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

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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 B_{12}) and have key roles in growth and development (Headey et al., 2018). However, some studies have shown that high intakes of red meat increase the risk of

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cardiovascular diseases and cancer (Kaluza et al., 2015; Bellavia et al., 2016). However, greater consumption of eggs and dairy has shown conflicting results on cardiometabolic 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 bioelectrical impedance analysis (Avis 333 Plus, Jawon Medical Co., Ltd., Gyeongsan, Korea). Body mass index (BMI) was calculated by dividing weight by height squared kg/m^2. Obesity was defined as BMI >30 kg/m^2. 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 physcial 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±9.74	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; DPB, diastolic blood pressure.
Data are expressedas mean±SD.
P-values were calculated using independent samples and U Mann-Whitney tests.

Table 2. Multivariable-adjusted odds ratios (OR) and 95% confidence intervals (CI) for risk of metabolic syndrome (MetS) across animal source food intake categories

Dietary intake	OR (95% CI)			*P*-trend
	<2 times/wk	2~5 times/wk	>5 times/wk	
Red and processed meat				
Crude	1	0.27 (0.62~5.50)	0.55 (0.27~2.01)	0.294
Model 1[1)]	1	0.87 (0.25~3.02)	0.58 (0.19~1.74)	0.294
Model 2[2)]	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	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	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 it's components for dairy intake

MetS and it's components	OR (95% CI)			*P*-trend
	<3 times/d	3~5 times/d	>5 times/d	
MetS				
Crude	1	0.24 (0.09~0.68)	0.28 (0.10~0.75)	0.004
Model 1[1)]	1	0.20 (0.06~0.65)	0.20 (0.06~0.65)	0.003
Model 2[2)]	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	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	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	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	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	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-

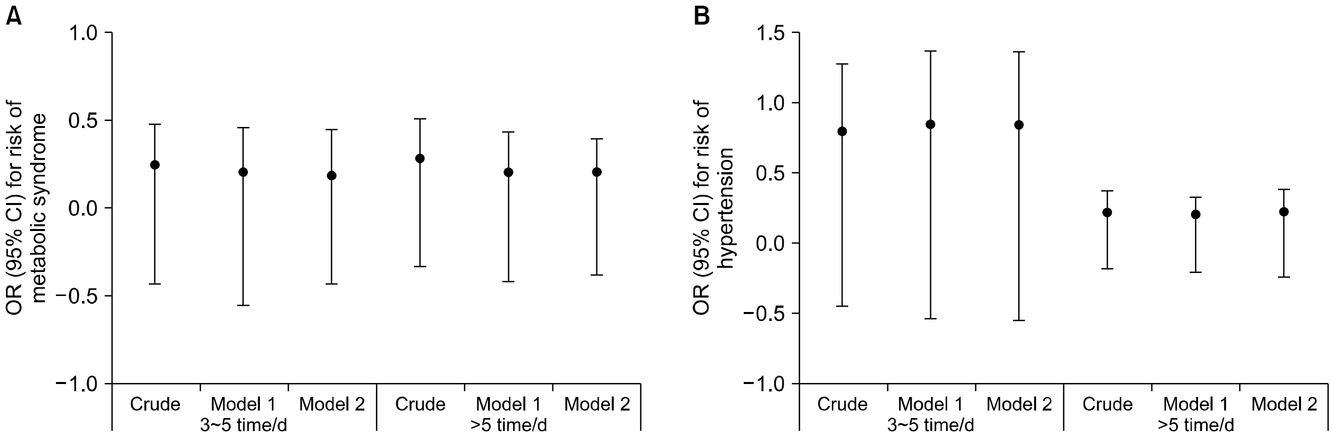

Fig. 1. (A, B) Multivariable-adjusted odds ratios (OR) and 95% confidence intervals (CI) for metabolic syndrome and hypertension across categories of dairy intake among food suppliers. Adjusted model 1 was controlled for age, and model 2 was controlled for age, body mass index, and physical activity.

ciated with the risk of hypertension (Wang et al., 2015). 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 vasodilatation (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.

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AUTHOR DISCLOSURE STATEMENT

The authors declare no conflict of interest.

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