Eat Weight Disord (2017) 22:717–724
DOI 10.1007/s40519-017-0385-x

ORIGINAL ARTICLE

Association of white and red meat consumption with general and abdominal obesity: a cross-sectional study among a population of Iranian military families in 2016

Arasb Dabbagh-Moghadam[1] · Hassan Mozaffari-Khosravi[2] · Morteza Nasiri[3] · Ali Miri[4] · Maliehe Rahdar[5] · Omid Sadeghi[6]

Received: 10 January 2017 / Accepted: 25 March 2017 / Published online: 18 April 2017

Abstract
Purpose To assess the association of red and white meat consumption with general and abdominal obesity among Iranian military families.
Methods In this cross-sectional study, 525 subjects with age range of 19–55 years belong to military families of Army of Islamic Republic of Iran were recruited during 2016. Dietary data were collected using semi-quantitative food-frequency questionnaire. A self-reported questionnaire was used to collect data on demographic characteristics and anthropometric measurements. General obesity was defined as body mass index ≥25 kg/m^2 and abdominal obesity as waist circumference ≥80 cm for women and ≥94 cm for men. Finally, we had complete data on 170 subjects for analysis.
Results Mean age of subjects was 33.78 ± 6.48. We found a significant positive association between red meat consumption and abdominal obesity in fully adjusted model, so that subjects in the fourth quartile had 4.51 more odds to be abdominally obese compared with those in the first quartile of red meat consumption (OR 4.51, 95% CI 1.32–15.40). Such relationship was not seen for general obesity. In addition, white meat consumption was not associated with general and abdominal obesity either before or after adjustment for covariates.
Conclusions Red meat consumption was positively associated with abdominal obesity. No significant relationship was found between white meat consumption, and general and abdominal obesity. Therefore, further studies are needed to shed light our findings.

Keywords Anthropometry · Obesity · Red meat · Diet · Military family · Iran

✉ Omid Sadeghi
omidsadeghi69@yahoo.com

1 Deputy of Health, AJA University of Medical Sciences, Tehran, Iran

2 Department of Nutrition, School of Health, Shahid Sadoughi University of Medical Sciences, Yazd, Iran

3 Department of Operating Room Technology, School of Paramedicine, Qom University of Medical Sciences, Qom, Iran

4 Department of Nutrition, School of Health, Zabol University of Medical Sciences, Zabol, Iran

5 Department of Nursing, School of Nursing and Midwifery, Zabol University of Medical Sciences, Zabol, Iran

6 Department of Community Nutrition, School of Nutritional Sciences and Dietetics, Tehran University of Medical Sciences, Tehran, Iran

Introduction

Obesity is an epidemic problem in all over the world [1] and is associated with greater risk of death and a number of chronic diseases including diabetes mellitus, cardiovascular diseases, and some types of cancer [2–4]. In US, overall age-adjusted prevalence of obesity was reported 37.7% in adults' population from 2013 to 2014 [5]. Recently, the prevalence of obesity is increasing at an alarming rate, especially in Asian countries [1]. Based on the recent National Survey in Iran, the prevalence rate of obesity among adults increased from 12% in 2000 to 22% in 2011 [6]. It was reported that general and abdominal obesity is prevalent in 9.7 and 27.7% of the Iranian adults, respectively [7].

It has been shown that several factors including genetic and environmental factors are involved in the obesity epidemic [8]. It seems that diet, as an environmental factor, has an important role in etiology of obesity [9]. Red meat is one of the important parts of the human diet, which provides high-quality nutrients (zinc, iron, vitamin B_6, protein, and vitamin B_{12}), but that also constitutes a relevant source of cholesterol and saturated fatty acids [10, 11].

Today, several epidemiologic studies have investigated the association of red meat consumption with general and abdominal obesity, but findings in this regard are conflicting [12]. Some studies have indicated a positive association between red meat consumption and obesity [13–17], while others have failed to reach any significant relationships [18, 19]. Most prior studies have mainly focused on red meat, and the association between white meat consumption, and general and abdominal obesity has less been paid attention and results are more contraversial in this regard [20, 21]. Furthermore, earlier studies are mostly done on general population, and few data are available on military population [21]. Most military individuals and their families have different dietary patterns compared to general population [22, 23]. Therefore, it is important to assess the association between dietary intakes and obesity in this population independently. Current study aimed to examine the association of white and red meat consumption with general and abdominal obesity among Iranian military families.

Materials and methods

Subjects and design

This is a cross-sectional study which was done on a population of military families affiliated to Army of Islamic Republic of Iran during 2016. A self-administered questionnaire containing information on demographic characteristics, anthropometric measurements, and dietary intakes was delivered to 525 individuals, aged 19–55 years. Totally 468 subjects gave back the questionnaires, which among those we excluded individuals with missing data ($n=53$) and those who had over-reporting and under-reporting for dietary intakes on the basis of total calorie intake outside the range of 800–4200 kcal/day ($n=245$). Finally, we had complete data on 170 subjects including 85 men and 85 women for the current analysis.

The Bioethics Committee of AJA University of Medical Sciences, Tehran, Iran, approved the study. A written informed consent form was taken from all subjects prior to study enrolment.

Dietary assessment

We assessed the usual dietary intakes of subjects using a 168-item semi-quantitative food-frequency questionnaire (FFQ). This questionnaire contains a list of food items and a standard serving size for each item. At first, subjects were instructed how to fulfil the questionnaire by two trained dietitions, who had more than 5 years' experience for administration of this questionnaire. Then, subjects were asked to report their consumption frequency of each item during the previous year on a daily (e.g., bread), weekly (e.g., rice or meat), monthly (e.g., fish), or yearly basis, and then report the amount of consumption for each time based on serving size. We converted the portion size of consumed foods to grams using household measures. Daily intakes of nutrients for each subjects were calculated using the US Department of Agriculture's (USDA) national nutrient databank [24]. The previous studies have shown that the FFQ provided valid and reliable data on long-term intake of food groups and nutrients [25]. In the current study, we obtained the total red meat consumption by summing up the consumption of all kind of red meat (beef, veal, mutton, and lamb) and visceral meats (lamb's liver, kidney, and heart). Processed meat (sausages, hamburgers, hot dogs) was not considered as red or white meat, because in food industries of Iran, different kinds of meat including red and white meats are used to produce processed meat. To calculate the total white meat consumption, we summed up the consumption of chicken, poultry and fish.

Demographic and anthropometric measurments

Data on age (year), education (high school diploma, below/above high school diploma), smoking status (non-smoker, former smoker, current smoker), and economic status (based on monthly salary of the head of family: 1 million toman or below/above 1 million toman) were collected using a self-reported questionnaire. Subjects with the monthly salary of 1 million toman or below were considered as poor economic status and those with above 1 million toman monthly salary were considered as well-economic status. In addition, a self-reported questionnaire was applied to collect data on weight, height, and waist circumference. Body mass index (BMI) was calculated as weight in kilograms divided by the height in meters squared. We classified subjects into two categories based on their BMI: normal weight ($\leq$24.9 kg/m^2) and overweight or obese ($\geq$25 kg/m^2). Based on waist circumference, abdominal obesity was defined. We considered abdominal overweight and obesity based on criteria reported by Lean et al., and the National Cholesterol Education Program (NCEP), respectively [25, 26]. Subjects were categorized into two groups according to Lean et al., criteria: normal (<80 cm for women, <94 cm for men) and with abdominal obesity ($\geq$80 cm for women and $\geq$94 cm for men).

Statistical analyses

In this study, we first obtained energy-adjusted intakes of red and white meat using the residual method [27]. Then, subjects were categorized by quartiles of energy-adjusted red and white meat consumption. We used one-way analysis of variance (ANOVA) to assess the differences in continuous variable including age and intakes of food groups and nutrients across quartiles of red and white meat consumption. To assess the distribution of subjects in terms of categorical variables across quartiles of red and white meat consumption, we applied the Chi-square test. Binary logistic regression in different models was used to examine the association of red and white meat consumption with general and abdominal obesity. In the first model, age (continuous), gender and energy intake (continuous) were adjusted. In the second or final model, further adjustments were done for education (high school diploma or below/above high school diploma), smoking status (non-smoker, former smoker, and current smoker), and economic status (poor and well). In all analyses, the first quartile of red and white meat consumption was considered as the reference category. To determine the overall trend of odds ratios across increasing quartiles of red and white meat consumption, we considered these quartiles as an ordinal variable in the logistic regression models. All statistical analyses were done with SPSS software (version 19.0; SPSS Inc, Chicago, IL, USA). Significant level was considered as *P* values <0.05.

Results

Mean age of subjects was 33.78 ± 6.48, and 50% were female. Totally, general and abdominal overweight/obesity were prevalent in 50.6 and 53.8% of subjects, respectively. General characteristics of subjects across quartiles of red and white meat consumption are presented in Table 1. Compared with the first quartile, subjects in the fourth quartile of white meat consumption were more likely to be current smoker. No significant differences were observed in age, gender, education, and economic status across quartiles of red and white meat consumption.

Dietary and nutrient intakes of subjects across quartiles of red and white meat consumption are shown in Table 2. Subjects in the top quartile of red meat consumption had higher intakes of fruits, legumes and protein and lower intakes of vegetables, dairy, whole grains, energy, carbohydrate, and dietary fiber compared with those in the bottom quartile. In addition, subjects had significantly different intakes of refined grains, fat, fructose, and folate across categories of red meat consumption. In terms of white meat consumption, compared with the lowest quartile, subjects

Table 1 General characteristics of subjects across quartiles of red and white meat consumption

	Quartiles of red meat consumption					Quartiles of white meat consumption				
	Q1	Q2	Q3	Q4	*P*[a]	Q1	Q2	Q3	Q4	*P*[a]
Age	32.7 ± 5.9	33.7 ± 6.4	34.6 ± 6	33.1 ± 6.4	0.51	33.7 ± 0.9	34 ± 0.8	32.5 ± 0.8	33.9 ± 1.1	0.7
Gender (female) (%)	54.8	47.6	47.6	52.4	0.88	50	45.2	59.5	47.6	0.57
Education (higher than high school diploma) (%)	35.7	28.6	26.2	28.6	0.79	33.3	21.4	33.3	31	0.58
Economic status (well) (%)	42.9	51.2	50	60	0.48	51.2	56.1	48.8	47.6	0.87
Smoking status (current smoker) (%)	7.1	9.5	7.1	0	0.28	14.3	4.8	0	4.8	0.04

Data are presented as mean ± standard deviation (SD) or percent

[a] Obtained from ANOVA or Chi-square test, where appropriate

Table 2 Dietary and nutrient intakes of subjects across quartiles of red and white meat consumption

	Quartiles of red meat consumption					Quartiles of white meat consumption				
	Q1	Q2	Q3	Q4	P^b	Q1	Q2	Q3	Q4	P^b
Food groups (g/day)										
Fruits	341.5 ± 41.5	168.8 ± 23.8	294.6 ± 41.8	293.5 ± 36.1	0.008	277.7 ± 37.4	241 ± 38.5	257.6 ± 37.2	322 ± 37.3	0.46
Vegetables	401.6 ± 52.8	219.8 ± 21.5	286.7 ± 27.6	292 ± 29.3	0.004	305.2 ± 32.9	272.1 ± 29.3	318.6 ± 46.1	304.3 ± 34.4	0.82
Dairy	562.7 ± 74.6	304.5 ± 32.1	546.2 ± 52.5	418.8 ± 32.6	0.001	483.9 ± 61.4	328.9 ± 33.3	438.3 ± 43	581 ± 63	0.008
Red meat						50.2 ± 8.5	27 ± 4.2	49.1 ± 6.4	56.6 ± 8.9	0.02
Processed meat	5.1 ± 0.9	4.6 ± 0.7	6.6 ± 3.1	3.8 ± 0.6	0.72	3 ± 0.5	2.4 ± 0.3	5.9 ± 0.8	8.9 ± 3.1	0.02
White meat	22.5 ± 2.6	17.9 ± 2.4	31.8 ± 3.8	33.7 ± 4.7	0.005					
Legumes	42.3 ± 7	28.9 ± 3.5	37.7 ± 5.9	67.3 ± 7.7	<0.001	40.2 ± 6.2	38.2 ± 5.2	43.7 ± 5.6	54 ± 8.6	0.33
Nuts	13.3 ± 3.4	7.1 ± 1.6	6.9 ± 0.9	7.7 ± 0.9	0.08	12.5 ± 3.4	7.1 ± 1.6	7.7 ± 1	7.7 ± 1.1	0.22
Whole grains	114.3 ± 23.1	48 ± 5	56.5 ± 6.8	76.8 ± 12.8	0.005	96.9 ± 17.2	76.1 ± 18.7	70.5 ± 10	52.1 ± 7.8	0.17
Refined grains	345.2 ± 30.4	428.5 ± 43.4	299.9 ± 16.9	337.1 ± 26.7	0.02	440.2 ± 48	312.2 ± 22.8	339.2 ± 19.3	319.1 ± 23.9	0.01
Nutrients										
Energy (Kcal/day)[a]	2617.8 ± 88	1973.3 ± 93	2256.5 ± 117	2374.8 ± 99	<0.001	2497.5 ± 96	2039.3 ± 102	2295.6 ± 113	2390.1 ± 100	0.01
Protein (g/day)	85.6 ± 4.6	67.6 ± 6.2	83.5 ± 4.6	94.4 ± 4.5	0.003	87.5 ± 6.3	65 ± 4.2	80.3 ± 4.4	98.2 ± 4.4	<0.001
Fat (g/day)	81.5 ± 3.5	63.9 ± 4.7	79.1 ± 4.7	84.6 ± 4.3	0.005	83.5 ± 5.2	67.5 ± 3.6	80.2 ± 4.8	77.9 ± 3.7	0.06
Carbohydrate (g/day)	403 ± 17	298.1 ± 15.6	317.5 ± 18.8	320.2 ± 16.4	<0.001	370 ± 19	305 ± 17.6	325.6 ± 18.3	338.1 ± 16	0.07
Dietary fiber (g/day)	22.8 ± 1.5	14.8 ± 0.8	18.1 ± 1.3	19.8 ± 1.2	<0.001	19.9 ± 1.3	16.5 ± 1.2	18.8 ± 1.4	20.3 ± 1.2	0.18
Fructose (g/day)	13.1 ± 1	7.6 ± 0.7	10.9 ± 1.1	11.1 ± 0.8	0.001	10.5 ± 0.9	9 ± 0.9	10.5 ± 0.9	12.8 ± 1	0.05
Folate (µg/day)	357.3 ± 25	242.3 ± 15.1	320.1 ± 27.3	328.4 ± 17.7	0.002	328.1 ± 26.5	265.3 ± 17.7	302.6 ± 20.1	352.1 ± 23.9	0.04
Caffeine (mg/day)	157.6 ± 19.7	131.6 ± 19	219 ± 80.8	160.5 ± 20.1	0.54	229.2 ± 80.5	136.6 ± 16.5	145.9 ± 17.1	156.9 ± 24.6	0.42

Data are presented as mean ± standard error (SE)

[a]Energy was not adjusted

[b]Obtained from ANOVA

in the highest quartile had higher intakes of dairy, processed meat, and protein and lower intakes of refined grains and energy. Furthermore, subjects across quartiles of white meat consumption had different intakes of folate.

Multivariable-adjusted odds ratios for general and abdominal obesity across quartiles of red and white meat consumption are indicated in Table 3. No significant association was observed between red meat consumption and general obesity. This relationship was non-significant even after adjustment of potential confounders. Moreover, there was no significant relationship between red meat consumption and abdominal obesity. When potential confounders were taken into account, a significant positive association was found between red meat consumption and abdominal obesity, so that subjects in the fourth quartile had 4.51 more odds to be abdominally obese compared with those in the first quartile of red meat consumption (OR 4.51, 95% CI 1.32–15.40). No overall significant association was observed between white meat consumption, general, and abdominal obesity either in crude or adjusted models.

Discussion

To the best of our knowledge, this study is the first to examine the association of red and white meat consumption with general and abdominal obesity among Iranian military families. In this cross-sectional study, we found a significant positive association between red meat consumption and abdominal obesity in fully adjusted model. Such relationship was not seen for general obesity. In addition, white meat consumption was not associated with general and abdominal obesity either before or after adjustment for covariates.

Most previous studies have mainly done on general population and assessed the association of red meat consumption with general and abdominal obesity, and few evidences are available on white meat consumption [12, 28]. In line with our findings, Wang et al. reported in a US national cross-sectional study that red meat consumption is positively associated with central adiposity [15]. Another study conducted by Wang et al. in a Chinese population, indicated that greater intake of red meat consumption was significantly associated with higher abdominal obesity risk [16]. In addition, Montonen et al. reported that subjects in the top quartile of red meat consumption have greater WC and BMI compared with those in the bottom quartile [13]. In another study in Japanese-Brazilians population, Cristofoletti et al. reported that the red meat consumption was associated with abdominal obesity only in women after adjustment of covariates [17]. In another study by Babio et al., results showed that individuals in the fourth quartile of red meat consumption had an increased risk of central

Table 3 Odds ratio (95% CI) for general and abdominal obesity according quartiles of red and white meat consumption

	Quartiles of red meat consumption					Quartiles of white meat consumption				
	Q1	Q2	Q3	Q4	*p*-trend	Q1	Q2	Q3	Q4	*p*-trend
General obesity										
Crude	1	0.95 (0.40–2.25)	0.90 (0.37–2.18)	0.58 (0.33–1.86)	0.57	1	1.10 (0.46–2.58)	0.72 (0.30–1.76)	1.47 (0.62–3.48)	0.57
Model 1[a]	1	1.06 (0.41–2.74)	0.91 (0.36–2.32)	0.81 (0.33–1.97)	0.57	1	1.23 (0.50–3.03)	0.80 (0.32–2.00)	1.53 (0.63–3.73)	0.53
Model 2[b]	1	1.12 (0.42–2.94)	0.88 (0.34–2.26)	0.85 (0.34–2.12)	0.61	1	1.20 (0.47–3.09)	0.79 (0.30–2.04)	1.45 (0.58–3.62)	0.6
Model 3[c]	1	1.04 (0.38–2.83)	0.85 (0.32–2.26)	0.82 (0.32–2.10)	0.6	1	1.28 (0.49–3.33)	0.78 (0.30–2.05)	1.51 (0.59–3.86)	0.58
Abdominal obesity										
Crude	1	0.70 (0.27–1.83)	0.94 (0.36–2.42)	2.54 (0.93–6.88)	0.05	1	1.15 (0.44–3.00)	0.50 (0.19–1.29)	0.93 (0.37–2.37)	0.52
Model 1	1	0.67 (0.22–1.96)	0.99 (0.35–2.79)	2.83 (0.97–8.22)	0.03	1	1.39 (0.47–4.08)	0.38 (0.13–1.10)	1.00 (0.37–2.73)	0.48
Model 2	1	0.57 (0.18–1.79)	0.84 (0.28–2.49)	3.68 (1.14–11.88)	0.02	1	1.63 (0.51–5.25)	0.43 (0.14–1.33)	1.06 (0.37–3.07)	0.57
Model 3	1	0.64 (0.19–2.15)	0.98 (0.31–3.05)	4.51 (1.32–15.40)	0.009	1	1.67 (0.50–5.56)	0.43 (0.14–1.37)	1.33 (0.43–4.04)	0.87

Data are OR (95% CI)

[a]Model 1: adjusted for gender, age, and energy intake

[b]Model 2: additionally adjusted for economic status, education, and smoking status

[c]Model 3: further adjustment for dietary intakes of fruits, vegetables, whole grain, and dietary fiber

obesity at the end of the follow-up compared to the lowest quartile [19]. In Spanish Mediterranean population, it was reported by Sotos Prieto et al. that red meat consumption was associated with greater weight and prevalence of obesity [29]. In contrast with our findings, Wagemakers et al. in a prospective cohort study in British adults revealed no significant association between red meat consumption and abdominal obesity [18]. In addition, in a study on Belgian military population, Mullie et al. reported that 5 year adherence to meat dietary pattern increased the risk of general obesity [30]. However, abdominal obesity was not assessed in this study; its findings on general obesity are inconsistent compared with our findings which may be due to differences in subjects' culture, health status, and genetic and psychological factors. Furthermore, different cooking and process of red meat in various cultures might be another reason for different findings in this regard.

The association between red meat consumption and abdominal obesity is complex. In our study, individuals in the fourth quartile of red meat consumption had lower intake of fruits, vegetables, whole grain, and dietary fiber compared to those in the first quartile. It has been shown that lower intake of fruits, vegetables, whole grain, and dietary fiber is associated with greater odds of abdominal obesity. Although we adjusted these potential confounders for obtaining an independent association between red meat consumption and abdominal obesity, assessing whole dietary intakes or dietary patterns in relation to abdominal obesity is better than focusing on single food or nutrient intake due to decreasing the co-linearity problem which might occur when assessing single food and nutrient intakes. This subject should be considered in future studies in this regard.

Some hypothesis can be mentioned on the positive association between red meat consumption and abdominal obesity. Red meat and its products are one of the high-energy density foods, because it is rich source of protein, cholesterol, and saturated fatty acids [31]. A significant positive association between energy density and obesity has been established previously [32]. Although we did not assess the kinds of red meat (lean, low fat, and full fat) in this study, but Iranian people often consume full-fat red meats. Therefore, we can consider red meats as high-energy density foods in Iran. In addition, consumption of red meat increases the count of some gut microbiota such as Bacteroides entero type [33]. Some studies have shown a significant positive association between presence of these gut microbiota and obesity [33, 34]. However, this relationship is controversial and further studies are required to confirm this relationship.

In the current study, we found no significant association between white meat consumption and both kinds of obesity. In line with our findings, Winkvist et al. reported in a cross-sectional study that white meat consumption was not associated with obesity among adolescents in Western Sweden [35]. In contrast, other studies showed significant association between white meat consumption and obesity. Vergnaud et al. reported that higher poultry consumption is related to lower odds for having general obesity [21]. In addition, findings from Maskarinec et al. showed a significant positive association between white meat consumption and obesity [36]. Such findings were also seen in the Oxford Vegetarian Study [37]. Differences in the previous findings might be explained by different processing and cooking of white meat or consumption of various kinds of white meats including poultry and fish in different cultures.

Some limitations should be considered for interpreting our findings. Due to cross-sectional design of current study, we cannot infer a causal link between meat consumption, and general and abdominal obesity. Therefore, findings of current study need to be confirmed in prospective studies. In addition, obese subjects may have low dietary intake to lose weight. Therefore, these residual confounding effects may attenuate the risk estimates and actual results may be even stronger than those obtained. Although some confounders were adjusted in current study to reach an independent association between meat consumption and obesity; some other confounders such as menopausal status, hormone therapy, and psychological factors should be controlled in mentioned relationship in future studies.

Conclusion

Red meat consumption was positively associated with abdominal obesity, but such a significant relationship was not seen for general obesity. In addition, no significant relationship was found between white meat consumption, and general and abdominal obesity. Further studies are needed to shed light our findings.

Acknowledgements Authors appreciate the valuable assistance of all subjects. We also would like to thank the authorities of AJA University of Medical Sciences, Tehran, Iran, for their cooperation.

Compliance with ethical standards

Funding This study was supported by AJA University of Medical Sciences, Tehran, Iran.

Conflict of interest Authors declared no personal or financial conflicts of interest.

Ethical approval All procedures performed in this study were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent Informed consent was obtained from all subjects included in the study.

References

1. Smith KB, Smith MS (2016) Obesity statistics. Prim Care 43(1):121–135. doi:10.1016/j.pop.2015.10.001
2. Deng T, Lyon CJ, Bergin S, Caligiuri MA, Hsueh WA (2016) Obesity, inflammation, and cancer. Annu Rev Pathol 11:421–449. doi:10.1146/annurev-pathol-012615-044359
3. Saltiel AR, Olefsky JM (2017) Inflammatory mechanisms linking obesity and metabolic disease. J Clin Invest 127(1):1–4. doi:10.1172/JCI92035
4. Sadeghi O, Askari G, Maghsoudi Z, Ghiasvand R, Khorvash F (2016) The association between abdominal obesity and characteristics of migraine attacks in Iranian adults. Iran J Nurs Midwifery Res 21(3):271–277. doi:10.4103/1735-9066.180378
5. Flegal KM, Kruszon-Moran D, Carroll MD, Fryar CD, Ogden CL (2016) Trends in obesity among adults in the United States, 2005 to 2014. JAMA 315(21):2284–2291. doi:10.1001/jama.2016.6458
6. Bakhshi E, Etemad K, Seifi B, Mohammad K, Biglarian A, Koohpayehzadeh J (2016) Changes in obesity odds ratio among Iranian adults, since 2000: quadratic inference functions method. Comput Math Methods Med 2016:7101343. doi:10.1155/2016/7101343
7. Saneei P, Esmaillzadeh A, Keshteli AH, Feizi A, Feinle-Bisset C, Adibi P (2016) Patterns of dietary habits in relation to obesity in Iranian adults. Eur J Nutr 55(2):713–728. doi:10.1007/s00394-015-0891-4
8. Arroyo-Johnson C, Mincey KD (2016) Obesity epidemiology worldwide. Gastroenterol Clin North Am 45(4):571–579. doi:10.1016/j.gtc.2016.07.012
9. Katz DL (2016) The mass of humanity and the weight of the world: obesity and the environment at a confluence of causes. Curr Obes Rep 5(4):386–388. doi:10.1007/s13679-016-0236-5
10. Boada LD, Henríquez-Hernández LA, Luzardo OP (2016) The impact of red and processed meat consumption on cancer and other health outcomes: epidemiological evidences. Food Chem Toxicol 92:236–344. doi:10.1016/j.fct.2016.04.008
11. Kouvari M, Tyrovolas S, Panagiotakos DB (2016) Red meat consumption and healthy ageing: a review. Maturitas 84:17–24. doi:10.1016/j.maturitas.2015.11.006
12. Rouhani MH, Salehi-Abargouei A, Surkan PJ, Azadbakht L (2014) Is there a relationship between red or processed meat intake and obesity? A systematic review and meta-analysis of observational studies. Obesity Rev 15(9):740–748. doi:10.1111/obr.12172
13. Montonen J, Boeing H, Fritsche A, Schleicher E, Joost HG, Schulze MB et al (2013) Consumption of red meat and whole-grain bread in relation to biomarkers of obesity, inflammation, glucose metabolism and oxidative stress. Eur J Nutr 52(1):337–345. doi:10.1007/s00394-012-0340-6
14. Hashemipour S, Esmailzadehha N, Mohammadzadeh M, Ziaee A (2016) Association of meat and dairy consumption with normal weight metabolic obesity in men: the Qazvin Metabolic Diseases Study. Eat Weight Disord 21(3):419–425. doi:10.1007/s40519-015-0250-8
15. Wang Y, Beydoun MA (2009) Meat consumption is associated with obesity and central obesity among US adults. Int J Obesity 33(6):621–628. doi:10.1038/ijo.2009.45
16. Wang Z, Zhang B, Zhai F, Wang H, Zhang J, Du W et al (2014) Fatty and lean red meat consumption in China: differential association with Chinese abdominal obesity. Nutr Metab Cardiovasc Dis 24(8):869–876. doi:10.1016/j.numecd.2014.03.002
17. Cristofoletti MF, Gimeno SG, Ferreira SR, Cardoso MA, Japanese-Brazilian Diabetes Study Group (2013) Association of processed meat intake and obesity in a population-based study of Japanese-Brazilians. Arq Bras Endocrinol Metabol 57(6):464–472
18. Wagemakers JJ, Prynne CJ, Stephen AM, Wadsworth ME (2009) Consumption of red or processed meat does not predict risk factors for coronary heart disease; results from a cohort of British adults in 1989 and 1999. Eur J Clin Nutr 63(3):303–311. doi:10.1038/sj.ejcn.1602954
19. Babio N, Sorlí M, Bulló M, Basora J, Ibarrola-Jurado N, Fernández-Ballart J, Nureta-PREDIMED Investigators, et al (2012) Association between red meat consumption and metabolic syndrome in a Mediterranean population at high cardiovascular risk: cross-sectional and 1-year follow-up assessment. Nutr Metab Cardiovasc Dis 22(3):200–207. doi:10.1016/j.numecd.2010.06.011
20. Cocate PG, Natali AJ, de Oliveira A, Alfenas Rde C, Peluzio Mdo C, Longo GZ et al (2015) Red but not white meat consumption is associated with metabolic syndrome, insulin resistance and lipid peroxidation in Brazilian middle-aged men. Eur J Prev Cardiol 22(2):223–230. doi:10.1177/2047487313507684
21. Vergnaud AC, Norat T, Romaguera D, Mouw T, May AM, Travier N et al (2010) Meat consumption and prospective weight change in participants of the EPIC-PANACEA study. Am J Clin Nutr 92(2):398–407. doi:10.3945/ajcn.2009.28713
22. Park SY, Zhu K, Potter JF, Kolonel LN (2011) Health-related characteristics and dietary intakes of male veterans and non-veterans in the Multiethnic Cohort Study (United States). J Mil Veterans Health 19(2):4–9
23. Mullie P, Deliens T, Clarys P (2016) Relation between sugar-sweetened beverage consumption, nutrition, and lifestyle in a military population. Mil Med 181(10):1335–1339. doi:10.7205/MILMED-D-15-00453
24. US Food and Drug administration (1999) Whole-grain foods authoritative statement claim notification. US Department of Agriculture, Washington DC
25. Esmaillzadeh A, Mirmiran P, Azizi F (2005) Whole-grain intake and the prevalence of hypertriglyceridemic waist phenotype in Tehranian adults. Am J Clin Nutr 81:55–63
26. Lean ME, Han TS, Morrison CE (1995) Waist circumference as a measure for indicating need for weight management. BMJ 311(6998):158–161
27. No author (2002) Third report of the National Cholesterol Education Program (NCEP) expert panel on detection, evaluation, and treatment of high blood cholesterol in adults (adult treatment panel III) final report. Circulation 106(25):3143–3421
28. Araujo AM, Brandao SA, Araujo MA (2017) Overweight and obesity in pre-schoolers: prevalence and relation to food consumption. Rev Assoc Med Bras 63(2):124–133. doi:10.1590/1806-9282.63.02.124
29. Sotos Prieto M, Guillen M, Sorlí JV, Asensio EM, Gillem Sáiz P, González JI et al (2011) Meat and fish consumption in a high cardiovascular risk Spanish Mediterranean population. Nutr Hosp 26(5):1033–1040. doi:10.1590/S0212-16112011000500017
30. Mullie P, Clarys P (2016) Relation between dietary pattern analysis (principal component analysis) and body mass index: a 5-year follow-up study in a Belgian military population. J R Army Med Corps 162(1):23–29. doi:10.1136/jramc-2014-000356
31. Xu F, Yin XM, Tong SL (2007) Association between excess bodyweight and intake of red meat and vegetables among urban and rural adult Chinese in Nanjing, China. Asia Pac J Public Health 19(3):3–9

32. Rouhani MH, Mirseifinezhad M, Omrani N, Esmaillzadeh A, Azadbakht L (2012) Fast food consumption, quality of diet, and obesity among Isfahanian adolescent girls. J Obes 2012:597924. doi:10.1155/2012/597924
33. Wu GD, Chen J, Hoffmann C, Bittinger K, Chen YY, Keilbaugh SA et al (2011) Linking long-term dietary patterns with gut microbial enterotypes. Science 334(6052):105–108. doi:10.1126/science.1208344
34. Khan MJ, Gerasimidis K, Edwards CA, Shaikh MG (2016) Role of gut microbiota in the aetiology of obesity: proposed mechanisms and review of the literature. J Obes 2016:7353642. doi:10.1155/2016/7353642
35. Winkvist A, Hulten B, Kim JL, Johansson I, Toren K, Brisman J et al (2016) Dietary intake, leisure time activities and obesity among adolescents in Western Sweden: a cross-sectional study. Nutr J 15:41. doi:10.1186/s12937-016-0160-2
36. Maskarinec G, Takata Y, Pagano I, Carlin L, Goodman MT, Le Marchand L et al (2006) Trends and dietary determinants of overweight and obesity in a multiethnic population. Obesity (Silver Spring) 14(4):717–726. doi:10.1038/oby.2006.82
37. Appleby PN, Thorogood M, Mann JI, Key TJ (1998) Low body mass index in non-meat eaters: the possible roles of animal fat, dietary fibre and alcohol. Int J Obes Relat Metab Disord 22(5):454–460