Original Article

Access this article online

Quick Response Code:

Website:
www.jehp.net

DOI:
10.4103/jehp.jehp_12_19

Examination of the relationship of diet quality with cardiometabolic risk factors in apparently healthy college students

Rachel A. Williams, Angela M. Rose[1], Richard S. Bruno, Andrew S. Hanks[2], Julie A. Kennel, Joshua D. McDonald[3], Allison N. Labyk, Carolyn Gunther

Department of Human Sciences, Human Nutrition Program, The Ohio State University, [2]Department of Human Sciences, Consumer Sciences Program, The Ohio State University, Columbus, Ohio, [1]Department of Pediatrics and Communicable Diseases, Child Health Evaluation and Research Center, University of Michigan, Michigan, [3]Department of Human Nutrition, Winthrop University, South Carolina, USA

Address for correspondence:
Dr. Carolyn Gunther, 1787 Neil Ave, 313 Campbell Hall, Columbus, Ohio, USA.
E-mail: gunther.22@osu.edu

Received: 10-01-2019
Accepted: 13-07-2019

Abstract:

BACKGROUND: Preliminary evidence indicates that subclinical cardiometabolic abnormalities are present in apparently healthy nonobese young adults. Poor dietary habits may be a contributing factor.

OBJECTIVE: The objective of this study was to examine the presence of cardiometabolic abnormalities in apparently healthy college students and to assess the relationship between diet quality and cardiometabolic risk factors.

METHODS: Cross-sectional anthropometric, lipidemia, and glucose tolerance, blood pressure, and dietary Healthy Eating Index (HEI) data were collected (April 2015). Participants were undergraduate students. Ordinary least squares regression was used to examine associations between diet quality and cardiometabolic risk factors.

RESULTS: Participants (n = 147) were primarily nonHispanic Caucasian between 18 and 22 years and largely nonobese (95.0% of females, 85.1% of males). Total HEI score was 56.1 ± 16.1 for females and 53.2 ± 15.0 for males. Mean biochemical and clinical outcomes fell within normal limits. However, 71.0% of females and 80.9% of males met ≥1 or more metabolic syndrome criteria. HEI was not related to health outcomes.

CONCLUSIONS: Cardiometabolic abnormalities are present in a large proportion of apparently healthy undergraduates which may place them at risk for future cardiometabolic complications. There was no relationship between diet quality and cardiometabolic health.

Keywords:

College students, diet, metabolic syndrome, young adult

Introduction

Obesity remains a major U.S. public health concern affecting over one-third of adults.[1] Unfortunately, even young adults (18–29 years old) are at risk for the disease.[2] Indeed, 36.6% of college students are classified as either overweight or obese.[3] Obesity increases the risk for cardiometabolic illnesses such as heart disease, stroke, and type 2 diabetes; similarly, obesity is closely related to metabolic syndrome (MetS), which is associated with cardiovascular disease, type 2 diabetes, and some cancers.[4]

Emerging evidence indicates that subclinical cardiometabolic abnormalities are present in apparently healthy nonobese young adults, including college students.[5-8] In addition, almost all (95%) undergraduate students are consuming less than the recommended fruit and vegetable intake,[3] a dietary protective factor against chronic illness.[9] Determining the prevalence of

How to cite this article: Williams RA, Rose AM, Bruno RS, Hanks AS, Kennel JA, McDonald JD, *et al*. Examination of the relationship of diet quality with cardiometabolic risk factors in apparently healthy college students. J Edu Health Promot 2019;8:148.

cardiometabolic abnormalities in relation to diet will be a critical step in the development of strategies to mitigate the risk for future development of cardiometabolic disease in this nutritionally vulnerable population. Thus, the objective of this study was to determine the prevalence of cardiometabolic abnormalities in apparently healthy college students and the relationship of diet quality with risk for adverse cardiometabolic health.

Methods

Participants and ethical considerations

Participants were undergraduates at a large Midwestern University. Students who had previously taken part in a social marketing dairy campaign on the same campus during the 2014 fall semester were eligible to participate in an additional research opportunity. An invitation was sent through E-mail, and students were instructed to contact the study personnel to receive further information. Students who expressed an interest in taking part in this study met with study staff and who reviewed procedures before individuals provided written informed consent. Participants received a $20 Amazon gift card for taking part in the study. All study procedures were approved by the Institutional Review Board at the Ohio State University.

Measurements

Demographic information (e.g., gender, race/ethnicity, age, and class rank) reported through online survey during baseline data collection for the social marketing campaign (October 2014) was used.[10] Anthropometric, clinical, biochemical, and dietary data were collected by trained staff and assistants (i.e., graduate and undergraduate students) in April 2015. Measurements were collected in a fasted state (10–12 h).

Anthropometric measurements

Height, weight, and waist circumference were collected in duplicate with participants wearing light clothing and no shoes.[11] Height was measured to the nearest 0.1 cm using a stadiometer (Hopkins Road Rod® Portable Stadiometer; Caledonia, Michigan). Weight was measured to the nearest 0.1 kg using a digital scale (BFHA-B400SV Balance from digital scale; Tokyo, Japan). Measured height and weight were used to calculate body mass index (BMI). Waist circumference was measured at the top of the iliac crest to the nearest 0.1 cm using a body circumference tape measure.

Biochemical and clinical measurements

Venous blood samples were collected from the antecubital vein with single stick 20-G butterfly needles into 10 mL vacutainer tubes coated with lithium heparin. Plasma was obtained by centrifugation (1500 × *g*, 15 min, 4°C), aliquoted into cryovials, and snap-frozen in liquid nitrogen. All samples were stored at −80°C until analysis. Total cholesterol, High-density lipoprotein-cholesterol (HDL-C), triglyceride, and glucose were measured using spectrophotometric clinical assay kits (pointe scientific) and insulin by ELISA (Alpco Diagnostics, # 80-INSHU-E01.1) according to the manufacturer's specifications. Glycated hemoglobin was measured with an Alere Afinion AS100 Analyzer. Blood pressure was measured in triplicate using an automated blood pressure cuff (Panasonic EW3109W; Secaucus, New Jersey), once participants were rested in a seated position. Blood pressure measurements that deviated by >25% from the other two measurements were considered outliers and not used.

Dietary collection and diet quality assessment

Dietary intake (1 day) was obtained using an adapted group 24-h recall.[12] Portion size estimation was collected with the USDA Food Models for Estimating Portions during dietary collection.[13] Dietary data were subsequently converted to measurable portions with the accompanying USDA instructional booklet[13] and entered into the Nutrition Data System for Research software (2015) developed by the University of Minnesota Nutrition Coordinating Center. Diet quality was assessed using the Healthy Eating Index-2010 (HEI), a validated measure of dietary compliance with the Dietary Guidelines for Americans.[14] The HEI-2010 consists of 12 components (nine reflecting adequate intakes and three representing moderate intakes) that sum to provide a total HEI score ranging from 0 to 100 points.[15] According to previously described standards, a total HEI score >80 implies a "good" diet, a score of 51–80 reflects a diet that "needs improving," and a score <51 indicates a "poor" diet.[16]

Metabolic syndrome classification

MetS was determined based on individuals displaying at least three of the following five established criteria as follows:[17] (1) low HDL-C (<40 mg/dL in males, <50 mg/dL in females), (2) elevated triglycerides (≥150 mg/dL), (3) elevated fasting glucose (≥100 mg/dL), (4) elevated blood pressure (systolic ≥130 and/or diastolic ≥85 mmHg), and (5) abdominal obesity as measured by waist circumference (≥102 cm in males and ≥88 cm in females).

Statistical analysis

Statistical analysis was performed in Stata v13 (Stata Corp, College Station, TX). Relationships between cardiometabolic outcomes and HEI score were explored using ordinary least squares regression, with cardiometabolic outcomes as the dependent variable and HEI score as the primary factor of interest. Demographic covariates of race, age, undergraduate rank, gender, and

BMI (except when BMI is the dependent variable) were also included. Baseline variables for the demographic covariates were nonHispanic Caucasian, age 18 or younger, female, and freshman in college. All levels of race, age, and undergraduate rank were kept in the model to see the impact of each level of those factor variables. Nineteen individuals were not included in analyses due to incomplete data (e.g., demographic, cardiometabolic, or dietary data not collected) or age >30 years. Blood pressure could not be collected from one individual. To determine statistical significance, a Bonferroni correction was used to account for the multiple regressions run.

Results

Sample demographics

A total of 147 students completed the study. Participant characteristics are presented in Table 1. Relative to university demographics, a higher proportion of the study participants were female (68.0% vs. 47.7% at university level) and Asian/Pacific Islander (14.3% vs. 5.9% at university level).[18]

Anthropometric, biochemical, clinical, and dietary outcomes

More than half of females (76.0%; n = 76) and males (57.4%; n = 27) had a healthy BMI, and the majority of females (95.0%; n = 95) and males (85.1%; n = 40) were nonobese [Table 2]. Mean values for all biochemical and clinical outcomes fell within normal clinical limits, with the exception of blood pressure in males [Table 2]. However, when examining the data proportionally, a substantial number of individuals had abnormal values [Table 3]. For example, mean fasting glucose levels were normal (females: 93.1 mg/dL; males: 98.6 mg/dL) [Table 2], yet 21.0% of females (n = 21) and 40.4% of males (n = 19) demonstrated elevated fasting glucose (≥100 mg/dL) [Table 3]. In addition, although the mean blood pressure values were within a normal range for females, the mean systolic blood pressure was elevated for males [Table 2] and considered Stage 1 hypertension.[19] The proportion of individuals classified as having at least Stage 1 hypertension (systolic ≥130 and/or diastolic ≥80 mmHg) was high, particularly for males (57.4%; n = 27) and females (30.0%; n = 30).

The mean total HEI score (out of 100) was 56.1 ± 16.1 for females and 53.2 ± 15.0 for males [Table 4]. A high proportion of students received a score of zero for total fruit (29.3%; n = 43), whole fruit (34.0%; n = 50), greens and beans (53.7%; n = 79), whole grains (27.9%; n = 41), seafood and plant proteins (45.6%; n = 67), refined grains (21.1%; n = 31), and sodium (21.1%; n = 31). Furthermore, comparison of total HEI scores to previously described standards yielded the following: 39.5% (n = 58) consumed a "poor" diet, 53.7% (n = 79) consumed a diet that "needs improving," and 6.8% (n = 10) consumed a "good" diet.[16]

Table 1: Participant characteristics

Characteristic	Female (n=100), %	Male (n=47), %
Race/ethnicity		
Caucasian	79.0	63.8
African American	3.0	2.1
Hispanic	4.0	14.9
Asian/Pacific Islander	12.0	19.2
Native American	2.0	0.0
Age		
<18	14.0	14.9
19-20	49.0	38.3
21-22	30.0	29.8
23-25	6.0	12.8
25-30	1.0	4.2
Class rank		
Freshman	20.0	19.1
Sophomore	24.0	19.2
Junior	22.0	25.5
Senior	34.0	36.2

Table 2: Anthropometric, biochemical, and clinical outcomes of participants

Outcome	Females (n=100)	Males (n=47)
Anthropometrics		
Height (m), mean±SD	1.7±0.1	1.8±0.1
Weight (kg), mean±SD	64.1±12.9	79.7±13.1
Waist circumference (cm), mean±SD	81.6±9.9	90.0±9.9
BMI (kg/m^2), mean±SD	23.2±4.5	25.5±3.9
<18.5, %	3.0	0.0
18.5-24.9, %	76.0	57.4
25.0-29.9, %	16.0	27.7
≥30, %	5.0	14.9
Biochemical		
Total cholesterol (mg/dL)	181.8±31.8	175.6±31.1
HDL-C (mg/dL)	53.1±12.6	43.2±9.8
Triglyceride (mg/dL)	65.5±27.0	70.6±48.0
Glucose (mg/dL)	93.1±9.0	98.6±11.4
Insulin (uIU/mL)	6.5±5.0	6.5±5.3
HOMA-IR	1.5±1.2	1.6±1.4
HbA1c (%)	5.4±0.2	5.4±0.3
Clinical		
Systolic blood pressure (mmHg)	119.4±9.8	130.2±9.8
Diastolic blood pressure (mmHg)	74.2±7.9	79.0±8.7

SD=Standard deviation, BMI=Body mass index, HDL-C=High density lipoprotein-cholesterol, HbA1c=Glycated hemoglobin, HOMA-IR=Homeostatic Model Assessment of Insulin Resistance

Metabolic syndrome prevalence

Among females, low-HDL-C was the most common MetS criterion met (47.0%; n = 47) and for males, it was elevated blood pressure (51.1%; n = 24) [Table 3]. A large proportion of females (71.0%; n = 71) and males (80.9%; n = 38) presented with one or more MetS criteria, and

Table 3: Prevalence of metabolic syndrome*

Outcome	Females (*n*=100), %	Males (*n*=47), %
Elevated waist circumference	21.0	8.5
Low HDL-C	47.0	36.2
Elevated triglycerides	0.0	4.3
Elevated fasting glucose	21.0	40.4
Elevated blood pressure	17.2	51.1
Number of MetS criteria		
None	29.0	19.1
1	43.0	36.2
2	21.0	29.8
3 or more	7.0	14.9

*Based on NHLBI cut points: Elevated waist circumference (≥102 cm in males, ≥88 cm in females); low HDL-C (<40 mg/dL in males, <50 mg/dL in females); elevated triglycerides (≥150 mg/dL); elevated fasting glucose (≥100 mg/dL); elevated blood pressure (systolic ≥130 and/or diastolic ≥85 mmHg). NHLBI=National Heart, Lung, and Blood Institute, HDL-C=High density lipoprotein-cholesterol, MetS=Metabolic syndrome

Table 4: Dietary Healthy Eating Index (HEI) scores of participants*

HEI Component	Mean±SD	
	Females (*n*=100)	Males (*n*=47)
Total fruit	2.6±2.0	1.6±2.0
Whole fruit	2.9±2.2	1.9±2.1
Total vegetable	2.9±1.7	2.7±1.8
Greens and beans	1.8±2.3	2.0±2.2
Total protein foods	4.0±1.6	4.4±1.3
Seafood and plant proteins	2.7±2.4	1.8±1.3
Whole grains	4.3±3.7	3.5±3.9
Dairy	6.0±3.3	6.0±3.6
Fatty acids	4.6±3.8	5.1±3.7
Refined grains	5.5±4.0	4.3±3.8
Sodium	3.9±3.5	4.4±3.0
Empty calories	15.0±5.1	15.4±4.1
Total score	56.1±16.1	53.2±15.0

*Maximum HEI scores are the following: 5 for total fruit, whole fruit, total vegetable, greens and beans, total protein foods, and seafood and plant proteins; 10 for whole grains, dairy, fatty acids, refined grains, and sodium; 20 for empty calories; and 100 for total score. SD=Standard deviation, HEI=Healthy Eating Index

7.0% of females (n = 7) and 14.9% of males (n = 7) had three or more [Table 3].

Relationship of cardiometabolic risk factors to dietary intake

There was no relationship between diet quality (HEI-2010) (total score or individual components) and cardiometabolic health outcomes.

Discussion

In light of the emerging evidence demonstrating that apparently healthy nonobese young adults, specifically college students, are at risk for having one or more MetS criteria; the main objective of this study was to investigate the prevalence of cardiometabolic abnormalities in apparently healthy college students. Consistent with our hypothesis, a high percentage of individuals (71.0% of females and 80.9% of males; 74% overall) met at least one of the MetS criteria.

This is higher than the 30%–60% overall reported in the previous studies.[7,8,20-25] Differences in rates across studies may be partially due to environmental factors (e.g., country of residence).[21,22,24] Regardless, findings point to the need for intervention, which will require an understanding of the underlying causal factors (behavioral, environmental, and biological).

Given the contribution of diet to cardiometabolic health, and the data demonstrating poor dietary patterns among college students, and another objective of this study was to examine the relationship between diet quality and risk for cardiometabolic abnormalities. Contrary to our hypothesis, there was a lack of association between cardiometabolic risk and diet quality among this college student population. Despite students' mean HEI scores being consistent with the general U.S. population average of 57.8 or the "needs improvement" category,[25] neither HEI-2010 score nor total or individual components were related to cardiometabolic risk factors or MetS occurrence. In contrast, others have found these outcomes inversely related to total HEI-2005 scores.[26] Current guidance for the prevention and treatment of MetS recommends weight loss through physical activity and an energy-restricted diet.[27] Although the strength of the evidence varies, plant-based diets, following a Mediterranean diet, replacing other fats with olive oil, and moderate alcohol intake may contribute to the prevention of MetS.[27] When considering the relationship of total HEI score and cardiometabolic risk, it is important to note that quite different diets can achieve the same composite score,[26] which could ultimately impact findings. In addition, HEI scores are conventionally calculated from three 24-h recalls – taken over 2 week days and 1 weekend day. In this study, only one 24-h recall was recorded. This deviation may also explain the lack of correlation between diet and cardiometabolic risk factors.

Low-HDL-C was the most common MetS criterion present in females (47%) and the third-most common criterion present in males (36%). In previous studies, low-HDL-C has frequently been the most (or second most) common MetS criterion met.[7,8,21-23,28-30] Among males, elevated blood pressure was the most common MetS criterion (51%), compared to 17% of females. Despite these sex differences, the higher rate of increased blood pressure occurred without any difference by gender for HEI. Although dietary interventions for the various MetS criteria differ, it is well understood that adherence to the western style diet (red meat, processed foods, refined grains, sugars, and saturated fatty acids) is a risk factor for MetS.[27] Data from the dietary recall in our study show a high consumption of refined grains, fatty acids, empty calories, and sodium, consistent with that of a western style diet. Together, the presence of western style diet characteristics and a large proportion of individuals meeting one or more MetS criteria support the need for continued monitoring and implementation of early interventions that can lower cardiovascular disease risk.

Due to the cross-sectional nature of this work, merely a snapshot of an individual's health progression was taken. Individuals who were overweight could have been losing weight and improving their cardiometabolic profile, while normal weight individuals may have been on a trajectory of weight gain, thus worsening their cardiometabolic profile. This lack of knowledge makes it challenging to relate diet to cardiometabolic outcomes with certainty and reinforces the role for prospective studies that monitor dietary intake along with biochemical and clinical outcomes and MetS risk.

Being overweight or obese increases the likelihood of developing cardiometabolic abnormalities,[31] yet nearly three-quarters of students in the current study presented with one or more risk factors for MetS, even though 76.0% of females and 57.4% of males were classified as having a normal weight status. Weight status alone, however, does not confer risk, as some obese persons are metabolically healthy.[32] Furthermore, even in normal weight individuals, percent total body fat, and the presence of visceral adipose tissue influences the risk of experiencing cardiometabolic impairments.[5,6] These findings suggest that it may be important to consider the measurement of body fat percent in screening for cardiometabolic abnormalities in apparently healthy adults. Collection of fitness and physical activity data could also provide insight into why weight status and cardiometabolic abnormalities are not universally directly related.

Strengths and limitations

The main strength of the present study is its examination of the link between dietary data and biochemical parameters of cardiometabolic health. Most of the previous MetS research has focused on biochemical and clinical data without measurement of dietary intake. The main limitation of the current study is reliance on a convenience sample of college students who had previously taken part in a campus-wide social media campaign and thus, the generalizability of findings is limited. In addition, because we collected only one 24-h dietary recall in a group setting (vs. the standard protocol of 2–3 weekdays and 1 weekend day), it is possible that participants' dietary intakes do not represent their usual intake.

Conclusions

We demonstrated that apparently healthy nonobese college students are at risk for having cardiometabolic abnormalities and poor diet quality, yet there was no relationship of diet with health outcomes. Results from this study point to the urgent need for the development of screening and lifestyle behavioral modification interventions to mitigate risk for the onset of future chronic illness. Future intervention development efforts may benefit from reliance on concepts from the Health Belief Model, which posits that a person's likelihood of action is based in part on their self-perceived susceptibility and severity of the disease, and has shown success in addressing other health issues in the college student population (e.g., the use of condoms in reducing the risk of sexually-transmitted diseases).[33] Furthermore, given the differences in the most commonly observed MetS criterion between females and males, tailoring of intervention strategies should be considered. Finally, because of the conflicting data in the broader literature associating a healthy dietary intake with reduced risk for poor cardiometabolic health, future research would benefit from continued examination of the contributions of diet to disease risk using more rigorous research methods in diet assessment (i.e., 3 vs. 1 day 24-h dietary recalls) along with study designs that taken into consideration when the establishment of dietary habits occurs (e.g., in adolescence vs. young adulthood).

Acknowledgments

We would like to thank the Ohio State University Food Innovation Center for funding the study.

Financial support and sponsorship

This study was financially supported by Ohio State University Food Innovation Center.

Conflicts of interest

There are no conflicts of interest.

References

1. Ogden CL, Carroll MD, Kit BK, Flegal KM. Prevalence of childhood and adult obesity in the United States, 2011-2012. JAMA 2014;311:806-14.
2. Ogden CL, Carroll MD, Kit BK, Flegal KM. Prevalence of obesity and trends in body mass index among US children and adolescents, 1999-2010. JAMA 2012;307:483-90.
3. American College Health Association. National College Health Assessment II: Undergraduate Student Reference Group Executive Summary Fall 2016. Hanover, MD: American College Health Association; 2017.
4. O'Neill S, O'Driscoll L. Metabolic syndrome: A closer look at the growing epidemic and its associated pathologies. Obes Rev 2015;16:1-2.
5. Shea JL, King MT, Yi Y, Gulliver W, Sun G. Body fat percentage is associated with cardiometabolic dysregulation in BMI-defined

normal weight subjects. Nutr Metab Cardiovasc Dis 2012;22:741-7.

6. De Larochellière E, Côté J, Gilbert G, Bibeau K, Ross MK, Dion-Roy V, *et al.* Visceral/epicardial adiposity in nonobese and apparently healthy young adults: Association with the cardiometabolic profile. Atherosclerosis 2014;234:23-9.
7. Morrell JS, Byrd-Bredbenner C, Quick V, Olfert M, Dent A, Carey GB, *et al.* Metabolic syndrome: Comparison of prevalence in young adults at 3 land-grant universities. J Am Coll Health 2014;62:1-9.
8. Dalleck LC, Kjelland EM. The prevalence of metabolic syndrome and metabolic syndrome risk factors in college-aged students. Am J Health Promot 2012;27:37-42.
9. Van Duyn MA, Pivonka E. Overview of the health benefits of fruit and vegetable consumption for the dietetics professional: Selected literature. J Am Diet Assoc 2000;100:1511-21.
10. Rose AM, Williams RA, Rengers B, Kennel JA, Gunther C. Determining attitudinal and behavioral factors concerning milk and dairy intake and their association with calcium intake in college students. Nutr Res Pract 2018;12:143-8.
11. National Health and Nutrition Examination Survey. Anthropometry Procedures Manual, 2007. Centers for Disease Control and Prevention; 2007.
12. Scott A, Reed D, Kubena K, McIntosh W. Evaluation of a group administered 24-hour recall method for dietary assessment. J Ext 2007;45.
13. Using the USDA Food Models for Estimating Portions, 2007. US Department of Agriculture, Agricultural Research Service, Beltsville Human Nutrition Research Center, Food Surveys Research Group; 2007.
14. Guenther PM, Kirkpatrick SI, Reedy J, Krebs-Smith SM, Buckman DW, Dodd KW, *et al.* 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;144:399-407.
15. Guenther PM, Casavale KO, Reedy J, Kirkpatrick SI, Hiza HA, Kuczynski KJ, *et al.* Update of the healthy eating index: HEI-2010. J Acad Nutr Diet 2013;113:569-80.
16. Basiotis P, Carlson A, Gerrior S, Juan W, Lino M. The Healthy Eating Index: 1999-2000. U.S. Department of Agriculture, Center for Nutrition Policy and Promotion; CNPP-12; 2002.
17. Alberti KG, Eckel RH, Grundy SM, Zimmet PZ, Cleeman JI, Donato KA, *et al.* Harmonizing the metabolic syndrome: A joint interim statement of the International Diabetes Federation Task Force on Epidemiology and Prevention; National Heart, Lung, and Blood Institute; American Heart Association; World Heart Federation; International Atherosclerosis Society; and International Association for the Study Of Obesity. Circulation 2009;120:1640-5.
18. The Ohio State University Highlights of Fifteenth Day Enrollment for the Spring Term; 2015. http://oesar.osu.edu/student_enrollment.aspx.
19. Whelton PK, Carey RM, Aronow WS, Casey DE Jr., Collins KJ, Dennison Himmelfarb C, *et al.* 2017 ACC/AHA/AAPA/ABC/ACPM/AGS/APhA/ASH/ASPC/NMA/PCNA guideline for the prevention, detection, evaluation, and management of high blood pressure in adults: Executive summary: A report of the American College of Cardiology/American Heart Association task force on clinical practice guidelines. Hypertension 2018;71:1269-324.
20. Morrell JS, Cook SB, Carey GB. Cardiovascular fitness, activity, and metabolic syndrome among college men and women. Metab Syndr Relat Disord 2013;11:370-6.
21. Al Dhaheri AS, Mohamad MN, Jarrar AH, Ohuma EO, Ismail LC, Al Meqbaali FT, *et al.* A cross-sectional study of the prevalence of metabolic syndrome among young female emirati adults. PLoS One 2016;11:e0159378.
22. Martínez-Torres J, Correa-Bautista JE, González-Ruíz K, Vivas A, Triana-Reina HR, Prieto-Benavidez DH, *et al.* A cross-sectional study of the prevalence of metabolic syndrome and associated factors in Colombian collegiate students: The FUPRECOL-adults study. Int J Environ Res Public Health 2017;14. pii: E233.
23. Fernandes J, Lofgren IE. Prevalence of metabolic syndrome and individual criteria in college students. J Am Coll Health 2011;59:313-21.
24. de Freitas RW Jr., de Araújo MF, Marinho NB, de Vasconcelos HC, Lima AC, Pereira DC, *et al.* Prevalence of the metabolic syndrome and its individual components in Brazilian college students. J Clin Nurs 2013;22:1291-8.
25. Dietary Guidelines for Americans. 8th ed. US Department of Health and Human Services and US Department of Agriculture; 2015-2020.
26. Nicklas TA, O'Neil CE, Fulgoni VL 3rd. Diet quality is inversely related to cardiovascular risk factors in adults. J Nutr 2012;142:2112-8.
27. Pérez-Martínez P, Mikhailidis DP, Athyros VG, Bullo M, Couture P, Covas MI, *et al.* Lifestyle recommendations for the prevention and management of metabolic syndrome: An international panel recommendation. Nutr Rev 2017;75:307-26.
28. Huang TT, Shimel A, Lee RE, Delancey W, Strother ML. Metabolic risks among college students: Prevalence and gender differences. Metab Syndr Relat Disord 2007;5:365-72.
29. Yahia N, Brown CA, Snyder E, Cumper S, Langolf A, Trayer C, *et al.* Prevalence of metabolic syndrome and its individual components among midwestern university students. J Community Health 2017;42:674-87.
30. Topè AM, Rogers PF. Metabolic syndrome among students attending a historically black college: Prevalence and gender differences. Diabetol Metab Syndr 2013;5:2.
31. Fonseca VA. The metabolic syndrome, hyperlipidemia, and insulin resistance. Clin Cornerstone 2005;7:61-72.
32. Schulze MB. Metabolic health in normal-weight and obese individuals. Diabetologia 2019;62:558-66.
33. Glanz K, Rimer BK, Viswanath K. Health Behavior and Health Education Theory, Research, and Practice. 4th ed. San Francisco, CA: Wiley & Sons; 2002.