

## Relationship between Smoking, Metabolic Syndrome and Atherogenic index

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### Abstract

**Objective:** This study was done to explore the relationship between components of metabolic syndrome and smoking.

**Materials and Methods:** In this analytical cross-sectional study in Ahvaz, south west of Iran, the gathering data sheet was completed. Body mass index, abdominal and waist circumference, Fasting Blood sugar, Triglyceride, total cholesterol, LDL and HDL levels, systolic and diastolic blood pressure were measured. Atherogenic index, predictor of myocardial infarction, and Brinkman index to investigate cumulative impact of cigarette smoking was calculated.

**Results:** Of the 944 participants, 16.1% were smokers. Among male participants, 24.8% and in female participants, 8.7% were smokers. There was no significant correlation between cigarette smoking and metabolic syndrome. Systolic blood pressure, waist circumference and triglyceride levels were significantly higher in smokers. Comparison of Atherogenic index in participants with and without metabolic syndrome in smokers and non-smokers showed significant difference. In male participants, Atherogenic index was higher than female. Brinkman index showed no significant relationship with metabolic syndrome and its components.

**Conclusion:** Smoking does not show relationship with metabolic syndrome, but has a relationship with mean systolic blood pressure, serum triglyceride levels and waist circumference. Atherogenic index was higher in participants with metabolic syndrome, cigarette smoking and male gender. Brinkman index had no correlation with metabolic syndrome and its components.

**Keywords:** Metabolic syndrome, Cigarette, Atherogenic index, Brinkman index, Waist circumference

### Introduction

Metabolic syndrome or X syndrome is a group of cardiovascular and diabetes risk factors including dysglycemia, high blood pressure, elevated triglyceride level, elevated LDL level, decrease in HDL cholesterol level and obesity

especially in the abdominal area(1). Although there are various definitions for metabolic syndrome, the most practical method for clinical diagnosis is the use of Adult treatment Panel III (ATP III) criteria, in which an affected individual must have at least 3

existing cardiovascular risk factors simultaneously, smoking and alcohol consumption. Also environmental stress can increase the risk of cardiovascular diseases (1). Smoking is also a major risk factor for atherosclerosis and CVD (coronary vascular disease). Smokers have impaired lipoprotein metabolism and endothelial function (2). The reported prevalence of metabolic syndrome in various regions of the world is 12.8% to 41.1% (3,4). Iranian studies reported the prevalence of metabolic syndrome between 21.9% to 33.7%. The prevalence of metabolic syndrome is increasing worldwide (1,2,5,6). Unhealthy life style which causes metabolic syndrome are lack of physical activity and high calorie foods (8). In fact, smoking can increase triglycerides and decrease HDL and it has a strong correlation with total cholesterol and LDL levels (7). However, evidence suggests that smokers are more likely to develop insulin resistance and hyperinsulinemia (8).

Nicotine increases basal metabolism rate and can reduce the appetite. This can be the cause of lower weight in smokers compared to non-smokers. Also causes increase in weight after cigarette cessation. A mistaken belief among smokers is that smoking is good for weight control. Actually, smoking affects body fat distribution and is associated with abdominal fat and insulin resistance (9).

Based on this evidence, smoking is a major, changeable risk factor for metabolic syndrome (8). The aim of this study was to investigate the relationship between metabolic syndrome components and smoking in individuals older than 20 years in Ahvaz, south western region of Iran.

## Materials and Methods

This analytical cross-sectional study was performed with random cluster sampling method in 6 health care centers of Ahvaz, Iran. Written informed consent was obtained from each participant.

A checklist including: age, sex, smoking, amount of smoking, blood pressure, weight,

height, body mass index (BMI), abdominal and waist circumference was completed for each participant. Blood pressure was measured by a standard sphygmomanometer after 15 minutes rest in a sitting position. Blood pressure was measured twice with at least 30 minutes intervals between two measurements and the mean of two blood pressure measurements, was considered as participant's blood pressure. Anthropometric measurements were taken after removing shoes and wearing a light dress. Waist circumference was measured at the midpoint between the lowest rib and the upper border of the right iliac crest.

Blood samples were taken in the morning after 12 hours of fasting. Triglyceride (TG), Fasting Blood Sugar (FBS), Cholesterol and high density lipoprotein (HDL) were measured using an enzymatic colorimetric method with Pars Azmoon kit. (With Biotechnical instruments model BT-3000 Germany)

For diagnoses of metabolic syndrome at least three of the following five components were considered necessary (according to ATP III criteria 2005) (10,11).

- 1- Abdominal obesity (waist circumference  $\geq 102$  cm in men and  $\geq 88$  cm in women)
- 2- TG  $\geq 150$  mg/dl or anti-lipid medication
- 3- HDL  $\leq 40$  mg/dl in men and  $\leq 50$  mg/dl in women or anti-lipid medication
- 4- BP  $\geq 130/85$  mm/hg or anti-hypertensive medication
- 5- (FBS)  $\geq 100$  mg/dl, history of diabetes mellitus or anti-glycemic medication

Smoking was defined as present cigarette smoking. The first time smoking age and pack/years history was recorded.

The Atherogenic index is a strong predictor of myocardial infarction (12) that was calculated by the following formula:

$$\text{Atherogenic index} = \frac{(\text{Total cholesterol} - \text{HDL cholesterol})}{\text{HDL cholesterol}}$$

The Brinkman index (BI) is used to investigate cumulative amount of cigarette smoking (13), it was calculated by the following formula and participants were divided into two groups (BI < 600 and BI  $\geq 600$ ):

Brinkman index (BI) = (Years of smoking) x (Number of cigarettes used daily)

Data are expressed as mean  $\pm$  standard deviation and analyzed by spss19 software.  $P < 0.05$  was considered as statistically significant. For comparison of findings in different groups independent T test, chi square and Fisher's exact test was used.

## Results

Of the 944 individuals studied, 446 participants (47.2%) were male and 498 participants (52.8%) were female. Prevalence of metabolic syndrome according to ATP III criteria (2005) was 22.8% (15.9% male and 29.1% female) which showed significant differences between gender groups ( $P = 0.0001$ ). Prevalence of metabolic syndrome components in the studied population were: 29.2% for abdominal fat, 40.7% for high triglyceride, 40.2% for low HDL, 15.4% for high blood pressure and 37.8% for abnormal fasting blood glucose levels (4% in diabetes and 21.5% in impaired fasting blood glucose). One hundred and fifty three of all participants (16.1%) were smokers. About 110 (24.8%) of male participants and 43 (8.7%) of female participants were smokers. Smoking was significantly more prevalent among men compared to women ( $P = 0.0001$ ).

The mean age of starting smoking was  $21.29 \pm 7.7$  in the total study population ( $21.34 \pm 8.5$  years in men and  $21.17 \pm 4.8$  years in women). Significant difference was not found between age of starting smoking in men and women ( $P = 0.87$ ). The average prevalence

of smoking in different age groups is shown in table 1.

Metabolic syndrome was detected in 26% of smokers and 22.2% of non-smokers that showed no significant statistical difference ( $P = 0.31$ ). Metabolic syndrome frequency did not show a significant difference in smoker and non-smoker in both male and female participants ( $P = 0.18$  and  $0.08$  respectively). Smoking did not increase the risk of metabolic syndrome (OR: 0.81; 95% (CI): 0.54-1.21).

Average cigarettes smoked per day (in total studied population) was  $9 \pm 10.4$ . In smokers without metabolic syndrome it was  $8.8 \pm 10.4$  and in smokers with metabolic syndrome it was  $7.9 \pm 10.4$ . The least was one cigarette daily and the most was 60 daily. Statistical test did not show a significant difference between daily frequency of smoking in metabolic syndrome and non-metabolic syndrome participants ( $P = 0.65$ ).

The mean of smoking years in total was  $21.2 \pm 7.7$ . In participants without metabolic syndrome it was  $20.9 \pm 6.7$  years and in participants with metabolic syndrome  $21.4 \pm 7.6$  years that did not show a significant difference ( $P = 0.67$ ). Anthropometric and laboratory parameters in smokers and non-smokers are shown in Table 2. Comparison of metabolic syndrome components in smokers and non-smokers were shown in Table 3.

Systolic blood pressure, waist circumference and serum triglyceride level were significantly higher in smokers than non-smokers

**Table 1. Prevalence of cigarette smoking in different age groups**

Age	Total number	Smoker	Non smoker
<b>Men</b>			
20-29	86	19 (22.1%)	67 (77.9%)
30-39	80	29 (36.3%)	51 (63.8%)
40-49	112	26 (23.2%)	86 (76.8%)
50-59	95	21 (22.1%)	74 (77.9%)
60-69	44	11 (25%)	33 (75%)
70 $\geq$	19	1 (5.3%)	18 (94.7%)
<b>Total</b>	436	107 (24.5%)	329 (75.5%)
<b>Women</b>			
20-29	119	10 (8.4%)	109 (91.6%)
30-39	120	1 (0.8%)	119 (99.2%)
40-49	117	11 (9.4%)	106 (90.6%)
50-59	84	12 (14.3%)	72 (85.7%)
60-69	37	5 (13.5%)	32 (86.5%)
70 $\geq$	11	4 (36.4%)	7 (63.6%)
<b>Total</b>	488	43 (8.8%)	445 (91.2%)

**Table 2. Clinical anthropometric and laboratory parameters in smokers and non-smokers**

TEST	Non-smokers	Smokers	P-value
Fasting blood sugar	105.8±44.4	107.35±37.8	0.69
Triglyceride	156.9±106	188.7±127.4	0.001
Total cholesterol	204.3±44.7	207.45±47.5	0.44
LDL cholesterol	116±34.2	116.2±37.3	0.24
HDL cholesterol	57.6±12.2	55.4±14.4	0.05
BMI	27±4.6	27.1±5	0.72
Abdominal circumference	96.2±13.2	96.4±12.4	0.83
Waist circumference	87.3±12.1	89.9±11	0.013
Systolic blood pressure	114.3±21	119.4±23.9	0.006
Diastolic blood pressure	71.2±15.3	71.7±14.5	0.69

**Table 3. Comparison of metabolic syndrome components in smoker and non-smoker participants**

Metabolic syndrome components	Smokers (n=95)	Non-smokers (n=842)	P-value
Waist circumference ≥102cm in men and ≥88 in women	43(28.1%)	230(29.4%)	0.75
HDL ≤40 mg/dl in men and ≤50 in women	56(36.6%)	319(40.7%)	0.34
TG ≥150 mg/dl	70(47.6%)	301(39.2%)	0.058
FBS ≥100 mg/dl	65(43.3%)	287(36.8%)	0.13
BP ≥130/85 mmHg	17(11.3%)	124(16.1%)	0.13

( $P=0.006$ ,  $0.013$  and  $0.001$  respectively).

There was not any significant difference in blood sugar, cholesterol, LDL and HDL levels and diastolic blood pressure between the two groups ( $P=0.69$ ,  $0.44$ ,  $0.24$ ,  $0.05$  and  $0.69$  respectively).

There was no significant correlation between smoking and components of metabolic syndrome (Table 3).

Comparison of Atherogenic index among metabolic syndrome and non-metabolic syndrome participants and between smokers and non-smokers is shown in table 4 and comparison between two genders is shown in table 5.

The mean of Atherogenic index in all participants with metabolic syndrome was significantly higher than participants without metabolic syndrome ( $P=0.0001$ ).

In participants without metabolic syndrome the mean of Atherogenic index in smokers was  $2.7 \pm 0.9$  and in non-smokers was  $2.4 \pm 0.7$  that showed significant difference ( $P=0.004$ ).

There was no significant difference in Atherogenic index between smokers and non-smokers with metabolic syndrome ( $P=0.47$ ).

In male participants regardless of smoking and having metabolic syndrome, Atherogenic index was higher than female participants (Table 5).

The Brinkman index (BI) showed no significant relationship with metabolic syndrome in both groups ( $BI < 600$  and  $BI \geq 600$ ) ( $P=0.99$ ).

Also it showed no significant relationship with components of metabolic syndrome such as waist circumference, triglyceride level, HDL level, FBS, blood pressure ( $P=0.99$ ,  $0.24$ ,  $0.95$ ,  $0.95$ ,  $0.99$  respectively).

## Discussion

In this study prevalence of metabolic syndrome according to ATP III criteria (2005) was 22.8%. Of all participants 16.1% were smokers. The frequency of metabolic syndrome was not statistically different in smoker and non-smoker participants.

In Miyatake and colleagues study the prevalence of metabolic syndrome was higher in smokers than non-smokers (13). Lee et al. study also showed that the relative risk of metabolic syndrome in smokers who use more than 20 pack/year in comparison to non-smokers was 1.9 (95% CI 1.1-3.7) (14). In Chen et al. study the prevalence of metabolic syndrome in active smokers compared to non-smokers or former smokers was higher (15). In Ishizaka et al. study the prevalence of metabolic syndrome was higher in active

**Table 4. Comparison of Atherogenic index between metabolic syndrome and non-metabolic syndrome participants among smoker and non-smoker group**

Variable	The mean of atherogenic index in Syndrome (+)	The mean of atherogenic index in Syndrome (-)	P-value
Smoker	3.3±0.8	2.7±0.9	0.001
Non-smoker	3.1±0	2.4±0.7	0.0001
All participants	3.1±0.8	2.5±0.8	0.0001
	P=0.47	P=0.004	

**Table 5. Effect of metabolic syndrome and cigarette smoking on atherogenic index in two genders**

Variable	The mean of AIS*(-), S*(-)	The mean of AIS*(-), S*(+)	The mean of AIS*(+), S*(-)	The mean of AIS*(+), S*(+)
Men	2.7±0.7	3±0.8	3.4±0.7	3.4±0.8
Women	2.2±0.6	2±0.6	3±0.8	3±0.8
P value	0.0001	0.0001	0.003	0.07

\*AIS: Atherogenic Index in Syndrome, \*\*S: Smoking

smokers and former smokers who were smoker more than 10 years (16).

Santose et al. study showed no correlation between metabolic syndrome and smoking (17). One study in Iran showed higher rate of metabolic syndrome in non-smokers than smokers (7). This discrepancy maybe because of ethnic or geographic difference or higher rate of metabolic syndrome in women than men in Iran (2,5,6) and lower rate of smoking in female than male participants in this study.

The results of this study showed that smoking has no impact on components of the metabolic syndrome but mean systolic blood pressure, serum triglyceride and waist circumference were significantly higher in smokers than non-smokers.

In fact, smoking can increase triglycerides and decrease HDL. Smoking has a strong correlation with total cholesterol and LDL levels (7).

Oh et al. study showed that high triglyceride levels, low HDL levels, and abdominal obesity were associated with smoking, which is comparable with our study. Oh et al. Study also did not show a correlation between smoking and high fasting blood sugar and high blood pressure (8). Eliasson et al. study showed a relationship between smoking and high triglyceride and LDL levels (20); in this study a relationship was just seen with serum triglyceride. In Chen et al. study a significant correlation between metabolic syndrome, low HDL and high triglyceride levels were found (15) that are to some extent comparable with

our study. In Wareham et al. study, smokers had lower BMI than non-smokers which were not in accordance with our study (18).

In this study FBS levels were not significantly correlated with smoking, but Sargent et al. study showed that HbA1c was lower in non-smokers and had a dose dependent relationship between HbA1c levels and number of daily cigarette smoking (19) which was not investigated in this study.

Smoking is also a major risk factor for atherosclerosis and CVD (coronary heart disease). Smokers have impaired lipoprotein metabolism and endothelial function (2). Atherogenic index is a strong predictor of myocardial infarction (12). Comparison of Atherogenic index in participants with and without metabolic syndrome showed higher Atherogenic index in participants with metabolic syndrome ( $P=0.0001$ ).

In Miyatake et al. study Atherogenic index in smokers with metabolic syndrome was higher in men than other groups and in non-smokers with metabolic syndrome was higher in women. In this study the mean of Atherogenic index in non-smokers with and without metabolic syndrome showed significant difference between two genders ( $P\leq 0.003$ ). In smokers without metabolic syndrome the difference in both genders was significant ( $P=0.0001$ ) but in smokers with metabolic syndrome did not show significant difference ( $P=0.07$ ). The effect of smoking and metabolic syndrome on Atherogenic index was notable



in men. So smoking and metabolic syndrome were important risk factors for atherosclerosis. Brinkman index (BI) is used to investigate cumulative amount of cigarette smoking (13). In this study BI showed no significant relationship with metabolic syndrome; But Miyatake et al. study reported significant correlation between metabolic syndrome and BI. We suggest for future studies larger sample size and more female smoker participants.

## Conclusion

The findings suggest that although cigarette smoking does not show relationship with metabolic syndrome, but has a relationship with mean systolic blood pressure, serum

triglyceride levels and waist circumference. Atherogenic index was higher in participants with metabolic syndrome, cigarette smoking and male gender. So smoking and metabolic syndrome were important risk factors for atherosclerosis. Brinkman index had no correlation with metabolic syndrome and its components.

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