Original Article

Association of dietary fatty acids intake with pro-coagulation and inflammation in Saudi Adults

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The aim of the study was to understand whether dietary fatty acids such as saturated, polyunsaturated, and monounsaturated fatty acids act as inflammatory mediators or influence pro-coagulation in Saudi adults. The study sought to examine inflammatory factors such as C-reactive protein, tumor necrosis factor-alpha and activated plasminogen activator inhibitor 1. A total number of 232 consenting Saudi adults, aged 18–60 years were randomly selected in this cross-sectional study. Independent Student *t*-test was done to compare means of normally distributed data. Spearman correlation between the variables was determined. The values of different fatty acids and adipokines were transformed logarithmically/square root to normalize data before correlations were determined and statistical analyses performed. Statistical significance was set at $p<0.05$. The results show a significant positive correlation of dietary intake of poly and monounsaturated fatty acids, but not saturated fatty acids, with activated plasminogen activator inhibitor 1 (r=0.31, p=0.02, r=0.32 p=0.04). On the other hand, dietary intake of saturated fatty acids showed a negative correlation with serum C-reactive protein levels (p=0.001) in males. Dietary unsaturated fatty acids is possibly associated with the production of a pro-coagulation factor without enhancing the secretion of pro-inflammatory molecules, while saturated fatty acids have no effect on activated plasminogen activator inhibitor 1, but their level is negatively associated with the inflammatory factor C-reactive protein. We conclude that dietary intake may exert a gender-specific effect in inflammatory processes among adults. Further studies are warranted to confirm present findings.

Key Words: dietary fatty acid, adipokines, plasminogen activator inhibitor -1, proinflammatory molecules, CRP

INTRODUCTION

During the past four decades, the Arab gulf countries including Saudi Arabia have shown rapid changes in their socio-economic and health status as well as lifestyle and food consumption pattern. However, the lack of nutritional awareness is one of the major cause of overweight and obesity in the adult Saudi population.[1] Urbanization and economic development has diverted the traditional nutrition pattern of KSA towards a Western lifestyle, resulting in high prevalence of non-communicable diseases in the general population.[2]

Adipose tissue and its secreted products, the "adipokines", play a major role in the pathogenesis of various metabolic disorders including hypertension, atherosclerosis, and insulin resistance. The disturbed endocrine function of adipose tissue leads to an increased release of hormones and inflammatory molecules.[3] Substances connected with inflammation and secreted by adipocytes include, among others, tumor necrosis factor-alpha (TNF-α),

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activated plasminogen activator inhibitor 1 (aPAI-1), and C-reactive protein (CRP).[4] As the main component of adipose tissue, fatty acids and their turnover rate is essential in metabolism.[5,6] Thus it is important to clarify not only their biological function but also how their dysregulation impacts on adipokine production. More specifically, SFAs cause inflammation and modulate immune responses in the body.[7,8] By contrast, PUFAs alleviate a number of inflammatory diseases. Indeed, their involvement has been demonstrated in processes such as chemoattraction and activation of neutrophils.[9] Information regarding MUFA and adipokine regulation is limited and one study shows that obese subjects consuming a diet high in MUFA for eight weeks exhibit a decrease in the gene expression of IL-6 and monocyte chemoattractant protein-1 (MCP-1) receptors.[10]

PAI-1, the main regulator of fibrinolytic system, plays a major role in conditions involving high risk for cardiovascular diseases.[11] Dietary habits are one of the several factors that influence the levels of PAI-1. An inverse association exists between PAI-1 levels and the intake of carbohydrate and fibers,[12,13] while a positive correlation is reported with adipose tissue and alcohol intake.[14,15] TNF-α is a pro-inflammatory cytokine and its endogenous expression correlates positively with fat tissue mass and indices of adiposity.[16] TNF-α exerts numerous effects in adipose tissue, including the regulation of adipogenesis, lipid metabolism, insulin signaling and apoptosis.[17,18] CRP is a plasma protein that participates in the acute phase of the inflammatory response. Cytokines such as TNF-α and IL-6 up regulate the production of CRP following inflammatory stimuli.[19] The aim of the present study was to relate serum levels of aPAI-1, TNF-α, and CRP in Saudi adults and their association with dietary fatty acids intake.

METHODS AND MATERIALS

Subjects

In this cross-sectional study, a total number of 232 Saudi adults (122 men, and 110 women aged 18 to 60 years) were randomly selected from an existing database of more than 17,000 individuals, the Biomarker Screening in Riyadh (BSR), an on-going collaboration between the Biomarkers Research Program (BRP) of King Saud University and the Ministry of Health in Riyadh, Kingdom of Saudi Arabia (RIYADH Cohort). Subjects with morbid obesity (BMI >35 kg/m^2), with hepatic and/or renal dysfunction or with acute comorbidities were excluded from the study. Patients were recruited randomly from their homes using the cluster sampling strategy. They visited their nearest primary healthcare center (PHCC) which spans the entire Riyadh region. The population of each PHCC was taken as a cluster, and the allocations of the required numbers of patients were proportional to the populations served by the PHCCs. No expatriates were included in the conduct of this study. Ethical approval was obtained from the Ethics Committee of the College of Science Research Center of King Saud University, Riyadh, Saudi Arabia.[20]

Anthropometric data were collected by research nurses and expert physicians ascertained the following measurements: height (to the nearest 0.5 cm), weight (to the nearest 0.1 kg), waist and hip circumference utilizing standardized measuring tape in cm; and BMI (calculated as kg/m^2) as part of the long running Biomarker research program. The baseline investigation included a structured questionnaire and a clinical and functional examination.

Biochemistry

Fasting blood samples were collected and transferred immediately to a non-heparinized tube for centrifugation to separate the serum. Sample analysis was performed at the Biomarker Research Center, King Saud University, Riyadh, KSA. The quantification of serum aPAI-1, and TNF-α, were performed using multiple assay kits that utilize the Luminex xMAP technology platform (Luminexcorp, Austin, TX, USA). For parameters measured using the multiplex assay, the intra-assay variation was 1.4-7.9% and interassay variation was 21%. Minimum detectable concentrations (MDC) of TNF-α and PAI-1 were 0.14 pg/mL and 1.3 pg/mL, respectively. hsCRP was determined using enzyme-linked immunosorbent assays (ELISA) (Immunodiagnoztik AG, Bensheim, Germany) with an intra-assay variability of 5.5-6.0% and inter-assay variation of 11.6-13.8%.

Dietary intake

Data on dietary intake was assessed with a seven-day food records. For the verification and estimation of the size of individual portions, a picture booklet or household measurement units (graduated food models, bowl, cup, spoon and measuring cylinder) were provided to each participant with proper instructions. Subjects were instructed by trained nurses on how to fill out the food records. The completed food records by the participants were returned back to the nurse, which in turn was checked briefly by a nutritionist. Individual daily food consumption (total energy, fat, protein, carbohydrates, saturated fats, polyunsaturated fats, monounsaturated fats) were calculated from these seven-day records. Dietary intake was entered and analyzed for nutrient contents using a computerized food database from the US Department of Agriculture Health Tech Software Search and the Food Composition for the Middle East [21] as no other nutrient database with complete information on the composition of foods is available in Saudi Arabia. For traditional local foods, this software database is completed by information obtained from other local studies.[22, 23]

In order to query only the frequency of consumption of different foods items, irrespective of portion size, a checklist composed of a short, close-ended food list was also provided to the participants. The participants were instructed to place a check beside each food item they consume and respond to frequency categories as: less than 3, 4-5, 6-7 times per week and never. This checklist composed of 11 groups of food items based on similarity of nutrient profiles which further included many subgroups. These groups were: 1) grains and cereals; 2) fruits and fruit juices; 3) vegetables; 4) fat and oil; 5) meat; 6) fish; 7) eggs and dairy products; 8) nuts; 9) sweets and snacks; 10) sauce and spreads; 11) drinks and soups; and 12) fast foods.

Statistical analysis

Table 1 Anthropometric and dietary data of the subjects

	Women (n=110)	Men (n=122)	*p* value	DRI (g/d)† Women/Men	% Energy‡
Age	42.2 ± 9.7	47.0 ± 10.6	0.004	-	
BMI (kg/m^2)	30.4 ± 4.8	28.8 ± 4.5	0.009	-	
Waist (cm)	74.0 ± 24.3	73.4 ± 21.1	0.86	-	
Hips (cm)	96.9 ± 23.7	91.2 ± 30.6	0.11	-	
Energy (kcal)	2611 ± 865	2457 ± 788	0.15	1900/2900	
Protein (% kcal)	27.3 ± 8.1	29.5 ± 9.2	0.07	46/56	10-35%
Fat (% kcal)	23.1 ± 10.8	20.1 ± 9.8	0.16	100/60	20-35%
Carbohydrate (% kcal)	49.1 ± 9.1	50.8 ± 10.2	0.18	130/130	45-65%
SFA (g)	28.3 ± 1.3	25.1 ± 1.1	0.06	21/34	
MUFA (g)	27.2 ± 1.4	19.4 ± 1.1	<0.001	24/39	
PUFA (g)	11.2 ± 2.5	10.7 ± 2.3	0.11	11/17	
SFA (% kcal)	9.7 ± 1.9	9.2 ± 1.7	0.05		10%‡
MUFA (% kcal)	9.4 ± 1.0	7.1 ± 0.95	<0.001		15-20%§
PUFA (% kcal)	3.8 ± 1.0	3.9 ± 1.1	0.51		6-11%§, 2.5-3.5%¶
TNF-α (pg/mL)	6.8 ± 1.2	7.1 ± 1.4	0.08	-	-
CRP (μg/mL)	4.0 ± 1.8	3.6 ± 1.1	0.06	-	-
aPAI-1 (ng/mL)	21.2 ± 4.1	20.5 ± 3.8	0.17	-	-

Data are mean Mean ± standard deviation; *$p < 0.05$
†DRI (g/d): Dietary Reference Intakes for Energy, Carbohydrate, Fiber, Fat, Fatty Acids, Cholesterol, Protein, and Amino Acids (2002/2005); ‡values are same unless and otherwise stated as women/men.
‡U-AMDR; upper level of acceptable macronutrient distribution range, §AMDR; acceptable macronutrient distribution range, ¶AI; adequate intake: Report of a Joint FAO/WHO Expert Consultation on Fats and Fatty Acids in Human Nutrition, 10-14 November, 2008, WHO, Geneva, Switzerland.
TNF-α; tumor necrosis factor-alpha, CRP; C-reactive protein, aPAI-1; activated plasminogen activator inhibitor 1

Data were analyzed using SPSS for Windows version 16.0 (SPSS, Chicago, IL, USA). Data were expressed as mean±SD. The independent Student *t*-test was used to compare means of normally distributed data. Partial correlation was examined between the variables of interest adjusted for confounders such as age and BMI. The values for different fatty acids and adipokines were transformed logarithmically/square root to normalize data before correlations were examined and statistical analyses performed. Statistical significance was set at $p<0.05$. Power analysis was implemented in G*Power 3.1. Power analysis had shown that a total sample of 197 detected a power of 81% at alpha=0.05 level of significance.

RESULTS

Basic characteristics

There was significant difference in age, and body mass index (BMI), but not in waist and hip circumference in the male and female groups. Additionally, a significant difference was found in the total MUFA, with higher levels noted in women as compared to men ($p<0.001$). There was no gender difference in serum concentrations of aPAI-1, TNF-α and CRP (Table 1). The dietary intake of all fatty acids was low in men but higher in women as compared to dietary reference intakes (DRI) recommendation.[24] The percentage of energy (% kcal) provided by SFA was significantly higher in women as compared to men ($p<0.05$) and was almost close to upper level acceptable macronutrient distribution range (U-AMDR, 10%). The MUFA level was below AMDR (15-20%) in both groups, it was significantly higher in women than in men ($p<0.001$). In addition, PUFA level was found to be low as compared to AMDR (6-11%) but was in the range of adequate intake level (AI, 2.5-3.5%) in men and women.[25]

Correlation of dietary fatty acids with serum aPAI-1, TNF-α, and CRP

In women, greater intake of MUFA and PUFA was related to higher aPAI-1 ($p<0.04$ and 0.02), while in men, aPAI-1 was positively related only to MUFA intake ($p<0.04$). There was no significant effect in either men or women in aPAI-1 levels with total intake of saturated fatty acid (Table 2). Dietary fatty acids were not related to TNF-α in either men or women (Table 2). There was a significant negative association between serum CRP level ($p<0.001$) and SFA only in men (Table 2).

Food consumption pattern

Table 3 shows the frequency of consumption of food items among Saudi men and women. Daily consumption of grain and cereals was significantly more common in women than in men ($p<0.05$). Intake of some of the fruits, fruit juices and vegetables were also significantly higher in women as compared to men. Daily consumption of chicken was significantly higher ($p<0.001$) in men while consumption of canned meat ($p<0.001$) and sausage ($p<0.02$) was higher in women. Though not statistically significant, consumption of fish products were more common in women than in men. The food subgroups including, sweets, snack, sauces and drinks were significantly more often consumed by women, as compared to men. Overall, increased consumption of most food items was reported in women than in men.

DISCUSSION

The present results show a clear positive association between the intakes of MUFA, PUFA and the circulating aPAI-1 concentration. This pattern is present when the total amounts of saturated, monounsaturated, and polyunsaturated fatty acids in the diet are considered. The die-

Table 2 Partial correlation using aPAI-1, TNF-α, and CRP as dependent variables adjusted for age and BMI in men and women

	Total	Women (n=110)	Men (n=122)
aPAI-1			
Saturated FA	0.25	0.27	0.28
Monounsaturated FA	0.32*	0.59*	0.34*
Polyunsaturated FA	0.31*	0.65*	0.27
TNF- α			
Saturated FA	-0.02	0.04	-0.01
Mon unsaturated FA	-0.03	0.13	-0.07
Pol unsaturated FA	0.03	0.20	-0.05
CRP			
Saturated FA	-0.23	0.32	-0.38*
Monounsaturated FA	0.19	0.08	0.08
Polyunsaturated FA	0.11	0.45	-0.03

*$p < 0.05$

tary intake of SFA, MUFA and PUFA was below recommended levels in Men but higher in Women. The percentage of energy derived from protein, fat and carbohydrate was within the recommended range of 10-35%, 20-35% and 45-65%, respectively, as compared to dietary guidelines.[24] On the other hand, the percentage of energy provide by SFA (U-AMDR, 10%) was comparable as recommended for healthy American adults (<10% E)[26] and also corresponds to recommended daily intakes of SFA formulated by the Belgian Health Council (below10 en%).[27] The percentage of energy derived from MUFA ranged from 7-9% and was comparable to those of Japan (9%),[28] but was on the far lower end when compared to the USA (15%).[26] The percentage of energy derived from PUFA was below its recommended range (15-20%) and was lower as compared to Belgian (5.3-10.0 % E)[27] and American dietary intake guidelines (10% E)[26] but was close to dietary PUFA intakes (5%) as demonstrated in population-based survivor cohort study among older Australians.[29]

The rapid economic change in Saudi Arabia has affected daily dietary pattern by replacing the traditional diet containing high fiber content, low fat and cholesterol with a more Westernized diet with increased intake of fat, free sugars, sodium, and cholesterol.[30,31] An increase in daily per capita fat consumption (143%) and high intake of cholesterol[32] is reported from Middle Eastern countries along-with low consumption of fiber-rich foods such as whole grains, vegetables, and fruits.[33,34] The present study shows a non-significant but higher energy intake in women as compared to men.

A higher mean total fat intake by women than men might be explained by their more frequent consumption of fat-rich foods such as meat, eggs, fish, milk and dairy products. Moreover, high intake of drinks, fast foods, sweets and snacks may probably contribute to excess calories. A systematic review indicated that sedentary behaviors were found to be associated with lower fruit and vegetable intake and higher consumption of energy-dense snacks, drinks and fast foods.[35] For cultural reasons, the Saudi women, irrespective of the region, exhibit lower physical activity levels[36] and higher sedentary behaviour[37] as compared to men. During leisure time, they are mainly involved in watching television and eating fast food and snacks which could lead to excessive food intake and this dietary habit has also been associated with increasing rate of obesity in Saudi women.[38] Supporting the above result, a dietary study among college students (17-25 yr) showed the same trend and exhibited that 98% of the female students ate fast food rich in fat and calories from restaurants.[39] A cross sectional study among Saudi youth and adults aged 15yr and over demonstrated the prevalence of overweight (BMI 25-30) that was higher in men than women, while obesity (BMI >30) was higher among women than in men.[40] Additionally, a recent systematic review in Gulf Co-operation Council States,[41] reported a prevalence of overweight and obesity in adults of 25-50% and 13-50%, respectively, with a higher prevalence of obesity amongst women. The present study supports the above findings[40,41] showing that although non-significant, BMI in men (28.8 ± 4.5) is lower as compared to women (30.4 ± 4.8). Depending on gender, not much evidence is present about the intake of fatty acids in Saudi adult population. The dietary intake of fruits, whole milk and red meat (among sources of MUFA) has been demonstrated to be higher in Saudi men as compared to women.[36] On the contrary, one recent study demonstrated higher caloric intake of animal proteins and fats among men than women (p=0.001 for proteins, and p=0.035 for fats) but a significantly higher macronutrients caloric intakes were detected in women than in men (p=0.00).[42] In the present study, the lower fatty acid intake including MUFA in men is partly supported by the above finding.[42] As far as gender difference is concerned, the level of PAI-1 has been shown to be affected by genetic factors and is gender dependent.[43] There are contradictory findings regarding the gender-dependent effect of different fatty acids on PAI-1 levels and other fibrinolytic variables. For example, the dietary consumption of SFA, MUFA, and PUFA showed no differential effect on plasma levels of PAI-1 activity in both men and women.[44,45] On the other hand, Byberg and colleagues reported an increase in PAI-1 concentrations with augmented dietary unsaturated fatty acids while such an effect was not observed with SFA.[46] Tholstrup and colleagues showed lesser effect of dietary SFA on fibrinolysis as compared to dietary unsaturated fatty acids in healthy young men.[47] The present results partially supports the above findings [46] showing high serum PAI-1 level with augmented intake of unsaturated fatty acids (but not with SFA), but contradicts in a way that this is

Table 3. Food consumption pattern based on various food groups and subgroups in Saudi men (n=122) and women (n=110)

Food group and sub group	Women - Frequency (%)				Men - Frequency (%)				*p* value
	<3 Times/week	4-5 Times/week	6-7 Time/week	Never	<3 Times/week	4-5 Times/week	6-7 Time/week	Never	
Grains and cereals									
White Rice	71.1	6.6	4.4	17.9	67.1	7.8	6.7	18.4	0.86
Boiled Rice	74.4	2.2	5.5	17.9	63.1	3.9	1.3	31.7	0.07
Pasta	75.5	8.8	5.5	10.2	76.3	5.3	1.3	17.1	0.02
Bread	32.2	30.0	37.8	-	31.6	15.7	48.6	4.1	0.01
Cornflakes	77.7	2.2	1.1	19.0	65.7	-	2.6	31.7	<0.001
Nuts	82.2	2.2		15.6	65.7	2.6	-	31.7	0.01
Flakes	80.0	-	1.1	18.9	68.4	-	2.6	29.0	0.16
Fruits and fruit juices									
Apples	74.4	18.8	5.5	1.1	73.7	18.4	7.9		0.620
Pear	87.7	8.8	3.3		92.1	3.9	3.9		0.170
Orange	75.5	22.2	2.2		61.8	27.6	10.5		0.020
Banana	63.3	31.1	5.5		59.2	32.8	7.9		0.63
Canned Juice	86.6	1.1	4.4	7.7	68.4	9.2	1.3	21.0	<0.001
Fresh Juice	76.6	7.7	4.4	11.1	64.4	7.9	2.6	25.0	0.05
Fruit Syrup	82.2	3.3	3.3	11.1	69.7	5.3	1.3	23.7	0.04
Vegetables									
Potato	68.9	4.4	2.2	24.4	69.7	3.9	2.6	23.7	0.98
Peas	91.1	1.1	1.1	5.6	76.3	2.6	2.6	18.4	0.03
Green Vegetable	44.4	27.8	25.5	3.3	50.0	26.3	19.3	3.9	0.52
Carrot	66.7	13.3	13.3	6.7	55.2	15.7	9.2	19.7	0.01
Sweet Corn	76.6	2.2	-	21.1	69.7	1.3	1.3	27.6	0.33
Baked beans	81.1	-	-	18.9	65.8	1.3	-	32.8	0.02
Falafal	80.0	3.3	-	16.6	80.3	3.9	1.3	14.4	0.56
Homos	74.4	5.5	3.3	16.6	75.0	7.8	2.6	14.4	0.77
Onions	50.0	14.4	28.8	6.6	59.1	11.8	18.4	10.5	0.11
Fat and oil	40.3	18.3	9.8	31.6	38.6	17.6	8.2	35.6	0.93
Meat									
Beef	81.1	3.3	-	15.5	71.0	2.6	-	26.3	0.12
Sheep	57.7	21.1	11.1	10.1	57.8	16.0	21.0	5.2	0.11
Chicken	28.3	42.7	27.9	1.1	56.5	13.3	28.9	1.3	<0.001
Canned Meat	70.2	1.1	27.6	1.1	65.7	5.2	1.3	27.8	<0.001
Sausage	83.3	1.1	-	15.5	72.4	-	2.6	25.0	0.02
Liver/Kidney	74.4	-	2.2	23.3	67.1	3.9	3.9	25.0	0.14
Fish									
White Fish	71.1	2.2		26.6	69.8	2.6	1.3	26.3	0.60
Fish Finger	75.5	-	-	24.5	68.4	-	-	31.5	0.21
Fatty Fish	80.0	-	1.1	18.9	68.4	-	1.3	30.3	0.11
Canned Fish	83.3	1.1	1.1	14.4	69.7	1.3	1.3	27.6	0.11
Tuna	74.4	1.1	1.1	22.2	67.1	3.9	3.9	25.0	0.45
Shell Fish	80.0	-	-	20.0	71.1	1.3	-	26.3	0.19

Table 3. Food consumption pattern based on various food groups and subgroups in Saudi men (n=122) and women (n=110) (cont.)

Food group and subgroup	Women - Frequency (%)				Men - Frequency (%)				*p* value
	<3 Times/week	4-5 Times/week	6-7 Time/week	Never	<3 Times/week	4-5 Times/week	6-7 Time/week	Never	
Eggs and Dairy products									
Eggs	67.7	25.5	6.6		60.5	32.6	6.5		0.45
Milk	65.5	15.5	13.3	5.5	59.2	22.3	17.1	1.3	0.19
Cheese	83.3	-	2.2	14.4	76.3	2.6	-	21.0	0.07
Liquid cheese	74.4	11.1	8.8	5.5	78.9	9.2	5.3	6.5	0.72
Labana	71.1	4.4	3.3	21.1	82.9	2.6	1.3	13.1	0.18
Yogurt	76.6	3.3	2.2	17.7	75.0	6.5	2.6	15.7	0.75
Nuts	68.8	6.6	-	24.4	72.4	3.9	2.6	21.0	0.31
Sweets and snack foods									
Cakes	81.1	-	-	18.8	67.1	-	1.3	31.5	0.02
Arabic sweets	78.8	-	1.1	20.0	71.0	3.9	-	25.0	0.05
Local sweets	67.3	1.3	1.1	30.3	63.1	2.6	1.3	32.8	0.88
Haenni	76.6	2.2	-	21.1	67.1	1.3	-	31.5	0.27
Caramel custard	76.6	3.3	-	20.0	68.4	1.3	-	30.3	0.14
Chocolate	68.8	4.4	7.7	18.8	67.1	7.9	2.6	22.4	0.23
Miscellaneous: sauce & spreads									
Sauce	83.3	-	-	16.6	69.7	1.3	-	28.9	0.02
Mayonnaise	72.2	1.1	3.3	23.3	71.0	1.3	1.3	26.3	0.78
Ketchup	67.7	6.6	2.2	23.3	67.1	2.6	3.9	26.3	0.36
Cream salad	77.7	-	-	22.2	68.4	1.3	1.3	28.9	0.13
Salad sauces	81.1	-	1.1	17.7	65.8	1.3	-	32.8	0.01
Drinks and soups									
Soft Drinks	73.5	5.5	7.7	13.3	60.2	7.9	10.5	21.0	0.17
Diet Soft Drinks	76.6	-	2.2	21.1	69.7	2.6	-	27.6	0.10
Energy drinks	82.2	-	1.1	16.6	64.4	-	2.6	32.9	0.01
Vegetable Soup	83.3	4.4	7.7	4.4	61.8	7.9	10.5	19.7	<0.001
Cream soup	73.3	5.5	-	21.1	68.4	2.6	2.6	26.3	0.15
Lentil Soup	75.5	3.3	1.1	22.2	71.0	2.6	-	26.3	0.39
Fast foods									
Pizza	67.7	7.7	-	24.4	68.4	2.4	-	28.9	0.11
Burger	81.1	1.1		17.7	73.7	-	-	26.3	0.09

observed only in women and not in men. A possible reason for this discrepancy could be the high level of dietary unsaturated fatty acids in women as compared to men (Table 1).

Previous studies have demonstrated significant, as well as non-significant association between diet and levels of CRP, as well as other inflammatory markers.[48-50] As far as MUFA and PUFA are concerned, a weak inverse relation with CRP exist in women,[51] and a negative association between PUFA (omega-3) and CRP [52] has been replicated in men,[53] as well as in women.[54] However, Arya and colleague showed no significant relation between CRP levels and the daily intake of different fatty acids.[55] Supporting the later study, the present result identified no significant association between serum CRP and intake of either PUFA or MUFA.

Unlike unsaturated lipids, saturated fatty acids induce the activation and expression of several inflammatory markers.[56,57] As far as the circulating level of CRP is concerned, the published results are still not conclusive. Saturated fat consumption was modestly associated with high CRP levels in NHANES 1999-2000 with other fatty acids (MUFA, PUFA) showing inverse as well as positive (trans fatty acid) association with CRP levels.[58] Baer and colleagues showed that the consumption of SFA does not affect the level of CRP when compared to carbohydrates.[59] In addition, the study in adult men by Lithander and colleagues showed no significant between-treatment effects on circulating TNF-α, IL-6, and hsC-RP with high saturated:unsaturated fat (SFA:USFA) or lower SFA: USFA administration.[60] A report showed that for a women on a low fat diet [61] a greater SFA intake was inversely associated with progression of coronary atherosclerosis, described as an American paradox.[62] Hence, the effect of saturated fat cannot be independent and should always be considered with specific dietary conditions. In addition, the chain length of SFA and its presence (it is alone or added in the foods) could affect its atherogenic properties.[63,64] In the present study, a negative correlation was noted between SFA and CRP only in men, showing that a higher level of SFA led to lower circulating CRP concentrations. Our results do not support the above findings [62] in a direct manner, but it indicates that dietary SFA is associated with reduction of CRP levels, a good predictor of clinical complications of atherosclerosis. However this relation needs further confirmation regarding gender dependency, as the dietary intake of SFA in present study was already lower in men as compared to the recommended DRI values.

Being a cross sectional study, the results cannot show a causal relationship between dietary fatty acids and procoagulation and inflammatory factors. Another limitation in this study is self-reported dietary intake. This could be a possible reason for reported lower energy intake in men indicating the under-reporting of nutrient intakes as compared to women. Further studies are needed using a larger cohort to confirm the findings. Based on our observations, we conclude that the level of unsaturated fatty acids exerted a significant positive effect on aPAI-1 in men (MUFA) and women (MUFA, PUFA) while SFA showed negative effects on serum CRP concentrations only in men.

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AUTHOR DISCLOSURES

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Original Article

Association of dietary fatty acids intake with pro-coagulation and inflammation in Saudi Adults

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在沙烏地阿拉伯人膳食中脂肪酸攝取與促凝血及發炎之相關

本研究目的是了解在沙烏地阿拉伯成人中，膳食脂肪酸的攝取，如：飽和、多元不飽和以及單元不飽和脂肪酸，是否為發炎反應的調節物質或影響促凝血。本研究檢測發炎因子像是 C-反應蛋白、腫瘤壞死因子-α 和活化的 I 型纖溶酶原激活物抑制因子(aPAI-1)。在此橫斷面研究中，以隨機抽樣，總計 232 位沙烏地阿拉伯成人參與，年齡介於 18 到 60 歲之間。以獨立 Student t 檢定比較常態分佈資料的平均值。使用斯皮爾曼係數來確定變項間的相關。進行相關性測定之前，不同的脂肪酸和脂肪因子的數值先轉化成對數/平方根，將數據常態化，便於統計分析。統計上的顯著設定為 p 值小於 0.05。研究結果顯示，飲食攝取的多元和單元不飽和脂肪酸與 aPAI-1 有顯著的正相關，但飽和脂肪酸與其則無相關。另一方面，男性飲食攝取的飽和脂肪酸顯示與血清中 C-反應蛋白呈現負相關。膳食不飽和脂肪酸可能與產生促凝血因子而不增加促發炎因子的分泌有關；雖然飽和脂肪酸對 aPAI-1 沒有影響，但與發炎因子 C-反應蛋白呈現負相關。結論是，飲食攝取脂肪酸在成年男、女性中對發炎過程的影響可能有別。需要未來進一步的研究確認目前的研究結果。

關鍵字：膳食脂肪酸、脂肪因子、I 型纖溶酶原激活物抑制因子、促發炎因子、C反應蛋白