Eating and Weight Disorders - Studies on Anorexia, Bulimia and Obesity (2020) 25:481–486
https://doi.org/10.1007/s40519-018-0626-7

ORIGINAL ARTICLE

Unhealthy lifestyle and oxidative damage in childhood obesity

Rachele De Giuseppe[1] · Valeria Calcaterra[2,3] · Ginevra Biino[4] · Matteo Manuelli[1] · Noelia Rodriguez Mier[1,5] · Melissa Mantelli[6] · Maria De Filippo[2,3] · Gianguido Cossellu[7] · Hellas Cena[1,8]

Received: 12 August 2018 / Accepted: 8 December 2018 / Published online: 15 December 2018

Abstract

Purpose Oxidized LDL cholesterol (oxLDL) has been considered as a sensor of oxidative stress (OS) in childhood obesity. We integrated and related our oxLDL existing results previously assessed in overweight/obese children to lifestyle variables to investigate OS-related lifestyle variables.

Methods 178 Caucasian children/adolescents have been evaluated and according to BMI percentiles have been classified as normal weight (BMI < 75th); overweight (BMI 75–97th) and obese (BMI > 97th). Serum oxLDL levels have been measured. The dietary habits and physical activity have been also assessed.

Results No differences between normal weight and overweight/obese children were detected according to the total score of dietary habits section. Normal weight subjects reported a higher total physical activity score ($p = 0.001$) compared to overweight/ obese children. No correlation between oxLDL and total dietary habits and physical activity scores was noted. Increased oxLDL in subjects drinking < 1 L/day of water ($p = 0.022$) and in daily consumers of chocolate drinks at breakfast ($p = 0.029$) was observed, while a decreased oxLDL was reported in subjects consuming a breakfast based mainly on fruits ($p = 0.004$). Moreover, "high-fat diet" and "always eating a dessert at the end of the meal" were correlated with increased oxLDL with a trend towards significance. As regards physical activity, no correlations were observed.

Conclusions Diet and physical activity may not have an immediate impact on OS response in children with or without obesity. Unhealthy lifestyle, including increased fat, simple sugar intake, poor water intake, emerged as external exposome predictors of OS, that may be monitored to improve health status.

Level of evidence Level III, case-control analytic studies.

Keywords Childhood obesity · Dietary habits · Physical activity · Unhealthy lifestyle · Oxidative damage

✉ Valeria Calcaterra
v.calcaterra@smatteo.pv.it

[1] Dietetics and Clinical Nutrition Laboratory, Department of Public Health, Experimental and Forensic Medicine, University of Pavia, Pavia, Italy

[2] Department of Maternal and Children's Health, Pediatric Endocrinology Unit, Fondazione IRCCS Policlinico S. Matteo, P.le Golgi n.2, 27100 Pavia, Italy

[3] Department of Internal Medicine, University of Pavia, Pavia, Italy

[4] Institute of Molecular Genetics, National Research Council of Italy, Pavia, Italy

[5] KU Leuven, Leuven, Belgium

[6] Immunology and Transplantation Laboratory/Cell Factory/Pediatric Hematology/Oncology Department, Fondazione IRCCS Policlinico S. Matteo, Pavia, Italy

[7] Department of Biomedical, Surgical and Dental Sciences, University of Milan, Fondazione IRCCS Ca' Granda, Ospedale Maggiore Policlinico, Milano, Italy

[8] Clinical Nutrition and Dietetics Service, Unit of Internal Medicine and Endocrinology, ICS Maugeri IRCCS, University of Pavia, Pavia, Italy

Background

Obesity in childhood is a strong predictor of adult obesity with health and economic consequences for both the individual and the society [1].

Obesity-related oxidative stress (OS) has been linked to metabolic and cardiovascular disease [2, 3], although this association remains elusive especially in childhood [4, 5].

Recently, we analyzed the relation between circulating oxidized LDL cholesterol (oxLDL) and metabolic syndrome (MetS) in a pediatric population, to define whether plasma oxLDL levels were correlated to obesity and whether oxidative damage, evaluated by assessing oxLDL levels, was associated with MetS [6]. We demonstrated that overweight and obese children showed significantly higher oxLDL levels when compared to normal weight children [6]. Additionally, we found a correlation between oxLDL levels and increased waist/height ratio (WHeR, visceral adiposity marker) in obese children suggesting that oxidative damage was correlated with a hypertriglyceridemic waist phenotype and could be a precocious marker of MetS and thus cardiometabolic risk in obese children [6].

Based on our preliminary findings [6] and considering oxLDL as a sensor of OS in childhood obesity, according to the European Food Safety Authority Panel on Dietetic Products, Nutrition and Allergies [7], in this ancillary short communication, we integrated and related our oxLDL existing results to lifestyle variables of our pediatric population to investigate OS-related lifestyle variable with the purpose to prevent oxidative damage in children affected by overweight/obesity.

Methods

Subjects

This ancillary study, referred to a pediatric population, previously described by Calcaterra et al. [6]. Briefly, 178 Caucasian children and adolescents aged 11.8 ± 2.6 years (88 females and 90 males) were evaluated and classified as normal weight, affected by overweight and obesity, according to age–sex percentiles curves of body mass index (BMI) proposed by Cole [8] (BMI < 75th percentile; BMI 75–97th percentile; BMI > 97th percentile, respectively).

Lifestyle variables assessment

Lifestyle variables collection are recorded at the time of oxLDL analysis [6]. We assessed dietary habits and physical activity using two sections of a previously published questionnaire [9]. Each section consisted of questions (14 questions for dietary habits and 5 questions for physical activity) with the following response categories: always, often, sometimes, never. The score assigned to each response ranged from 0 to 3, with the maximum score assigned to the healthiest one and the minimum score to the least healthy questionnaire [9].

The dietary habits section was designed to investigate the food habits such as breakfast consumption, daily water assumption, daily number of meals, and consumption of fruit, vegetables, and soft drinks or alcoholic beverages [9].

Concerning physical activity, answers were structured to quantify the time spent weekly in physical activity, to investigate the activities spent during the free time (such as walking, watching TV, listening to music, using the computer, reading a book, practicing a sport and shopping), and to quantify the hours spent daily on the computer or in watching TV [9].

This study was conducted according to the Good Clinical Practice guidelines and was approved by the Human Ethics Committee of Fondazione IRCCS Policlinico S. Matteo of Pavia (Protocol number: 20150005231). The informed written consent of a parent or legal guardian was required for subjects aged < 18, and the subjects aged ≥ 8 were asked to give their written assent. Patients' parents and patients > 8 years gave their written consent to data publication. Ethics Committee also approved data publication.

Statistical analysis

Data quality control and statistical analyses were performed using STATA 11 (StataCorp, College Station, TX, USA). Descriptive statistics representing means and standard error concerning oxLDL levels were computed. A multiple regression analysis was applied to evaluate the association between serum oxLDL levels and total dietary habits and physical activity scores, taking into account the effect of age, sex, BMI and WHeR as possible confounders.

The analysis of variance (ANOVA) was used to verify patients' characteristics regarding dietary habits and physical activity level.

Results

As previously reported [6], based on the BMI percentiles threshold, 49 of the 178 patients (27.5%) were normal weight, 76 (42.7%) were affected by overweight and 53 (29.8%) were affected by obesity and children with obesity showed higher serum oxLDL levels compared to normal weight and children affected by overweight ($p < 0.05$).

Considering the total score of dietary habits section, ANOVA analysis reported no significant differences between

normal weight children and those affected by either overweight or obesity (Fig. 1a; Table 1).

The worst eating habits were skipping breakfast (about 20% of the sample); 30% did not drink milk or yogurt at breakfast; most subjects did not eat at least two portions of fruit and vegetables every day (80%). In 25% of the sample, consumption of cakes and sweets was too high, always eating a dessert at the end of the meal. Data showed inadequate water consumption (< 1 L/day) in one-third of the sample, with no differences according to BMI nor gender.

Normal weight children reported a significantly higher total physical activity score ($p = 0.001$) when compared to those of children affected by overweight and obesity (Fig. 1b; Table 1). Since multiple regression analysis reported no correlation between serum oxLDL levels and the total dietary habits and physical activity scores ($p = 0.73$, $r = -0.022$ and $p = 0.62$, $r = -0.07$, respectively), we analyzed the influence of each item of both sections on oxidative damage. BMI-adjusted ANOVA analysis reported significantly increased serum oxLDL levels only in subjects drinking < 1 L/day of water (64.0 ± 5.1 U/L; $p = 0.022$) in daily consumers of chocolate drinks at breakfast (88.5 ± 16.1; p value = 0.029) and significantly decreased oxLDL levels in subjects consuming a breakfast based mainly on fruits (48.5 ± 16.7; $p = 0.004$) (Tables 1, 2; Figs. 1a–c, 2). Moreover, as shown in Fig. 1d, e, "high-fat diet" and "always eating a dessert at the end of the meal" were correlated with increased serum oxLDL levels with a trend toward significance (Table 1). As regards physical activity, no correlations were reported.

Discussion

The prevalence of obesity in European and adolescents has increased at an alarming rate, becoming a major public health concern. The determinants for overweight and obesity include unhealthy lifestyle, environmental, familial and societal factors, widely accepted as primary driving forces behind the disease process of, among others, MetS [10].

In this ancillary short communication, we integrated and related our oxLDL existing results previously assessed in children affected by overweight/obesity [6] to lifestyle variables to investigate OS-related lifestyle variables.

Normal weight children and those affected by either overweight or obesity did not differ significantly in dietary habits

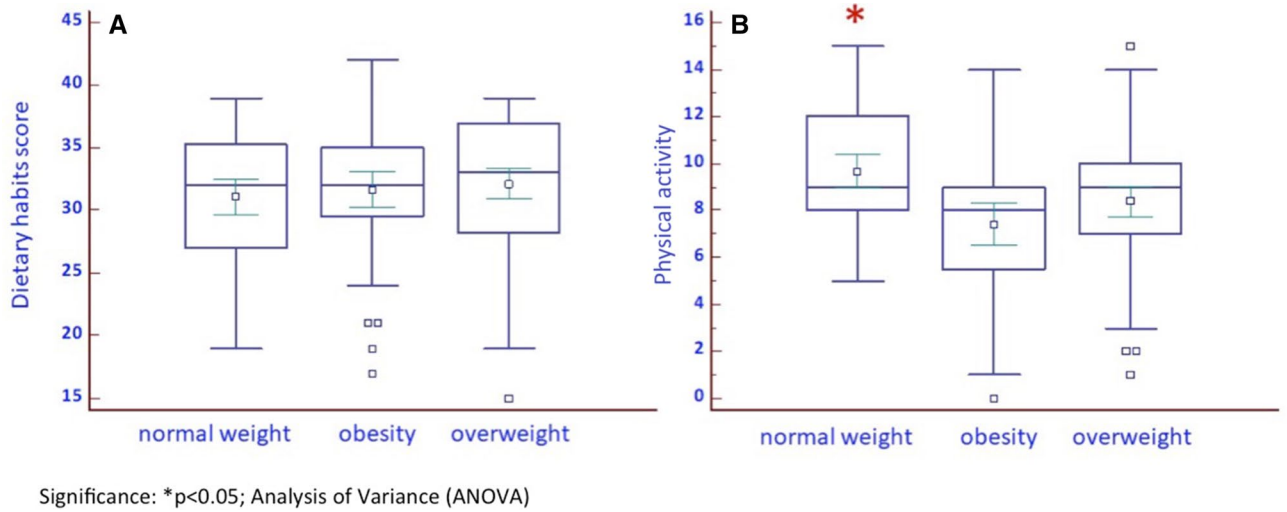

Fig. 1 Box and whisker plots of dietary habits (**a**) and physical activity (**b**) scores in the study population. Data are reported as means (error bars: 95% confidence interval for mean)

Table 1 Total dietary habits and physical activity score among study population

Score	Normal weight (*n*)		Overweight (*n*)		Obesity (*n*)		*p*
	Mean	SE	Mean	SE	Mean	SE	
Dietary habits	31.08	0.70	32.13	0.61	31.63	0.78	n.s
Physical activity	9.67	0.33	8.39	0.34	7.42	0.44	0.001

Significance: $p < 0.05$; analysis of variance (ANOVA)

Data are presented as mean and standard error (SE)

n.s. not significant

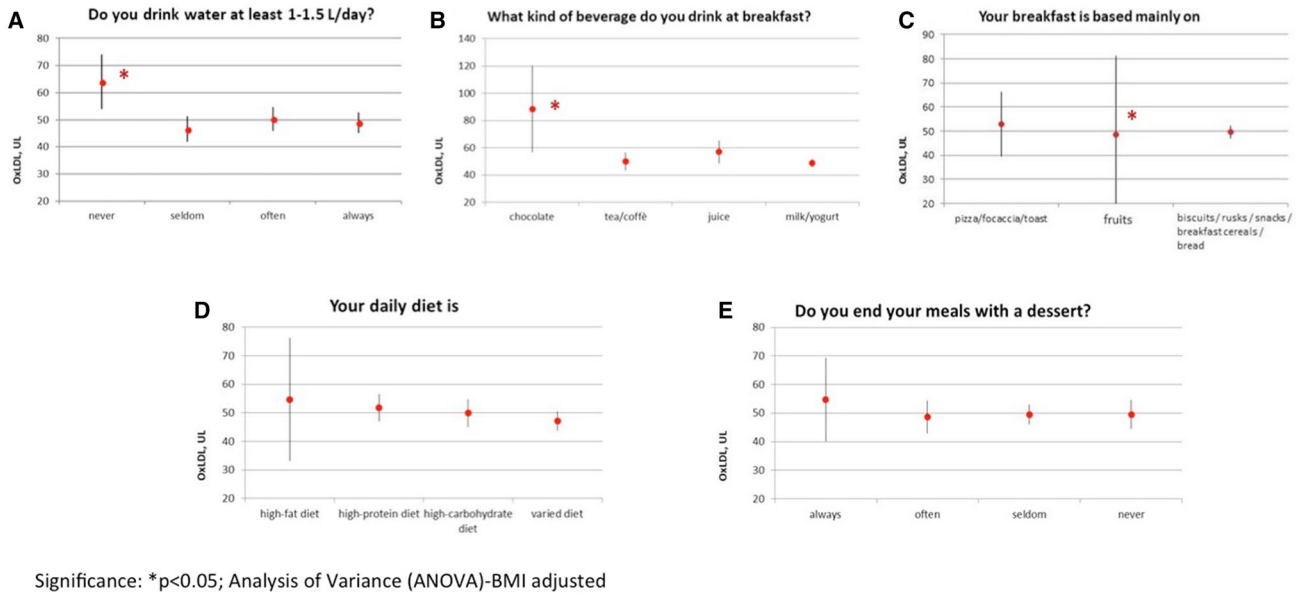

Fig. 2 Estimates of oxLDL levels related to certain items of dietary habits section. Data are presented as mean and standard error (SE)

Table 2 Influence of certain dietary habits on oxLDL levels

Question—answer	oxLDL levels	
	Mean	SE
Do you drink at least 1–1.5L of water in a day?		
Never	64.0	5.1*
Seldom	46.5	2.4
Often	50.3	2.3
Always	48.9	1.9
What kind of beverage do you drink at breakfast?		
Chocolate	88.5	16.1*
Tea/coffee	49.9	3.3
Juice	56.9	4.2
Milk/yogurt	48.7	1.4
Your breakfast is mainly based on		
Pizza/focaccia/toast	52.8	6.8
Fruits	48.5	16.7*
Biscuits/rusks/snacks/breakfast cereals/bread	49.6	1.3
Your daily diet is		
High fat	54.6	10.9
High protein	51.7	2.3
High carbohydrate	49.8	2.4
Varied	47.1	1.6
Do you end your meals with a dessert?		
Always	54.6	7.4
Often	48.7	2.9
Seldom	49.5	1.7
Never	49.5	2.5

Data are presented as mean and standard error (SE)

Significance: *$p < 0.05$; BMI-adjusted analysis of variance (ANOVA)

as previously reported in literature [11]. Thus, eating habits do not show significance differences, despite BMI. On the contrary, normal weight children reported a significantly higher total physical activity score, when compared to those of children affected by overweight and obesity. These findings suggest that physical activity has an important impact on BMI; to be specific, more physical activity is associated with lower BMI scores. Both low sedentary and high exercise activities contribute to increased energy expenditure, improved weight control and prevention of obesity. Exercise, if intensity is at least moderate, has also a positive effect on fat distribution by decreasing the proportion of abdominal and visceral fat [12, 13].

We analyzed the influence of each item of the dietary habits and physical activity scores on oxidative damage, since no correlation was found between serum oxLDL levels and the total scores of both sections.

Results showed significantly increased serum oxLDL levels in subjects drinking < 1 L/day of water. The benefit of water intake lies in the fact that water consumption could replace other caloric beverages and thereby reduce total calories consumed as highlighted in literature [14]. In a recent study, higher consumption of water (ml)/kg per weight was negatively associated with BMI, body fat, waist circumference, insulin levels, HOMA-IR, and positively with HDL cholesterol in children. In addition, overweight and obese children drank less water (ml)/kg per weight than normal weight ones [15].

Results also showed significantly increased OxLDL levels in daily consumers of chocolate drinks. In contrast, Khan et al. [16] found that regular consumption of cocoa powder

with milk reduces oxidized LDL levels in subjects at high risk of cardiovascular disease. A possible explanation for this contradictory finding is that it concerns different study populations and that the chocolate drinks drank by children in this study are not only made of cocoa powder and milk but probably contain a higher amount of sugar and fat.

Moreover, "high-fat diet" (HFD) and "always eating a dessert at the end of the meal" were correlated with increased serum oxLDL levels with a trend towards significance.

Kesh et al. [17] elucidated the mechanistic links between HFD-induced oxidative stress and its impact on metabolic complications development. However, in our study, we were not able to prove a significant association between a "high-fat diet" and increased oxLDL levels. This might be due to our study population. The effects of HFD might only become apparent over a longer time and since we focused on children, the effects may not have been apparent yet. Since it does show a trend towards significance, this might also be due to the small sample size. Therefore, expanding sampling is mandatory.

In a study by Jung et al. [18], the second factor, "always eating a dessert at the end of the meal", was significantly inversely associated with fluorescent oxidation products, a global index of oxidative stress. In our study, this association could not be proven significant. Considering that most desserts are high in sugar and fat and that consuming chocolate drinks every day for breakfast was significantly associated with serum oxLDL levels in this study, we expected to see a significant association between eating desserts and oxLDL levels. Again, this could be due to our small sample size and expanding the sample might reveal a significant association between both factors.

On the contrary, we found significantly decreased oxLDL levels in subjects consuming a breakfast based mainly on fruits. Holt et al. [19] described the beneficial effects of fruit and vegetable intake on markers of inflammation and oxidative stress in adolescents. A variety of fruits and vegetables contain folate and antioxidants, such as vitamin C and beta-carotene. These micronutrients have been related to lower levels of markers of inflammation and oxidative stress. These findings provide support for the dietary guideline to consume five or more servings a day of fruits and vegetables to promote health.

Although our results are consistent with findings suggesting that dietary choices and physical activity may not have an immediate impact on OS response in children with overweight and obesity, unhealthy eating pattern, in particular increased fat and sugar consumption and poor water intake, might be considered as external exposome predictors of OS, that need to be measured repeatedly in certain important life stages, as growth, to improve health status by predicting and preventing disease.

Compliance with ethical standards

Conflict of interest The funding organization(s) played no role in the study design; in the collection, analysis, and interpretation of data; in the writing of the report; or in the decision to submit the report for publication.

Ethical statement This study was conducted according to the Good Clinical Practice guidelines and was approved by the Human Ethic Committees of Fondazione IRCCS Policlinico S. Matteo of Pavia (Protocol number: 20150005231).

Informed consent The informed written consent of a parent or legal guardian was required for subjects aged < 18, and the subjects aged ≥ 8 were asked to give their written assent. Patients' parents and patients > 8 years gave their written consent to data publication. Ethics Committee also approved data publication.

References

1. Nishtar S, Gluckman P, Armstrong T (2016) Ending childhood obesity: a time for action. Lancet 387:825–827. https://doi.org/10.1016/S0140-6736(16)00140-9
2. Ho E, Karimi Galougahi K, Liu CC, Bhindi R, Figtree GA (2013) Biological markers of oxidative stress: applications to cardiovascular research and practice. Redox Biol 1:483–491. https://doi.org/10.1016/j.redox.2013.07.006
3. Yadav UC, Rani V, Deep G, Singh RK, Palle K (2016) Oxidative stress in metabolic disorders: pathogenesis, prevention, and therapeutics. Oxid Med Cell Longev 2016:9137629. https://doi.org/10.1155/2016/9137629
4. Lechuga-Sancho AM, Gallego-Andujar D, Ruiz-Ocaña P, Visiedo FM, Saez-Benito A, Schwarz M, Segundo C, Mateos RM (2018) Obesity induced alterations in redox homeostasis and oxidative stress are present from an early age. PLoS One 13:e0191547. https://doi.org/10.1371/journal.pone.0191547
5. Kilic E, Özer ÖF, Erek Toprak A, Erman H, Torun E, Kesgin Ayhan S, Caglar HG, Selek S, Kocyigit A (2016) Oxidative stress status in childhood obesity: a potential risk predictor. Med Sci Monit 22:3673–3679. https://doi.org/10.12659/MSM.897965
6. Calcaterra V, De Giuseppe R, Biino G, Mantelli M, Marchini S, Bendotti G, Madè A, Avanzini MA, Montalbano C, Cossellu G, Larizza D, Cena H (2017) Relation between circulating oxidized-LDL and metabolic syndrome in children with obesity: the role of hypertriglyceridemic waist phenotype. J Pediatr Endocrinol Metab 30:1257–1263. https://doi.org/10.1515/jpem-2017-0239
7. EFSA Panel on dietetic Products, Nutrition and Allergies (NDA) (2011) Guidance on the scientific requirements for health claims related to antioxidants, oxidative damage and cardiovascular health. EFSA J 9:2474. https://doi.org/10.2903/j.efsa.2018.5136
8. Cole TJ, Lobstein T (2012) Extended international (IOFT) body mass index cut-offs for thinness, overweight and obesity. Pediatr Obes 7:284–294. https://doi.org/10.1111/j.2047-6310.2012.00064.x
9. Turconi G, Celsa M, Rezzani C, Biino G, Sartirana MA, Roggi C (2003) Reliability of a dietary questionnaire on food habits, eating behavior and nutritional knowledge of adolescents. Eur J Clin Nutr 57:753–763. https://doi.org/10.1038/sj.ejcn.1601607
10. Bass R, Eneli I (2015) Severe childhood obesity: an under-recognised and growing health problem. Postgrad Med J 91:639–645. https://doi.org/10.1136/postgradmedj-2014-133033

11. Fonte ML, Casali MP, Roggi C, Turconi G, Cena H (2014) Does physical activity and sport practice lead to a healthier lifestyle and eating habits in male adolescents? J Nutr Health Sci 1:1. https://doi.org/10.15744/2393-9060.1.103
12. Fogelholm M (2008) How physical activity can work? Int J Pediatr Obes 3:10–14. https://doi.org/10.1080/17477160801896481
13. Hills AP, Andersen LB, Byrne NM (2011) Physical activity and obesity in children. Br J Sports Med 45:866–870. https://doi.org/10.1136/bjsports-2011-090199
14. Daniels MC, Popkin BM (2010) Impact of water intake on energy intake and weight status: a systematic review. Nutr Rev 68:505–521. https://doi.org/10.1111/j.1753-4887.2010.00311.x
15. Milla-Tobarra M, García-Hermoso A, Lahoz-García N, Notario-Pacheco B, Lucas-de la Cruz L, Pozuelo-Carrascosa DP, García-Meseguer MJ, Martínez-Vizcaíno V (2016) The association between water intake, body composition and cardiometabolic factors among children: the Cuenca study. Nutr Hosp 33:19–26. https://doi.org/10.20960/nh.312
16. Khan N, Monagas M, Andres-Lacueva C, Casas R, Urpi-Sarda M, Lamuela-Raventos RM, Estruch R (2012) Regular consumption of cocoa powder with milk increases HDL cholesterol and reduces oxidized LDL levels in subjects at high-risk of cardiovascular disease. Nutr Metab Cardiovasc Dis 22:1046–1053. https://doi.org/10.1016/j.numecd.2011.02.001
17. Kesh SB, Sarkar D, Manna K (2016) High-fat diet-induced oxidative stress and its impact on metabolic syndrome: a review. Asian J Pharm Clin Res 9:47–52. https://doi.org/10.1016/j.bbadis.2008.09.006
18. Jung S, Smith-Warner SA, Willett WC, Wang M, Wu T, Jensen M, Eliassen AH (2016) Healthy dietary patterns and oxidative stress as measured by fluorescent oxidation products in nurses' health study. Nutrients 8:587. https://doi.org/10.3390/nu8090587
19. Holt EM, Steffen LM, Moran A, Basu S, Steinberger J, Ross JA, Sinaiko AR (2009) Fruit and vegetable consumption and its relation to markers of inflammation and oxidative stress in adolescents. J Am Diet Assoc 109:414–421. https://doi.org/10.1016/j.jada.2008.11.036