Intake of Animal Source Foods in Relation to Risk of Metabolic Syndrome

Yahya Pasdar¹, Shima Moradi¹, Neda Hydarzadeh Esfahani², Mitra Darbandi¹, and Parisa Niazi¹

¹Department of Nutritional Sciences, Research Center for Environmental Determinants of Health (RCEDH), Health Institute and
²Student Research Committee, School of Nutritional Sciences and Food Technology, Kermanshah University of Medical Sciences, Kermanshah 6715847141, Iran

ABSTRACT: Metabolic syndrome (MetS) is a prevalent disorder associated with diabetes and cardiovascular diseases. Lifestyle and occupation can increase the risk of developing MetS. Since dietary pattern is a major component of lifestyle, this study aimed to determine the relationship between consumption of animal source foods (ASFs) and MetS among food suppliers. This cross-sectional study was conducted on 112 male food suppliers. We measured anthropometric indices, body composition, and blood pressure of the participants. Blood biochemistry was determined using 5 mL fasting blood samples. MetS was defined based on the guidelines described by the International Diabetes Federation (IDF). ASF intake, including dairy products, eggs, red meat, poultry, and fish, was assessed using food frequency questionnaires. Overall, 46.4% of participants had MetS. Participants who consumed dairy 3∼5 times/d and more than 5 times/d had lower risk of MetS [odds ratios (OR): 0.18 (confidence interval (CI) 95%: 0.05∼0.62) and OR: 0.20 (CI 95%: 0.06∼0.67), respectively] compared with participants in the lowest tertile. The risk of hypertension was significantly decreased in participants who consumed dairy products >5 times/d [OR: 0.22 (CI 95%: 0.07∼0.67)]. Other ASFs were not associated against the risk of MetS in crude and adjusted models. Our findings indicated that adhering to dairy products can decrease the risk of MetS. Higher adherence to dairy products was also protective against hypertension in these participants.

Keywords: animal source foods, dairy product, food suppliers, metabolic syndrome

INTRODUCTION

Metabolic syndrome (MetS) is a progressive problem worldwide that is associated with increased risk of chronic diseases (Ranasinghe et al., 2017; Pasdar et al., 2019a). MetS is highly prevalent in industrial and developing countries, although the highest prevalence occurs in developing countries (Ostovar et al., 2017; Hajian-Tilaki, 2018). Recent results from a systematic review have shown that the prevalence of MetS in adults (≥18 years of age) is 31.6% in Iran (Ostovar et al., 2017).

MetS includes obesity, hypertension, dyslipidemia [low level of high-density lipoprotein (HDL) and high plasma triglycerides (TG)], and dysglycemia (glucose intolerance) (Esposito et al., 2012; Je et al., 2017; Ostovar et al., 2017). MetS can be prevented by improving unhealthy lifestyles (Je et al., 2017). Dietary pattern is an important component of lifestyle; modifying dietary patterns can improve all risk factors of MetS, including central obesity, lipid profile, blood pressure, and insulin resistance (Aekplakorn et al., 2015). Lower adherence to western diets, such as high intake of red and processed meat, refined grains, and saturated and trans-fatty acids can decrease the risk of MetS (Becerra-Tomás et al., 2016; Pasdar et al., 2019b; Samadi et al., 2019). Nevertheless, healthy diets, particularly Mediterranean diets, have demonstrated beneficial effects for preventing MetS (Salas-Salvadó et al., 2015).

Animal source foods (ASFs) refer to foods derived from animals and include red meat, eggs, dairy, poultry, and seafood (Zhang et al., 2016; Samadi et al., 2020). These foods are rich in high biological value proteins and essential micronutrients (e.g., calcium, iron, zinc, choline, and vitamin B12) and have key roles in growth and development (Headley et al., 2018). However, some studies have shown that high intakes of red meat increase the risk of
cardiovascular diseases and cancer (Kaluza et al., 2015; Bellavia et al., 2016). However, greater consumption of eggs and dairy has shown conflicting results on cardio-metabolic status (Larsson et al., 2015; Praagman et al., 2015; Shin et al., 2017; Vissers et al., 2019).

There is a high prevalence of MetS among Iranian population; however no studies have yet examined ASFs intake and risk of MetS in this population. Therefore, we aimed to determine the relationship between ASFs consumption and risk of MetS among food suppliers.

MATERIALS AND METHODS

Study design and participants
This cross-sectional study was conducted on 112 males 30~65 years of age, who were engaged in the food supply industry in Kermanshah Province, Western Iran. The sample size was determined with 90% power and 95% confidence based on previous studies; the mean±standard deviation (SD) of cholesterol among normal and obese employed adults was calculated as 200±32.5 and 222 ±37.5 mg/dL, respectively (Saeedi et al., 2003; Rezaee et al., 2008). Participants were randomly selected from individuals with at least three years of experience in their current occupation, and included those working at patisseries, sandwich shops, restaurants, pizza and doughnut outlets, lamb liver kebab shops, and barbeques. Subjects who did not provide complete information were excluded from the study. The objectives of the study were explained to the participants and all participants gave written informed consent. The study was approved by the Ethics Committee of the Deputy of Research and Technology of Kermanshah University of Medical Sciences, Kermanshah, Iran (IR.KUMS.REC.1398.572).

Data collection and anthropometry
Demographic information was collected at the start of the study. Height was measured in standing position without shoes using a stadiometer with 0.1 cm precision. Weight and body composition, including percent of body fat, body fat mass, and soft lean mass, were measured by bio-electrical impedance analysis (Avis 333 Plus, Jawon Medical Co., Ltd., Gyeongsan, Korea). Body mass index (BMI) was calculated by dividing weight by height squared kg/m². Obesity was defined as BMI >30 kg/m². Waist and hip circumference (WC and HC, respectively) were measured three times using non-flexible tape and the averages were recorded. For WC measurements, the level of iliac crest was considered, and the largest diameter of the hips was considered for HC measurement. Waist to hip ratio (WHR) was calculated via dividing WC by HC. WHR >0.9 was considered the central obesity. Physical activity of participants was evaluated using the International Physical Activity Questionnaire-short form, the validity and reliability of which were confirmed in Iran (Gh and Azad, 2011).

Blood pressure (BP) and biochemical analysis
BP was measured using a calibrated digital brachial sphygmomanometer. Hypertension was considered as BP >130/85 mmHg, based on the guidelines from the International Diabetes Federation (IDF) for determining MetS (Alberti et al., 2005).

Fasting blood samples (5 mL) were obtained from all participants for assessing levels of fasting blood sugar (FBS) and lipid profile (including total cholesterol, HDL, and TG). After separating the serums, samples were kept frozen at −40°C in laboratory. FBS was measured by a RA1000-RAXT autoanalyzer (Technicon Instruments Corporation, Tarrytown, NY, USA) using enzymatic kits (Pars Azmoon, Tehran, Iran). Lipid profile was measured using photometric methods and a Monobind kit.

Outcome assessment
MetS was determined based on the IDF guidelines, based on the presence of the abdominal obesity and two other abnormalities, including FBS>100 mg/dL, HDL<40 mg/dL, TG>150 mg/dL, and BP>130/85 mmHg (Alberti et al., 2005).

ASFs
Dietary intake was assessed using the semi-quantitative food frequency questionnaire (FFQ) with 168 items via face to face interviews with a trained interviewer; the validity and reliability of this questionnaire were confirmed in an earlier study carried out in Iran (Mirmiran et al., 2010). FFQ includes a list of foods and a standard serving size for each item; subjects are asked multiple options, from never to more than six times per day. To determine the consumption patterns of ASFs, relevant food items were derived from the FFQ. Since ASFs include red meat, eggs, dairy, poultry, and seafood (Zhang et al., 2016), they are categorized into four groups, including red and processed meat, fish and poultry, egg, and dairy, according to the consumption patterns of the participants. To obtain the total consumption of each ASFs group, the intakes of each corresponding subgroup were combined. For example, the red meat, processed meat, and organ meat were combined into the red and processed meat group included. In addition, due to the low consumption of fish, intake of fish and poultry were combined in the white meat group. We classified participants’ responses into three categories as follows: <2 times per week, 2~5 times per week, and >5 times per week. We also combined intake of milk, cheese, dough, and yogurt into the dairy group, and categorized the frequency of consumption into categories of <3 times per day, 3~5 times per
day, and >5 times per day. Dairy products were consumed more often by participants, compared with the other ASFs.

**Statistical analysis**
All statistical analyses were performed using SPSS software (version 20.0., IBM Corp., Armonk, NY, USA). Mean±SD was used to report quantitative variables, and qualitative variables were reported as frequency (%). The frequency of consumption was categorized by red and processed meat, fish and poultry, egg and dairy to assess the association between ASFs and the risk of MetS. To determine this association, we used crude and adjusted binary logistic regression models. In the adjusted model, age (continuous), BMI (continuous), and physical activity (continuous) were controlled. The first category of ASFs intake was considered as the reference category in all binary logistic regression analyses. To determine the overall trend of the odds ratios (OR) of increased dietary intake, these categories were considered as an ordinal variable in the logistic regression models, and the P-trend was reported. After determining the association between dairy intake and the risk of MetS, dairy intake and all risk factors of MetS were evaluated separately. A P-value < 0.05 was considered significant in all analyses.

**RESULTS**
Overall, 46.4% of subjects had MetS. The mean values for age, weight, BMI, and body fat mass for subjects with MetS were significantly higher than for subjects without MetS (P<0.001, P=0.05, P=0.029, and P=0.004, respectively) (data not shown). Other subject characteristics, including biochemical analysis, physical activity, and ASFs intake, are presented in Table 1.

There was no significant association between ASFs intake (red and processed meat, fish and poultry, and egg) and risk of MetS. Even after adjusting for potential confounders including age, BMI, and physical activity level, no significant association was observed between these food groups and the risk of MetS. Multivariable-adjusted OR and 95% confidence intervals (CI) for MetS across categories of red and processed meat, fish and poultry, and egg intake are presented in Table 2.

However, we observed a significant association between dairy intake and lower risk of MetS. Those who consumed dairy 3–5 times/d or more than 5 times/d had a lower risk of MetS [OR: 0.24 (CI 95%: 0.09–0.68) and OR: 0.28 (CI 95%: 0.10–0.75), respectively], compared with subjects in the lowest tertile group (Table 3). This association was strengthened after controlling the potential confounders [OR: 0.18 (CI 95%: 0.05–0.62) and OR: 0.20 (CI 95%: 0.06–0.67), respectively] (Fig. 1A).

Multivariable-adjusted OR and 95% CI for MetS for all quantities of dairy intake revealed a significant correlation between dairy intake and the risk of hypertension in all analysis models in the third tertile compared with the reference category [OR: 0.22 (CI 95%: 0.07–0.62) in crude model, OR: 0.20 (CI 95%: 0.07–0.61) in age-adjusted model, and OR: 0.22 (CI 95%: 0.07–0.67) in multivariable-adjusted model] (Fig. 1B and Table 3).

There was significant association between other the components of MetS and dairy intake. However, after controlling for potential confounders, no significant association was observed between the other components of MetS and dairy intake (Table 3).

| Table 1. Subject characteristics |
|---------------------------------|
| Variables | Without MetS (n=60) | With MetS (n=52) | P-value |
|-----------|----------------------|------------------|---------|
| Biochemical analysis | | | |
| FBS (mg/dL) | 78.63±9.15 | 84.03±11.72 | 0.198 |
| TC (mg/dL) | 196.46±35.85 | 195.69±36.36 | 0.841 |
| LDL (mg/dL) | 107.96±21.27 | 107.51±18.73 | 0.258 |
| TG (mg/dL) | 159.6±81.92 | 198.19±87.20 | 0.006 |
| HDL (mg/dL) | 42.91±7.95 | 36.84±5.61 | 0.007 |
| SBP (mmHg) | 120.66±17.75 | 130.07±15.30 | 0.31 |
| DBP (mmHg) | 78.55±10.86 | 84.98±7.94 | 0.382 |
| Physical activity (Met h/week) | 272.93±35.23 | 364.85±50.59 | 0.01 |
| Animal source foods intake (serving/d) | | | |
| Dairy | 4.24±2.77 | 3.18±2.18 | 0.01 |
| Fish and poultry | 1.06±1.14 | 0.85±0.75 | 0.813 |
| Red and processed meat | 1.08±0.83 | 1.02±1.30 | 0.12 |
| Egg | 0.38±0.42 | 0.34±0.29 | 0.577 |

MetS, metabolic syndrome; FBS, fasting blood sugar; TC, total cholesterol; LDL, low density lipoprotein; TG, triglyceride; HDL, high density lipoprotein; SBP, systolic blood pressure; DBP, diastolic blood pressure.

Data are expressed as mean±SD.

P-values were calculated using independent samples and U Mann-Whitney tests.
| Dietary intake                  | OR (95% CI) <2 times/wk | 2−5 times/wk | >5 times/wk | P-trend |
|-------------------------------|--------------------------|--------------|-------------|---------|
| Red and processed meat        |                          |              |             |         |
| Crude                         | 1                        | 0.27 (0.62−5.50) | 0.55 (0.27−2.01) | 0.294   |
| Model 1<sup>1)</sup>          | 1                        | 0.87 (0.25−3.02) | 0.58 (0.19−1.74) | 0.294   |
| Model 2<sup>2)</sup>          | 1                        | 0.99 (0.28−3.48) | 0.65 (0.21−1.99) | 0.388   |
| Fish and poultry              |                          |              |             |         |
| Crude                         | 1                        | 1.87 (0.62−5.66) | 1.38 (0.46−4.14) | 0.79    |
| Model 1                       | 1                        | 2.77 (0.75−10.21) | 1.66 (0.45−6.07) | 0.778   |
| Model 2<sup>2)</sup>          | 1                        | 2.55 (0.67−9.64) | 1.56 (0.42−5.78) | 0.84    |
| Egg                           |                          |              |             |         |
| Crude                         | 1                        | 0.48 (0.20−1.15) | 1.45 (0.37−5.63) | 0.647   |
| Model 1                       | 1                        | 0.64 (0.24−1.71) | 2.91 (0.66−12.77) | 0.503   |
| Model 2<sup>2)</sup>          | 1                        | 0.61 (0.22−1.65) | 2.89 (0.64−13.00) | 0.545   |

1) Adjusted for age.
2) Adjusted for age, body mass index, and physical activity.

### Table 3. Multivariable-adjusted odds ratios (OR) and 95% confidence intervals (CI) for metabolic syndrome (MetS) and its components for dairy intake

| MetS and it’s components | OR (95% CI) <3 times/d | 3−5 times/d | >5 times/d | P-trend |
|--------------------------|------------------------|-------------|------------|---------|
| MetS                     |                        |             |            |         |
| Crude                    | 1                      | 0.24 (0.09−0.68) | 0.28 (0.10−0.75) | 0.004   |
| Model 1<sup>1)</sup>     | 1                      | 0.20 (0.06−0.65) | 0.20 (0.06−0.65) | 0.003   |
| Model 2<sup>2)</sup>     | 1                      | 0.18 (0.05−0.62) | 0.20 (0.06−0.67) | 0.003   |
| Central obesity          |                        |             |            |         |
| Crude                    | 1                      | 0.80 (0.27−2.30) | 0.58 (0.21−1.60) | 0.302   |
| Model 1                  | 1                      | 0.75 (0.21−2.67) | 0.48 (0.13−1.84) | 0.291   |
| Model 2<sup>2)</sup>     | 1                      | 0.80 (0.19−3.05) | 0.15 (0.01−1.32) | 0.152   |
| High TG level            |                        |             |            |         |
| Crude                    | 1                      | 0.83 (0.32−2.16) | 0.60 (0.23−1.56) | 0.304   |
| Model 1                  | 1                      | 0.82 (0.31−2.12) | 0.60 (0.23−1.55) | 0.295   |
| Model 2<sup>2)</sup>     | 1                      | 0.80 (0.31−2.10) | 0.57 (0.22−1.49) | 0.259   |
| Low HDL level            |                        |             |            |         |
| Crude                    | 1                      | 0.75 (0.29−1.92) | 1.21 (0.47−3.16) | 0.809   |
| Model 1                  | 1                      | 0.75 (0.29−1.94) | 1.22 (0.47−3.17) | 0.802   |
| Model 2<sup>2)</sup>     | 1                      | 0.74 (0.29−1.92) | 1.16 (0.44−3.05) | 0.879   |
| Hypertension              |                        |             |            |         |
| Crude                    | 1                      | 0.79 (0.31−2.03) | 0.22 (0.07−0.62) | 0.006   |
| Model 1                  | 1                      | 0.84 (0.32−2.22) | 0.20 (0.07−0.61) | 0.007   |
| Model 2<sup>2)</sup>     | 1                      | 0.84 (0.31−2.25) | 0.22 (0.07−0.67) | 0.01    |
| High FBS level           |                        |             |            |         |
| Crude                    | 1                      | 1.19 (0.13−5.33) | 1.05 (0.09−2.78) | 0.289   |
| Model 1                  | 1                      | 1.25 (0.10−5.45) | 1.06 (0.09−2.82) | 0.329   |
| Model 2<sup>2)</sup>     | 1                      | 1.00 (0.06−5.37) | 0.79 (0.05−2.91) | 0.228   |

TG, triglyceride; HDL, high density lipoprotein; FBS, fasting blood sugar.
1) Adjusted for age.
2) Adjusted for age, body mass index, and physical activity.

### DISCUSSION

This study highlights the importance of dairy consumption for reducing the risk of MetS. Specifically, adherence to consuming dairy products had a protective effect on decreasing the risk of hypertension. Similarly, Martins et al. (2015) found that a higher intake of dairy products decreased the risk of MetS [OR: 0.53 (CI 95%: 0.30−0.93)]; the calcium content is thought to be responsible for this association. The Framingham Heart Study showed that consumption of all dairy products, including those containing low and high amounts of fat, is inversely asso-
Dairy products contain proteins of high biological value and essential minerals, such as calcium and phosphorus (Talaei et al., 2017). These proteins are precursors of peptides that inhibit angiotensin-I converting enzyme and may contribute to the antihypertensive effect of dairy products (Abedini et al., 2015; Schwingshackl et al., 2017). The mineral content of dairy products, in particular that of calcium, can decrease blood pressure by increasing urinary sodium excretion, inducing vasodilation (by increasing nitric oxide synthesis), blocking calcium channels, and reducing intracellular calcium content (Wang et al., 2015). Moreover, a correlation was observed between intake of dairy products and other components of MetS, including central obesity, low levels of serum HDL, and high levels of TG and FBS. However, other studies have stated that dairy consumption may contribute to central obesity (Schwingshackl et al., 2016), insulin resistance (Hirahatake et al., 2014), and increased dyslipidemia (Abedini et al., 2015). The high protein content in dairy products reduces energy intake with increased satiety and helps reduce obesity, especially central obesity (Abreu et al., 2012). Calcium from dairy products improves the function of pancreatic beta cells, reduces inflammation and, consequently, improves glycemic status (Pasdar et al., 2020; Talaei et al., 2018). Studies have shown conflicting results in terms of dairy consumption and dyslipidemia due to the saturated fat content (Duffey et al., 2010; van Meijl and Mensink, 2011; Sun et al., 2014; Abedini et al., 2015).

This current study did not show any association between intake of non-dairy ASFs (red and processed meat, fish and poultry, and egg) and the risk of MetS. Even after adjusting for potential confounders, no association was observed between intake of these food groups and the risk of MetS. Intake of red and processed meat, the main components of western diets, can increase the risk of MetS, probably due to the high saturated fatty acids content (Drake et al., 2018; Luan et al., 2020). Another possible mechanism may be related to the presence of heme iron in red and processed meat and high amounts of sodium in processed meat, which also increase the risk of MetS (Becerra-Tomás et al., 2016). In addition, white meat is protective against development of MetS (Kim and Je, 2018), especially seafood due to its high content of omega 3 poly unsaturated fatty acids (Kim et al., 2016). In a study of 130,420 Korean subjects, a higher adherence to egg intake was protective against all components of MetS in men and women, except for HDL levels in men (Shin et al., 2017). Although it has been recommended that egg consumption should be reduced due to the high cholesterol content (NAAS, 2006), many studies have not reported any adverse effects of egg consumption on lipid profiles or MetS (Andersen et al., 2013; Kishimoto et al., 2016; Richard et al., 2017).

This study is the first to evaluate intake of all ASFs in the diets of middle-aged Iranian men. This study has several limitations. Firstly, the study included a small sample size and women were not invited to participate. In addition, dietary intake was assessed by FFQ, so we cannot exclude the possibility of measurement errors or misclassification by study participants, which may have influenced the results. However, the questionnaire was asked by trained nutritionists, therefore minimizing the chance of errors. Furthermore, the study was limited by the observational study design.

We found that consuming higher amounts of dairy products on a daily basis is associated decreased risk of MetS, even after controlling potential confounders. Of the five components of MetS, intake of dairy products is favorable for protecting against risk of hypertension. However, we did not observe any association between intake of other ASFs (red and processed meat, fish and poultry, and egg) and the risk of MetS, even after controlling for
potential confounders.

ACKNOWLEDGEMENTS

We thank the participants involved in our study. Also, the authors gratefully acknowledge the Research Council of Kermanshah University of Medical Sciences for the financial support.

AUTHOR DISCLOSURE STATEMENT

The authors declare no conflict of interest.

REFERENCES

Abedini M, Falahi E, Roosta S. Dairy product consumption and the metabolic syndrome. Diabetes Metab Syndr. 2015. 9:34-37.
Abreu S, Santos R, Moreira C, Vale S, Santos PCS, Soares-Miranda L, et al. Association between dairy product intake and abdominal obesity in Azorean adolescents. Eur J Clin Nutr. 2012. 66:830-835.
Aekplakorn W, Satheanoppakao W, Putwanna P, Tanepanichskul S, Kessomboon P, Chongsuvivatwong V, et al. Dietary pattern and metabolic syndrome in Thai adults. J Nutr Metab. 2015. 2015:468759. https://doi.org/10.1155/2015/468759
Alberti KG, Zimmet P, Shaw J; IDF Epidemiology Task Force Consensus Group. The metabolic syndrome—a new worldwide definition. Lancet. 2005. 366:1059-1062.
Andersen CJ, Blesso CN, Lee J, Barona J, Shah D, Thomas MJ, et al. Egg consumption modulates HDL lipid composition and increases the cholesterol-accepting capacity of serum in metabolic syndrome. Lipids. 2013. 48:557-567.
Becerra-Tomás N, Babio N, Martinez-González MÁ, Corella D, Estruch R, Ros E, et al. Replacing red meat and processed red meat for white meat, fish, legumes or eggs is associated with lower risk of incidence of metabolic syndrome. Clin Nutr. 2016. 35:1442-1449.
Bellavia A, Stilling F, Wolk A. High red meat intake and all-cause cardiovascular and cancer mortality: is the risk modified by fruit and vegetable intake?. Am J Clin Nutr. 2016. 104:1137-1143.
Drake I, Sonestedt E, Ericson U, Wallström P, Orho-Melander M. A Western dietary pattern is prospectively associated with cardio-metabolic traits and incidence of the metabolic syndrome. Br J Nutr. 2018. 119:1168-1176.
Duffy KJ, Gordon-Larsen P, Steffen LM, Jacobs DR Jr, Popkin BM. Drinking calorific beverages increases the risk of adverse cardiometabolic outcomes in the Coronary Artery Risk Development in Young Adults (CARDIA) Study. Am J Clin Nutr. 2010. 92:954-959.
Esposito K, Chiodini P, Colao A, Lenzi A, Giugliano D. Metabolic syndrome and risk of cancer: a systematic review and meta-analysis. Diabetes Care. 2012. 35:2402-2411.
Gh FM, Azad E. Evaluation of the reliability and validity of Azad-Fesharaki’s physical activity questionnaire (AFPAQ). Arak Med Univ J. 2011. 14:36-44.
Hajian-Tilaki K. Comparison of competitive models of metabolic syndrome using structural equation modeling: a confirmatory factor analysis. Diabetes Metab J. 2018. 42:433-441.
Headey D, Hirvonen K, Hoddinott J. Animal sourced foods and child stunting. Am J Agric Econ. 2018. 100:1302-1319.
Hirahatake KM, Slavin JL, Maki KC, Adams SH. Associations between dairy foods, diabetes, and metabolic health: potential mechanisms and future directions. Metabolism. 2014. 63:618-627.
Je Y, Kim Y, Park T. Development of a self-assessment score for metabolic syndrome risk in non-obese Korean adults. Asia Pac J Clin Nutr. 2017. 26:220-226.
Kaluza J, Åkesson A, Wolk A. Long-term processed and unprocessed red meat consumption and risk of heart failure: a prospective cohort study of women. Int J Cardiol. 2015. 193:42-46.
Kim Y, Je Y. Meat consumption and risk of metabolic syndrome: results from the Korean population and a meta-analysis of observational studies. Nutrients. 2018. 10:393. https://doi.org/10.3390/nu10040390
Kim YS, Xun P, Iribarren C, Van Horn L, Steffen L, Daviglus ML, et al. Intake of fish and long-chain omega-3 polyunsaturated fatty acids and incidence of metabolic syndrome among American young adults: a 25-year follow-up study. Eur J Nutr. 2016. 55:1707-1716.
Kishimoto Y, Taguchi C, Suzuki-Sugihara N, Saito E, Usuda M, Wang W, et al. The effect of the consumption of egg on serum lipids and antioxidant status in healthy subjects. J Nutr Sci Vitaminol. 2016. 62:361-365.
Larsson SC, Åkesson A, Wolk A. Egg consumption and risk of heart failure, myocardial infarction, and stroke: results from 2 prospective cohorts. Am J Clin Nutr. 2015. 102:1007-1013.
Luan D, Wang D, Campos H, Baylin A. Red meat consumption and metabolic syndrome in the Costa Rica Heart Study. Eur J Nutr. 2020. 59:185-193.
Martins ML, Kac G, Silva RA, Bettiol H, Barbieri MA, Cardoso VC, et al. Dairy consumption is associated with a lower prevalence of metabolic syndrome among young adults from Ribeirão Preto, Brazil. Nutrition. 2015. 31:716-721.
Mirmiran P, Esfahani FH, Mehrabi Y, Hedayati M, Azizi F. Reliability and relative validity of an FFQ for nutrients in the Tehran lipid and glucose study. Public Health Nutr. 2010. 13:654-662.
NAAS. Standard Food Composition Table. 7th ed. National Institute of Agricultural Sciences, Rural Development Administration, Wanju, Korea. 2006. p 138-139.
Ostovar R, Kiani F, Sayehmiri F, Yasemi M, Mohsenzadeh Y, Mohsenzadeh Y. Prevalence of metabolic syndrome in Iran: a meta-analysis. Electron Physician. 2017. 9:5402-5418.
Pasdar Y, Marzadjavid J, Vakilian M, Vejdani P, Navabi F, et al. Association between dairy product intake and abdominal obesity in Azorean adolescents. Eur J Clin Nutr. 2012. 66:830-835.
Preto, Brazil. Nutrition. 2015. 31:716-721.
Ranasinghe P, Mathangasinghe Y, Jayawardena R, Hills AP, Misra A. Prevalence and trends of metabolic syndrome among adults in the asia-pacific region: a systematic review. BMC Public Health. 2017. 17:101. https://doi.org/10.1186/s12889-017-4041-1
Rezaee J, Davoodpour B, Ariannejad J, Afzal Aghaei M, Mirdad M, Blood lipids levels in obese patients with body mass index over than 40. J Med Sci Azad Uni Mashhad. 2008. 4:23-27.
Richard C, Cristall L, Fleming E, Lewis ED, Ricupero M, Jacobs RL, et al. Impact of egg consumption on cardiovascular risk fac-
Animal Protein in Relation to Metabolic Syndrome

Saeedi MR, Ray AR, Rezaei M. Prevalence of hyperlipidemia among adult residents of Kermanshah in 1997-1998. Sci J Kurdistan Uni Med Sci. 2003. 3:49-54.

Salas-Salvadó J, Guasch-Ferré M, Lee CH, Estruch R, Clish CB, Ros E. Protective effects of the Mediterranean diet on type 2 diabetes and metabolic syndrome. J Nutr. 2015. 146:920S-927S.

Samadi M, Moradi S, Azadbakht L, Rezaei M, Hojati N. Adherence to healthy diet is related to better linear growth with open growth plate in adolescent girls. Nutr Res. 2020. 76:29-36.

Samadi M, Moradi S, Moradinazar M, Mostafai R, Pasdar Y. Dietary pattern in relation to the risk of Alzheimer’s disease: a systematic review. Neurol Sci. 2019. 40:2031-2043.

Schwingshackl L, Hoffmann G, Schwedhelm C, Kalle-Uhlmann T, Missbach B, Knüppel S, et al. Consumption of dairy products in relation to changes in anthropometric variables in adult populations: a systematic review and meta-analysis of cohort studies. PLoS One. 2016. 11:e0157461. https://doi.org/10.1371/journal.pone.0157461

Schwingshackl L, Schwedhelm C, Hoffmann G, Knüppel S, Iqbal K, Andriolo V, et al. Food groups and risk of hypertension: a systematic review and dose-response meta-analysis of prospective studies. Adv Nutr. 2017. 8:793-803.

Shin S, Lee HW, Kim CE, Lim J, Lee JK, Lee SA, et al. Egg consumption and risk of metabolic syndrome in Korean adults: results from the Health Examinees Study. Nutrients. 2017. 9:687. https://doi.org/10.3390/nu9070687

Sun Y, Jiang C, Cheng KK, Zhang W, Leung GM, Lam TH, et al. Milk consumption and cardiovascular risk factors in older Chinese: the Guangzhou Biobank Cohort Study. PLoS One. 2014. 9:e84813. https://doi.org/10.1371/journal.pone.0084813

Talaie M, Pan A, Yuan JM, Koh WP. Dairy food intake is inversely associated with risk of hypertension: the Singapore Chinese Health Study. J Nutr. 2017. 147:235-241.

Talaie M, Pan A, Yuan JM, Koh WP. Dairy intake and risk of type 2 diabetes. Clin Nutr. 2018. 37:712-718.

van Meijl LE, Mensink RP. Low-fat dairy consumption reduces systolic blood pressure, but does not improve other metabolic risk parameters in overweight and obese subjects. Nutr Metab Cardiovasc Dis. 2011. 21:355-361.

Vissers LET, Rijksen J, Boer JMA, Verschuren WMM, van der Schouw YT, Sluijs I. Fatty acids from dairy and meat and their association with risk of coronary heart disease. Eur J Nutr. 2019. 58:2639-2647.

Wang H, Fox CS, Troy LM, Mckeown NM, Jacques PF. Longitudinal association of dairy consumption with the changes in blood pressure and the risk of incident hypertension: the Framingham Heart Study. Br J Nutr. 2015. 114:1887-1899.

Zhang Z, Goldsmith PD, Winter-Nelson A. The importance of animal source foods for nutrient sufficiency in the developing world: the Zambia Scenario. Food Nutr Bull. 2016. 37:303-316.