (1.2)
A1C	5.7–6.4%	25 (23.8)	0 (0.0)	5 (38.5)	20 (24.1)
	≥ 6.5%	3 (2.9)	0 (0.0)	1 (7.7)	2 (2.4)
Blood pressure	Prehypertension (130/85)	13 (12.4)	0 (0.0)	5 (38.5)	8 (9.6)
	Hypertension (≥ 140/90)	14 (13.3)	0 (0.0)	0 (0.0)	14 (16.9)
Total cholesterol	200–239 mg/dL	10 (9.5)	0 (0.0)	3 (23.1)	7 (8.4)
	≥ 240 mg/dL	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.00)
LDL	130–159 mg/dL	19 (18.1)	0 (0.0)	2 (15.4)	17 (20.5)
	≥ 160 mg/dL	5 (4.8)	0 (0.0)	0 (0.0)	5 (6.0)
Triglyceride	150–199 mg/dL	3 (2.9)	0 (0.0)	0 (0.0)	3 (3.6)
	≥ 200 mg/dL	7 (6.7)	0 (0.0)	0 (0.0)	7 (8.4)
HDL	< 40 mg/dL in men (n = 23); < 50 mg/dL in women (n = 82)	78 (74.3)	0 (0.0)	0 (0.0)	78 (94.0)

BMI, body mass index; LDL, low-density lipoprotein cholesterol; mEOSS, modified Edmonton Obesity Staging System.

Dietary habits and nutrient intakes

Overall dietary quality was poor (mean score: 62.1, standard deviation: 11.52) although calorie intake met 2010 dietary recommendations. In particular, mEOSS-1 and mEOSS-2 groups reported lower dietary quality scores than the mEOSS-0 group. There was a significant difference in dietary quality between mEOSS-1 and mEOSS-0 groups (P = 0.037).

Most of the participants' calorie and sodium intakes were comparable to the 2010 Dietary Guidelines for Americans (DGA), although a wide range of results existed: 326.7–3287.8 Kcal/day (calorie intake) and 416.3–4285.4 mg/day (sodium consumption). Added sugar consumption, however, was almost two times higher than AHA recommendations, but were within DGA recommendations (5–15% of total calorie intake).

© 2015 Wiley Publishing Asia Pty Ltd.

Table 5. Dietary quality and nutrient intakes

	2010 Dietary Guidelines for Americans	mEOSS-0 (n = 9) Mean ± SD	mEOSS-1 (n = 13) Mean ± SD	mEOSS-2 (n = 83) Mean ± SD	P-value
Dietary quality (DQIR-Y)	N/A				
Total score	Range: 0–95	68.6 ± 6.6	58.2 ± 10.7	62.0 ± 11.8	0.110
Food diversity sub-score	Range: 0–10	5.5 ± 2.0	4.5 ± 1.7	4.8 ± 1.8	0.428
Total calories (Kcal)	1800–2600 Kcal	1682.0 ± 590.9	1759.1 ± 715.1	1758.7 ± 567.7	0.932
Total added sugar (g/day)	< 25 g for women; 37.5 g for men	48.6 ± 27.4	63.9 ± 32.2	58.0 ± 28.2	0.461
Total dietary fiber (g/day)	(14 g/1000 Kcal)	19.0 ± 5.6	14.9 ± 6.5	16.9 ± 8.0	0.473
Total sodium (g/day)	≤ 1500–2300 mg	1917.5 ± 720.8	2055.2 ± 895.9	2126.5 ± 787.0	0.739
Cholesterol	< 300 mg	251.5 ± 130.2	215.4 ± 113.6	227.7 ± 104.2	0.736
Trans fat	0 mg	1.8 ± 0.7	2.6 ± 1.2	2.3 ± 0.8	0.114
Calcium	1000 mg	898.3 ± 425.0	723.3 ± 272.6	742.9 ± 316.3	0.366
Magnesium	310 mg for women; 400 mg for men	284.9 ± 89.4	226.0 ± 83.7	248.4 ± 97.7	0.366
Vitamin D	600 IU	263.3 ± 226.0	204.2 ± 170.2	185.6 ± 164.2	0.423
Fruit	2 cups	1.2 ± 0.6	1.1 ± 1.0	1.5 ± 1.2	0.490
Vegetables	3 cups	3.0 ± 1.3	2.0 ± 1.4	2.1 ± 1.4	0.175
% of energy sources					
% of carbohydrate	45–65%	54.8 ± 5.4	54.2 ± 5.9	53.3 ± 6.5	0.763
% of added sugar	< 5–15%	11.2 ± 3.1	14.7 ± 4.7	13.2 ± 5.3	0.305
% of protein	10–35%	17.9 ± 4.0	14.2 ± 2.1	15.9 ± 3.2	0.028
% of total fat	20–35%	27.7 ± 3.6	32.7 ± 4.7	31.4 ± 5.3	0.064
% of saturated fat	< 10% of total calorie	9.1 ± 1.8	11.4 ± 1.7	10.4 ± 2.4	0.065

DQIR-Y, Dietary Quality Index Revised for young adults; IU, international unit; mEOSS, modified Edmonton Obesity Staging System; SD, standard deviation.

On average, the participants met 2010 DGA recommendations for carbohydrate, protein, and total fat intakes. However, the EOSS-0 group consumed less saturated fat (9.1 ± 1.8% of total calorie intake) and more protein (17.9 ± 4.0% of total calorie) than the other two groups. Fruit and vegetable consumption did not meet recommended levels, but the EOSS-0 group reported consumption closest to the recommendation. The average reported dietary fiber (16.8 g/1753.5 Kcal) was much lower than the recommendation (14 g/1000 Kcal), and all participants consumed trans fat (2.3 ± 0.9 g/day) (see Table 5).

Concerning dietary patterns, 14.3% of participants skipped breakfast, and 21.2% of young adults consumed late night snacks more than three times per week. About 12% of young adults consumed fried food more than four times per week outside of the home. Approximately 30% of young adults added sugar to their foods or beverages, and sugar sweetened beverage (SSB) consumption was very popular (90.5%). The majority of the participants drank fruit juice (n = 90, 85.7%), and the preferred milk options were 2% milk or whole milk (54.3%) and chocolate milk (23.8%). Only 24.7% of the participants drank skim milk or 1% milk. As expected, regular and diet sodas were very commonly consumed; 78.1% (n = 82) of participants consumed regular or diet soda, and 12.4% of them drank more than one can of regular or diet soda per day. In particular, the young adults categorized in mEOSS-2 consumed diet soda twice more often than the mEOSS-1 group and 8.5 times more than the mEOSS-0 group. Detailed information on these dietary patterns by mEOSS group is presented in Table 6.

DISCUSSION

This study successfully delineated key target lifestyle elements in overweight and obese young adults in order to prevent obesity progression and promote cardiometabolic health. For instance, the mEOSS-1 group was more vulnerable to cardiometabolic risk than the mEOSS-0 group, although their BMI was significantly lower (P = 0.036, see Table 3). This may be because of their poorer dietary habits compared to the mEOSS-0 group. Thus, evidence-based intervention targeting age-linked behaviors (e.g. monitoring added sugar and saturated fat consumption) needs to be developed with practical advice (Knowles *et al*., 2005).

In this study, there was no significant difference in the physical activity levels of the groups, but this finding may be because of the inclusion of less than 90 min leisure time activity per week, unequal numbers in each EOSS group, and a threshold effect of physical activity on health outcome (Fretts *et al*., 2012; Chen *et al*., 2013). Accumulated evidence shows that physical activity not only improves energy balance but also increases insulin sensitivity, improves beta-cell function, and controls blood pressure and cholesterol (Grundy *et al*., 2005; Chen *et al*., 2013). Therefore, a study with a larger sample of overweight and obese young adults reporting a wide range of physical activity should be replicated for further exploration.

Our findings underscore the importance of prevention and early treatment of obesity in young adults. Because the main goal of the current study was to identify the lifestyle factors that increase metabolic abnormality, we applied lower HDL

© 2015 Wiley Publishing Asia Pty Ltd.

Table 6. Dietary patterns

Beverage consumption (serving/day)	mEOSS-0 (n = 9) Mean ± SD	mEOSS-1 (n = 13) Mean ± SD	mEOSS-2 (n = 83) Mean ± SD	P-value
Sugar sweetened beverages (soda, sweetened tea, or punch)	0.5 ± 0.8	1.2 ± 1.4	0.8 ± 0.8	0.208
Diet soda	0.02 ± 0.05	0.08 ± 0.2	0.2 ± 0.5	0.524
Milk	0.6 ± 0.8	0.4 ± 0.3	0.4 ± 0.4	0.214
Chocolate milk	N/A	0.02 ± 0.05	0.05 ± 0.1	0.400
Coffee	0.4 ± 0.5	0.2 ± 0.3	0.2 ± 0.3	0.132
Tea	0.4 ± 0.4	0.08 ± 0.2	0.2 ± 0.3	0.062
Alcohol	0.3 ± 0.3	0.09 ± 0.1	0.2 ± 0.2	0.043
Dietary habits	n (%)	n (%)	n (%)	P-value
No breakfast	1 (11.1)	0 (0.0)	15 (18.1)	N/A
Frequency of fried food at home	n (%)	n (%)	n (%)	P-value
Never	8 (88.9)	5 (38.5)	36 (43.4)	0.064
1–2 times/week	1 (11.1)	6 (46.2)	42 (50.6)	
≥ 3 times/week		2 (15.4)	5 (6.0)	
Frequency of fried food out	n (%)	n (%)	n (%)	P-value
Never/less than once per week	4 (44.4)	5 (38.5)	19 (22.9)	0.267
1–3 times/week	5 (55.6)	5 (38.5)	54 (65.1)	
≥ 4 times/week	0 (0.0)	3 (23.1)	10 (12.0)	
Number of times eat late snacks out‡	n (%)	n (%)	n (%)	P-value
Never	6 (66.7)	4 (30.8)	33 (39.8)	0.252
1–2 times/week	3 (33.3)	4 (30.8)	32 (38.6)	
≥ 3 times/week	0 (0.0)	5 (38.5)	17 (20.5)	

In beverage consumption, 0.14 serving per day refers to one serving per week. ‡Data for one participant was missing. SD, standard deviation.

cut-off points when defining the obesity staging system than those used in a study by Padwal *et al.* (2011). If we applied a HDL of ≥ 60 mg/dL, a prevention score (-1 of Framingham Point Score) proposed by Padwal *et al.* to reduce 10-year risk for CVDs, none of our participants would have been classified into the "healthy obesity" EOSS-0 group. That is, "healthy overweight and obesity" may exist for a much shorter period in overweight (overweight: BMI of 25.00–29.99) and low-risk obese individuals (Class 1 obesity: BMI of 30.00–34.99) with healthy lifestyles than researchers previously believed. Longer obesity periods and/or morbidly obese conditions (BMI ≥ 35) leave individuals very vulnerable to obesity progression, regardless of their lifestyle habits. Thus, obesity prevention and early proactive obesity treatment (e.g. bariatric surgery, weight loss regime) may be the best way to promote cardiometabolic health, regardless of current metabolic aberration (Kramer *et al.*, 2013; Kwok *et al.*, 2014). [Correction added on 28 August, 2015, after first online publication: 'CDVs' has been corrected to 'CVDs' in the above paragraph.]

A reduction of SSBs and diet sodas needs to be emphasized in overweight and obese young adults (Malik *et al.*, 2010; Van Horn *et al.*, 2010). As Table 5 shows, 91% of participants drank SSBs, a much higher rate than was reported in a previous study (72%) (Bleich *et al.*, 2011). SSBs are a major source of added sugar (about 30–50% of added sugar) and additional calories without essential nutrients (U.S. Department of Agriculture and U.S. Department of Health & Human Services, 2010; Hedrick *et al.*, 2012). As Table 6 shows, the mEOSS-2 group drank diet soda more frequently than other groups. Diet soda may be an alternative to regular soda to avoid additional calorie intake; however, there is a growing concern that diet soda increases the risk of development of T2D and CVDs later in life (Gardener *et al.*, 2012). Moreover, this risk is even greater for overweight and obese individuals (Gardener *et al.*, 2012). A nutrition education program focusing on the selection of the "right" beverage, as well as healthier food choices, needs to be developed to help overweight and obese young adults.

Finally, modifications of dietary habits based on young adults' current dietary patterns need to be a key area of nutrition education for young adults. For instance, the mEOSS-1 and mEOSS-2 groups showed a higher prevalence of late night snack consumption than the mEOSS-0 group. In particular, the mEOSS-2 group frequently ate fried food and skipped breakfast (see Table 6). Thus, increased education about eating a balanced and good quality diet is necessary in this population.

© 2015 Wiley Publishing Asia Pty Ltd.

Limitations

The authors acknowledge several limitations to this study. While the YAQ is a valid and reliable instrument to assess youth dietary habits (Rockett *et al.*, 1995; 1997), issues related to a self-reported food frequency questionnaire may cause study limitations. For instance, the YAQ may not include all food items (e.g. sport drinks) consumed frequently by young adults, which may have led to underreporting of food consumption and underestimation of caloric intake. Also, the questionnaire challenges participants to recall what they ate in the past year, which is a very long recall period for an activity that one does daily. This recall bias is also applicable to the self-reporting of physical activity. The use of an objective measure of physical activity (e.g. accelerometer) needs to be considered for future studies.

Poor estimation skills of portion size may also generate inaccurate study findings. Because assessing participants' portion size estimation skills was not a research aim for this study, we have very limited knowledge about whether participants correctly understood the serving sizes referenced in the questionnaire. To overcome these limitations, future research needs to use additional dietary assessments, such as a 24-hour dietary recall or an instrument using food photographs, in order to capture more accurate dietary habits in overweight and obese young adults (Jia *et al.*, 2012).

Another limitation of this study is related to the limitations of the EOSS, an evolving tool to assess obesity risk and its progression (Sharma & Kushner, 2009; Padwal *et al.*, 2011). However, we endorse the developers' conclusion that "the EOSS is a meaningful framework to guide obesity treatment/counseling decisions" (Sharma & Kushner, 2009), although we acknowledge the need to replicate the study with a larger sample size. Finally, our convenient sampling method, small sample size, and female (78.1%) and African-American (66.7%) dominant sample reduce the external validity of our findings. To overcome this limitation, a study using a national representative sample is warranted.

CONCLUSIONS

Overweight and obese young adults can improve their cardiometabolic health with a healthy lifestyle. To take action, young adults need practical and strategic dietary advice about beverage choices, diet quality, and macronutrient and micronutrient sources. In addition, increasing overall activity and minimizing sedentary behavior needs to be emphasized for young adults in order to achieve physical activity goals. The findings of the current study highlight the great need for prevention and early treatment measures through lifestyle modification for overweight and obese young adults in order to prevent and cease obesity progression.

ACKNOWLEDGMENTS

This study was supported by the National Institute of Nursing Research (K01NR012779), Emory University (University Research Committee and Atlanta Clinical and Translational Science Institute collaborative grant), and a Public Health Service grant (UL1 RR025008) from the Clinical and Translational Science Award Program, National Institutes of Health, National center for research resources. The authors express sincere gratitude to Dr. K. M. Venkat Narayan (Emory University) and Dr. Judith A. Erlen (University of Pittsburgh) for their mentoring throughout Dr. Cha's early career development training, supported by the K01 award. The authors are very grateful to Ms. Morenike Bello for her editorial service. The authors also thank study staff, participants, and community partners.

CONTRIBUTIONS

Study Design: ESC, KHK, MKA, SBD.
Data Collection and Analysis: ESC, KHK, CRD, HML, MKA.
Manuscript Writing: ESC, KHK, MKA, GU, CRD, SBD.

REFERENCES

American Diabetes Association. Standards of medical care in diabetes – 2011. *Diabetes Care* 2011; **34**: S11–S61.

Bleich SN, Pickett-Blakely O, Cooper LA. Physician practice patterns of obesity diagnosis and weight-related counseling. *Patient Educ. Couns.* 2011; **82**: 123–129.

Brochu M, Tchernof A, Dionne IJ *et al*. What are the physical characteristics associated with a normal metabolic profile despite a high level of obesity in postmenopausal women? *J. Clin. Endocrinol. Metab.* 2001; **86**: 1020–1025.

Center for Disease Control and Prevention. Overweight and obesity. n.d. [Cited 13 Feb 2015.] Available from URL: http://www.cdc.gov/nccdphp/dnpa/obesity/.

Center for Disease Control and Prevention. Facts about physical activity. U.S. Physical Activity Statistics 2014.

Cha E, Kim KH, Lerner HM *et al*. Health literacy, self-efficacy, food label use, and diet in young adults. *Am. J. Health Behav.* 2014; **38**: 331–339.

Cha E, Umpierrez G, Kim KH, Bello MK, Dunbar SB. Characteristics of American young adults with increased risk for type 2 diabetes: a pilot study. *Diabetes Educ.* 2013; **39**: 454–463.

Chen Z, Black MH, Watanabe RM *et al*. Self-reported physical activity is associated with beta-cell function in Mexican American adults. *Diabetes Care* 2013; **36**: 638–644.

Devereux RB, Alderman MH. Role of preclinical cardiovascular disease in the evolution from risk factor exposure to development of morbid events. *Circulation* 1993; **88**: 1444–1455.

Flegal KM, Carroll MD, Ogden CL, Curtin LR. Prevalence and trends in obesity among US adults, 1999–2008. *JAMA* 2010; **303**: 235–241.

Fretts AM, Howard BV, McKnight B *et al*. Modest levels of physical activity are associated with a lower incidence of diabetes in a population with a high rate of obesity: the strong heart family study. *Diabetes Care* 2012; **35**: 1743–1745.

Gardener H, Rundek T, Markert M, Wright CB, Elkind MS, Sacco RL. Diet soft drink consumption is associated with an increased risk of vascular events in the Northern Manhattan Study. *J. Gen. Intern. Med.* 2012; **27**: 1120–1126.

Grundy S, Cleeman JI, Daniels SR *et al*. Diagnosis and management of the metabolic syndrome: an American Heart Association/National Heart, Lung, and Blood Institute scientific statement. *Circulation* 2005; **112**: 2735–2752.

© 2015 Wiley Publishing Asia Pty Ltd.

Grundy SM. Pre-diabetes, metabolic syndrome, and cardiovascular risk. *J. Am. Coll. Cardiol.* 2012; **59**: 635–643.

Health gov. Physical activity guidelines advisory committee report 2008.

Hedrick VE, Savla J, Comber DL *et al*. Development of a brief questionnaire to assess habitual beverage intake (BEVQ-15): sugar-sweetened beverages and total beverage energy intake. *J. Acad. Nutr. Diet.* 2012; **112**: 840–849.

Hu FB. Obesity and mortality: watch your waist, not just your weight. *Arch. Intern. Med.* 2007; **167**: 875–876.

Jia W, Yue Y, Fernstrom JD *et al*. Imaged based estimation of food volume using circular referents in dietary assessment. *J. Food Eng.* 2012; **109**: 76–86.

Knowles MS, Holton EF, Swanson RA. *The Adult Learner: The Definitive Classic in Adult Education and Human Resource Development*. Boston, MA: Taylor & Francis Ltd, 2005.

Kramer CK, Zinman B, Retnakaran R. Are metabolically healthy overweight and obesity benign conditions?: a systematic review and meta-analysis. *Ann. Intern. Med.* 2013; **159**: 758–769.

Kriska AM. Modifiable activity questionnaire. *Med. Sci. Sports Exerc.* 1997; **29**: S73–S78.

Kriska AM, Edelstein SL, Hamman RF *et al*. Physical activity in individuals at risk for diabetes: diabetes prevention program. *Med. Sci. Sports Exerc.* 2006; **38**: 826–832.

Kuk JL, Ardern CI, Church TS *et al*. Edmonton Obesity Staging System: association with weight history and mortality risk. *Appl. Physiol. Nutr. Metab.* 2011; **36**: 570–576.

Kwok CS, Pradhan A, Khan MA *et al*. Bariatric surgery and its impact on cardiovascular disease and mortality: a systematic review and meta-analysis. *Int. J. Cardiol.* 2014; **173**: 20–28.

Malik VS, Popkin BM, Bray GA, Despres JP, Willett WC, Hu FB. Sugar-sweetened beverages and risk of metabolic syndrome and type 2 diabetes: a meta-analysis. *Diabetes Care* 2010; **33**: 2477–2483.

McCullough ML, Feskanich D, Stampfer MJ *et al*. Diet quality and major chronic disease risk in men and women: moving toward improved dietary guidance. *Am. J. Clin. Nutr.* 2002; **76**: 1261–1271.

Moser M. Comments on the new AHA recommendations for blood pressure measurement. *J. Clin. Hypertens. (Greenwich)* 2005; **7**: 71–72.

Nelson MC, Story M, Larson NI, Neumark-Sztainer D, Lytle LA. Emerging adulthood and college-aged youth: an overlooked age for weight-related behavior change. *Obesity (Silver Spring)* 2008; **16**: 2205–2211.

Newby PK, Hu FB, Rimm EB *et al*. Reproducibility and validity of the Diet Quality Index Revised as assessed by use of a food-frequency questionnaire. *Am. J. Clin. Nutr.* 2003; **78**: 941–949.

Ogden CL, Carroll MD, Kit BK, Flegal KM. Prevalence of obesity in the United States, 2009–2010. [Cited 5 Sep 2013.] Available from URL: http://www.cdc.gov/nchs/data/databriefs/db82.htm.

Padwal RS, Pajewski NM, Allison DB, Sharma AM. Using the Edmonton obesity staging system to predict mortality in a population-representative cohort of people with overweight and obesity. *CMAJ* 2011; **183**: E1059–E1066.

Rockett HR, Breitenbach M, Frazier AL *et al*. Validation of a youth/adolescent food frequency questionnaire. *Prev. Med.* 1997; **26**: 808–816.

Rockett HR, Wolf AM, Colditz GA. Development and reproducibility of a food frequency questionnaire to assess diets of older children and adolescents. *J. Am. Diet. Assoc.* 1995; **95**: 336–340.

Sharma AM, Kushner RF. A proposed clinical staging system for obesity. *Int. J. Obes. (Lond)* 2009; **33**: 289–295.

Tudor-Locke C, Craig CL, Brown WJ *et al*. How many steps/day are enough? For adults. *Int. J. Behav. Nutr. Phys. Act.* 2011; **8**: 79.

U. S. Department of Agriculture and U. S. Department of Health & Human Services. *Dietary Guidelines for American 2010*. Washinton, DC: US Government Printing Office, 2010.

Unwin BK, Goodie J, Reamy BV, Quinlan J. Care of the college student. *Am. Fam. Physician* 2013; **88**: 596–604.

Van Horn L, Johnson RK, Flickinger BD, Vafiadis DK, Yin-Piazza S. Translation and implementation of added sugars consumption recommendations: a conference report from the American Heart Association Added Sugars Conference 2010. *Circulation* 2010; **122**: 2470–2490.

© 2015 Wiley Publishing Asia Pty Ltd.