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**Original Article**

# Factor Analysis of Metabolic Syndrome among Iranian Male Smokers

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## Abstract

**Background:** Recent studies show cardiovascular disease (CVD) risk factors have the tendency to intermingle. Integration between some biological and homodynamic risk factors have made the new hypothesis for etiology of CVDs. The aim of this study was to determine the clustering pattern of metabolic variables and left ventricular (LV) mass among smoker and non-smoker individuals and the interrelationship between these risk factors.

**Methods:** 50 smokers and 50 non-smoker healthy males aged 20 to 60 yrs participated in the study. After completing a WHO standard questionnaire regarding smoking habits, medications and history of other diseases, physical fitness, blood pressure, fasting blood sugar, plasma insulin, total cholesterol, HDL, triglycerides and lipoprotein (a). A 12-lead electrocardiography and echocardiography studies were done to determine the LV mass.

**Results:** No significant differences were found between smokers or non-smokers in regard to the studied metabolic variables except for LV mass (228.4±48.6 *vs*. 196.4±57.3 g; $P<0.05$). The interrelationship of metabolic syndrome variables and other CVD risk factors among smokers was greater than non-smokers ($P<0.05$). In the factor analysis, three components were retained both for smokers and non-smokers. A total of 59.5% of variance was explained in data for all subjects.

**Conclusions:** Smoking has probably no relationship with components of metabolic syndrome; however the correlation between these risk factors and other homodynamic measures and LV mass was greater among smokers than non-smokers. No single factor can explain the clustering of the metabolic syndrome among smokers.
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**Keywords** ● Metabolic syndrome ● factor analysis ● cardiovascular diseases ● risk factors ● smoking

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## Introduction

Cardiovascular diseases (CVDs) including coronary artery disease (CAD) are the major cause of mortality and disability in developed and developing countries.[1,2] CAD is highly prevalent and is the single greatest cause of mortality in Iran.[3,4] The main known CAD risk factors are

dyslipidemia, hypertension, smoking and diabetes.[5] High insulin and lipoprotein levels as well as increased muscle mass of the left ventricle (LV) are considered among CAD risk factors as well.[5]

Some people have a set of major, life-habit, and emerging risk factors that constitute a condition called metabolic or insulin resistance syndrome.[6] People with metabolic syndrome are at increased risk for developing diabetes mellitus,[7] and CVDs,[8] as well as increased mortality from CVDs and all causes.[9]

Despite intensive prevention and education programs, smoking remains one of the classical risk factors for cardiovascular disease.[10] Enhanced oxidative stress, chronic inflammation, hypercoagulation and endothelial dysfunctions are found to be involved in vascular damage associated with smoking.[11] Several reports indicating that the increased cardiovascular risk factors in smokers might be related to a higher degree of insulin resistance,[11-13] and thus the development of the metabolic cardiovascular syndrome.[14] Considering smoking as a main CAD risk factor and its probable role in causing metabolic disorders,[10-12] this study was conducted to determine whether the clustering of metabolic variables and LV mass is greater in smokers compared with non-smokers and if there is any interrelationship between these risk factors.

## Patients and Methods

The study was approved by the ethical committee of Isfahan University of Medical Sciences, Isfahan, Iran. In a study, 50 male smokers (defined as current smokers with a history of smoking at least 10 pack years) between 20 and 60 years old and 50 male non-smokers as control group (who have never been smokers) participated. All individuals gave their informed consent after being advised about the study. They were recruited from male volunteers consulting Isfahan Cardiovascular Research Center following a public announcement through university health centers.

Before entering the study, each individual underwent physical examination and was interviewed about smoking habits, drug medication and history of other diseases. Exclusion criteria included those participants with evidence of known cardiovascular, diabetes and metabolic diseases, or using drugs that likely affecting blood level of variables under investigation. Clinical examination consisted of measurements of height, weight, waist and pelvic circumference, blood pressures and pulse rate using World Health Organization (WHO) standard methods.[15] Blood samples were obtained after 12 hrs fasting and blood glucose (FBG), plasma total cholesterol (TC) and triglycerides (TG) was measured using standard enzymatic methods.

High-density lipoprotein cholesterol (HDL) was determined after dextran–$Mg^{2+}$ precipitation and low-density lipoprotein cholesterol (LDL) was calculated according to the Friedewald formula if the triglyceride level was ≤ 400 mg/dl.[16] Fasting serum insulin and serum lipoprotein (a) (LP-a) levels were measured by reliable and standardized enzyme-linked immuno sorbend assay (ELISA) procedure and Marco LP-a kits. Insulin resistance (IR) was calculated by the homeostasis model assessment (HOMA) using the following formula as stated by Friedewald et al.[16] Assay performance was monitored every 20 tests using lipid control serum.

The intra– and inter–assay coefficients of variation were 1.64% and 2.9% for FBG, 4.2% and 3.03% for TC, 10.6% and 11.8% for HDL, 2.3% and 3.5% for LDL, 2.8% and 2.7% for TG, 4% and 6.3% for insulin and 3.3% and 4.5% for Lp-a, respectively. A 12-lead ECG was done for each participant, and then all ECGs were studied using the Minnesota codes.[17]

Echocardiographic study was done for all participants to determine the left ventricular (LV) muscle mass and to assess the function of the heart. The LV internal dimension (LVID) at the end of left ventricular diastole (LVEDD), LV septal thickness, LV posterior wall thickness (PWT), interventricular septal thickness (IVST) and ejection fraction were measured. LV mass was calculated using the following formula.[18]

$$LVM=1.05\ [(LVID+IVST+PWT)^3 - LVID^3]$$

While the heart specific gravity equals 1.05 gr/$cm^2$.

*Statistical analysis*

Data are presented as mean±SD. Mean values were compared using *Student's* t-test. Mann-Whitney U test, correlation coefficient, multiple regression and logistic analysis as well as path analysis were used to determine the independency and dependency of studied variables. P value less than 0.05 was considered statistically significant. Factor analysis was used for clustering of variables. Factor analysis, a linear method of data reduction is a three step process: (i) extraction of the initial component, (ii) transformation (rotation) of the principal component and (iii) interpretation of the factors. An orthogonal rotation (Varimax rotation) was used to obtain the factors that maintaining their independence and an absolute loading value >0.40 was used to interpret the resulting factor pattern.[21]

**Table 1:** Cardiovascular disease risk factors distribution among study population (smokers *vs*. non-smokers)

| Variables | Smokers | Non-Smokers | Total |
|---|---|---|---|
| Age (yrs) | 42.1±9.1 | 39.1±9.6 | 40.2±9.1 |
| WHR | 0.81±0.09 | 0.86±0.06 | 0.83±0.7 |
| BMI (kg/m$^2$) | 24.3±3.1 | 23.5±3.5 | 24.2±3.1 |
| MS/Total | 9/50 | 7/50 | 16/100 |
| **Homodynamic** | | | |
| SBP (mmHg) | 118±15 | 115±16 | 116±15 |
| DBP (mmHg) | 79±10 | 77±11 | 78±11 |
| MAP (mmHg) | 92.1±12 | 90.07±12 | 91.1±12 |
| HR (bpm) | 74.2±8.7 | 71.8±8.2 | 72.9±8.4 |
| **Laboratory** | | | |
| FSI (µIU/ml) | 11.8 ±6.5 | 10.8±5.5 | 11.3±6 |
| FBG (mg/dl) | 95±17 | 90±12 | 92±15 |
| TG (mg/dl) | 210±82 | 236±82 | 222±82 |
| TC (mg/dl) | 216±39 | 211±48 | 214±43 |
| HDL (mg/dl) | 40±8 | 41±7 | 40±7 |
| LDL (mg/dl) | 134±33 | 136±34 | 135±33 |
| Lp-a (IU/ml) | 15.3±14.1 | 12.5±12.1 | 13.9±13.1 |
| **Echocardiography** | | | |
| LVPWT (mm) | 9.8±1.6 | 8.9±1 | 9±1.4 |
| LVEDD (mm) | 48±3 | 48±4 | 48±3.8 |
| LVST (mm) | 10.8±1.2 | 9±1.3 | 10±1.4 |
| LVM (gm) | 228.4±48.6 | 196.4±57.3 | 212.7±55.8 |
| EF (%) | 62.2±6.1 | 65.2±5.6 | 63.7±6.1 |
| **ECG Findings** | | | |
| Sokolov Index (mm) | 17.3±4.6 | 21.3±5.8 | 19.3±5.6 |
| R in aVL (mm) | 2.1±1.8 | 2.4±2 | 2.1±1.8 |
| R in LI + S in LIII (mm) | 4.5±2.7 | 5.5±3.1 | 5.05±2.9 |

WHR= Waist to hip ratio; BMI= Body mass index; MS= Metabolic syndrome; SBP= Systolic blood pressure; DBP= Diastolic blood pressure; MAP= Mean arterial blood pressure; HR= Heart rate; bpm= beats/min; FBS= Fasting blood sugar; FSI= Fasting serum insulin; TG= Triglyceride; TC= Total cholesterol; Lp-a = Lipoprotein a; LVPWT= Left ventricular posterior wall thickness; LVEDD= Left ventricular end-diastolic diameter; LVST= Left ventricular septum thickness; LVM= Left ventricularar mass; EF= Ejection fraction; LI and LIII = Lead I and Lead III

## Results

The mean age of all participants was 40.2±9.1 years. There were no significant differences between smokers or non-smokers regarding metabolic/hemodynamic or ECG characteristics. However, echocardiographic variables reflecting LV mass were significantly higher among smokers compared to non-smoker men (P<0.05, Table 1). Although serum Lp-a, insulin level and IR were higher among smokers than non-smokers, their differences were not significant (Table 1).

The bivariate correlation between metabolic syndrome variables, Lp-a and LV mass in both smokers and non-smokers are presented in Table 2. Among the studied variables, WHR showed a significant positive association with SBP, DBP, FBG, TG, total and LDL cholesterol among smokers and non-smokers (P<0.05). While correlation between FSI and metabolic or hemodynamic variables was not significant among smokers, it was positively correlated with FBG, TG and LV mass among non-smokers (Table 2). Among both smoker and non-smoker individuals, Lp-a showed no significant correlation, except with TC P<0.05. The inverse relationship between HDL and SBP among smokers, FBG among smokers and non-smokers has been presented in table 2 as well. LV mass showed significant association with SBP, DBP, FBG and TC among smokers P<0.05, while among non-smokers LV mass was strongly related to SBP, DBP, FSI and TG level.

Principle component analysis of the metabolic variables resulted in three factor groups are presented in Table 3. In the factor analysis, three components were retained both for smokers and non-smokers. A total of 59.5% of variance was explained in the data for all subjects. Among smokers, factor 1 was characterized by positive factor loadings for WHR, SBP, DBP, FSI, FBG, TG, TC, LDL and HDL. This factor explained 26.5% of the variance in the data. Factors 2 and 3 among smokers were characterized by positive factor loadings for FBG, TG, SBP, DBP, BMI, LV mass, Lp-a , FSI and TG, respectively. The amount of variance explained by factors 2 and 3 were 25.7% and 11.7%, respectively. Results obtained from non-smokers showed similar findings, as the amount of variance explained by factors 1 and 2 were similar. Factor 1 was characterized by positive factor loadings for FSI, FBG, TG, SBP, DBP, BMI and LV mass and explained 26.2% of the variance in the data, while factor 2 among non-smokers was characterized by positive loading for TC, LDL and WHR which explained 20.8% of the variance. Factor 3 was characterized by positive loading for Lp-a and HDL which explained 12.4% of the variance in the data (Table 3). In smokers FBG and TG were significantly loaded in both factors 1 and 2, while these variables were loaded only in factor 1 in non-smokers (Table 3).

## Discussion

Metabolic syndrome consists of a cluster of metabolic disorders, many of which promote the development of atherosclerosis and increase the risk of CVDs.[19] Insulin resistance may lay at the core of the metabolic syndrome.

**Table 2:** Pearson correlation between metabolic variables associated with Insulin resistance and LV mass (non-smoker/smoker)

| | WHR | SBP | DBP | FSI | FBG | TG | TC | HDL | LDL | Lp-a | LVM |
|---|---|---|---|---|---|---|---|---|---|---|---|
| WHR | • | 0.16/ 0.3* | 0.33/ 0.51* | 0.18/ 0.07 | 0.28/ 0.45* | 0.35/ 0.47* | 0.38/ 0.49* | -0.02/ 0.1 | 0.42/ 0.33* | -0.2/ 0.13 | 0.21/ 0.11 |
| SBP (mmHg) | | • | 0.81/ 0.75* | 0.23/ -0.07 | 0.16/ 0.55* | 0.38/ 0.33 | 0.07/ 0.37* | -0.1/ 0.24* | 0.27/ 0.3* | -0.09/ 0.11 | 0.45*/ 0.43* |
| DBP (mmHg) | | | • | 0.38/ 0.02* | 0.21/ 0.57* | 0.21/ 0.57* | 0.44/ 0.44* | -0.05/ 0.14 | 0.48/ 0.41* | -0.01/ 0.0 | 0.48*/ 0.28* |
| FSI (µIU/ml) | | | | • | 0.46/ -0.15* | 0.3*/ 0.0 | 0.18/ -0.01 | -0.02/ -0.04 | 0.12/ 0.06 | 0.00/ -0.2 | 0.45*/ -0.05 |
| FBS (mg/dl) | | | | | • | 0.32*/ 0.58* | 0.09/ 0.65* | -0.2*/ 0.37* | 0.13/ 0.49* | -0.02/ -0.07 | 0.21/ 0.36* |
| TG (mg/dl) | | | | | | • | 0.06/ 0.66* | 0.15/ -0.2 | 0.08/ 0.36* | 0.02/ -0.1 | 0.38*/ 0.15 |
| TC (mg/dl) | | | | | | | • | 0.35*/ 0.52* | 0.9*/ 0.86* | 0.16/ 0.6* | 0.07/ 0.25* |
| HDL (mg/dl) | | | | | | | | • | 0.17/ 0.36* | 0.2/ 0.1 | -0.00/ 0.8 |
| LDL (mg/dl) | | | | | | | | | • | 0.1/ 0.16 | 0.04/ 0.17 |
| Lp-a (IU/ml) | | | | | | | | | | • | -0.01/ -0.00 |
| LVM (gm) | | | | | | | | | | | • |

* P<0.01 For abbreviations see Table 1

It has long been recognized that smokers exhibit a number of established risk factors for CVD such as elevated fibrinogen and triglycerides as well as lower HDL.[20,21] Recent studies have shown that smoking can acutely impair insulin action in healthy individuals.[10] Furthermore, chronic smokers exhibit insulin resistance as well as various manifestations of insulin resistance syndrome.[10,22,23] Results of the present study revealed that there was no significant difference among male smokers and matched non-smoking males groups in regard to fasting plasma lipoproteins, glucose, insulin level or resistance (Table 1). These results are similar to other reports which were able to adjust for all the possible confounding factors related both to smoking and to insulin resistance.[24] A probable explanation is that the smoking habits and the degree of insulin resistance as well as the extent of metabolic perturbations in heavy smokers have increased insulin resistant and exhibited more pronounced risk profile of the various abnormalities associated with metabolic syndrome than do light smokers.[23,25] This dose-response relationship may account for the inability of our study to document insulin resistance in smokers.

It is also possible that age, family history of diabetes, obesity, diet and physical activity which considered being associated with insulin resistance,[22,25-28] may have acted as confounders affecting the difference between smokers and non-smokers in regard to insulin resistance syndrome. Some studies have shown that healthy normoglycemic, or diabetic, non-obese smokers with a normal fasting TG levels are lipid intolerant and have postprandial hypertriglyceridemia and low HDL cholesterol,[29,30] a finding which was not settled with the present study, since postprandial lipoprotein levels were not measured in smoker or non-smoker males.

Laboratory methods that measure plasma insulin do not specifically measure true insulin.[31] They also measure proinsulin or proinsulin metabolites which may be responsible for higher insulin concentrations that found in smokers as compared to non-smoker. However, we think this is unlikely because in individuals with normal FBS, almost all measured insulin with immunoassay method is true insulin.[31]

A pattern of LV hypertrophy, evident in ECG, is a harbinger of morbidity and mortality from CVD. Echocardiography permits another noninvasive determination of LV mass and the examination of its role as a precursor of morbidity and mortality. An increase in LV mass predicts a higher incidence of clinical events, including death, attributable to CVD.[32] The role of smoking in increasing LV mass has been reported before,[33,34] and the results of the present study are strikingly similar to those. The increase in mass may be related to increased catecholamine release, raised blood viscosity due to increased fibrinogen and hematochrite levels as well as transitory but repeated increases heart rate and systolic blood pressure caused by cigarette smoke.[36]

Another hypothesis underlying our study was to examine the relationship between variables of metabolic, LV mass, Lp-a and other hemodynamics in smokers and non-smokers using Pearson correlation coefficient (Table 2). Smoking as a major risk factor for CAD has a higher correlation with some risk factors as of non-smoking. In general smokers more corre-

**Table 3:** Results of factor analysis with metabolic; homodynamic variables; factors (F1, F2, F3) and factor loadings in smokers and non-smokers

| | Smokers | | | Non-Smokers | | |
|---|---|---|---|---|---|---|
| **Variables** | **F1** | **F2** | **F3** | **F1** | **F2** | **F3** |
| LP-a (IU/ml) | 0.15 | -0.08 | -0.78 | 0.05 | -0.06 | 0.74 |
| FSI (µIU/ml) | 0.12 | -0.07 | 0.74 | 0.64 | 0.05 | -0.09 |
| FBG (mg/dl) | 0.59 | 0.57 | 0.003 | 0.55 | -0.005 | -0.29 |
| TG (mg/dl) | 0.55 | 0.45 | 0.19 | 0.54 | -0.005 | -0.18 |
| TC(mg/dl) | 0.90 | 0.33 | 0.06 | 0.23 | 0.86 | 0.25 |
| HDL(mg/dl) | 0.63 | -0.01 | -0.11 | -0.13 | 0.23 | 0.71 |
| LDL(mg/dl) | 0.85 | 0.13 | 0.04 | 0.09 | 0.90 | 0.18 |
| SBP(mmHg) | 0.29 | 0.76 | -0.28 | 0.72 | 0.17 | 0.10 |
| DBP(mmHg) | 0.38 | 0.72 | -0.04 | 0.74 | 0.39 | 0.07 |
| WHR | 0.48 | 0.35 | 0.05 | 0.20 | 0.70 | -0.37 |
| BMI | 0.23 | 0.74 | 0.2 | 0.54 | 0.34 | -0.16 |
| LV Mass | -0.005 | 0.78 | 0.007 | 0.79 | -0.02 | 0.14 |
| EV (%) | 26.52 | 25.76 | 11.77 | 26.23 | 20.82 | 12.46 |
| CV (%) | 26.52 | 52.28 | 64.06 | 26.23 | 47.05 | 59.52 |

Loading with absolute values > 0.4
EV= Explained Variance; CV= Cumulative Variance. For abbreviations see Table 1.

lation exists between metabolic factors (FBG, TG, LDL, TC) and hemodynamic variables (SBP, DBP, LVM) than non-smokers. This may be explained by the fact that smoking increases the relationship between these variables.

Factor analysis using the principle component method has been adopted to identify major factors of the metabolic syndrome.[35] This analysis identifies subsets of correlated variables that group together and explain the majority of the variance in the original data. Previous studies in regard to factor analysis among metabolic variables found at least two and usually three or four factors.[19] Our data identified three factors in both smokers and non-smokers, although the interrelationship among smokers was greater than non-smokers (Table 3). In non-smokers, fasting insulin loaded onto factors considered as measures of obesity, LV mass, FBG, TG and systolic and diastolic blood pressures. Fasting insulin, as used in the present study too, as stated by Laakso is a marker for insulin resistance in persons without diabetes.[35] Some of the previous studies as well as our study revealed that insulin induces loadings among more than one factor.[18] We have also found that FBG and TG loaded on the same factor in both smokers and non-smokers (Table 3). The present study showed no overlap between systolic or diastolic blood pressures and other metabolic risk factors or LV mass in either smokers or non-smokers, which is similar to other reports.[19] This may be explained by the possibility that blood pressure is the most linked factor with other variables of metabolic syndrome. While previous studies showed no difference between smokers and non-smokers in connection to LV mass,[37] the present study showed a greater LV mass among smokers compared to non-smokers (Table 1). LV mass was clustered with BMI, SBP, DBP, TC and TG in the factor analysis of smoking and non-smoking people. Although increased LV mass was significantly related to blood pressure in hypertensive individuals, however the presence of other risk factors than of LV hypertrophy in hypertensive patients have been reported in several studies before.[35,36]

One limitation of our study was low sample size, which may explain the unlikely differences which might exist between smokers and non-smokers. However, data of both smokers and non-smokers showed similar patterns in separated factor analysis. Lp-a was loaded with FSI, TG among smokers and with HDL among non-smokers was positively correlated to TC among smokers (Table 3). Some investigators even have found a dependency of Lp-a as a risk factor on LDL levels.[36] However, this clustering and their relationship with other risk factors was not previously studied among smokers.

## Conclusion

We did not find significant difference for the frequency of metabolic syndrome in smokers versus non-smokers. This is probably due to the limitation of study including small sample sizes or excluding women from study. However, the interrelationship of metabolic syndrome and other cardiovascular disease risk factors among smokers was greater than non-smokers. No single factor can explain the clustering of the metabolic syndrome among smokers.

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## References


1 Uemura K, Pisa Z. Trends in cardiovascular disease mortality in industrialized countries since 1950. *World Health Stat Q* 1988; 41: 155-78.

2 Alwan A. Prevention and control of cardiovascular diseases. Alexanderia, WHO Regional Office for the Eastern Mediterranean, 1995 EMRO Technical Publications, No 22.

3 Sarraf-Zadegan N, Tabatabai FA, Basharddoost N, et al. The prevalence of coronary artery disease in an urban population in Isfahan, Iran. *Acta Cardiologica* 1999; 54: 257-63.

4 Sarraf-Zadegan N, Boshtam M, Malek-Afzali H, et al. Secular trends in cardiovascular mortality in Iran, with special reference to Isfahan. *Acta Cardiologica* 1999; 54: 327-33.

5 Farmer JA, Gotto AM. Dyslipidemia and other risk factors for coronary artery disease. In Braunwald. Heart Diseases. Philadelphia: USA; WB Sounders Co; 1997. p. 1126-61.

6 Executive summary of the third report of the National Cholesterol Education program (NCEP) expert panel on Detection, Evaluation and Treatment of high blood cholesterol in adults (Adult Treatment Panel III). *JAMA* 2001; 285: 2486-97.

7 Haffner SM, Valdez RA, Hazuda HP, et al. Prospective analysis of the insulin resistance syndrome (Syndrome X). *Diabetes* 1992; 41: 715-22.

8 Isomaa B, Almgren P, Tuolmito M, et al. Cardiovascular morbidity and mortality associated with the metabolic syndrome. *Diabetes care* 2001; 24: 683-9.

9 Bruno G, Merletti F, Biggeri A, et al. Metabolic syndrome as a predictor of all-cause and cardiovascular mortality: the Casale Monferrato Study. *Diabetes Care* 2004; 27: 2689-94.

10 *Dzien, C. Dzien-Bischinger, F. Hoppichler. M. Lechleitner.* The metabolic syndrome as a link between smoking and cardiovascular disease. *Diabetes, Obesity and Metabolism* 2004; 6: 127-30.

11 Reaven G, Tsao PS. Insulin resistance and compensatory hyperinsulinemia. The key player between cigarette smoking and cardiovascular disease. *J Am Coll Cardiol* 2003; 41: 1044-7.

12 Magis D, Geronooz I, Scheen AJ. Smoking, insulin resistance and type 2 diabetes. *Rev Med Liege* 2002; 57: 575-81.

13 Geslain-Biquez C, Vol S, Tichet J, et al. The metabolic syndrome in smokers. The D.E.S.I.R. study. *Diabetes Metab* 2003; 29: 226-34.

14 Reaven G. Metabolic syndrome: pathophysiology and implication for management of cardiovascular disease. *Circulation* 2002; 106: 286-8.

15 Rose GA, Blackburn H. Cardiovascular survey methods. Geneva: WHO, 1982.

16 Friedewald WI, Levy RI, Frederickson DS. Estimation of the concentration of low density lipoprotein cholesterol in plasma, without use of the preparative ultracentrifuge *Clin Chem* 1972; 18: 499-502.

17 Matthews Dr, Hosker JP, Rudenski AS, et al. Homeostasis model assessment: insulin resistance and beta-cell function from fasting plasma glucose and insulin concentrations in man. *Diabetologia* 1985; 28: 412-9.

18 Perineas RJ, Crow RS, Blackburn H. The Minnesota Code: Manual of Electrocardiographic findings. John Wright PSG, Boston, USA. 1982.

19 Choi KM, Lee J, Kim KB, et al. Factor analysis of the metabolic syndrome among elderly Koreans--the South-west Seoul Study. *Diabetic Med* 2003; 20: 99-104.

20 Ernest E, Resch KL. Fibrinogen as a cardiovascular risk factor: a meta-analysis and review of he literature. *Ann Intern Med* 1993; 118: 956-63.

21 Craig WY, Palomaki GE, Haddow JE. Cigarette smoking and serum lipid and lipoprotein concentrations: an analysis of published data. *Br Med J* 1989; 298: 784-8.

22 Lee WY, Jung CH, Park JS, et al. Effects of smoking, alcohol, exercise, education, and family history on the metabolic syndrome as defined by the ATP III. Diabetes *Res Clin Pract* 2005; 67: 70-7.

23 Smith U. Smoking elicits the insulin resistance syndrome: new aspects of the harmful effect of smoking. *J of Internal Medicine*1995; 237: 435-7.

24 Wareham NJ, Ness EM, Byrne CD, et al. Cigarette smoking is not associated with hyperinsulinemia: evidence against a causal relationship between smoking and insulin resistance. *Metabolism* 1996 Dec; 45:1551-6.

25 Fredrikson GN, Hedblad B, Nilsson JA, et al. Association between diet, lifestyle, metabolic cardiovascular risk factors, and plasma C-reactive protein levels. *Metabolism* 2004; 53: 1436-42.

26 Zhu S, St-Onge MP, Heshka S, Heymsfield SB. Lifestyle behaviors associated with lower risk of having the metabolic syndrome. *Metabolism* 2004; 53: 1503-11.

27 Rosenthal M, Haskell WL, Solomon R, et

al. Demonstration of a relationship between level of physical training and insulin-stimulated glucose utilization in normal humans. *Diabetes* 1983; 32: 408-11.
28 Villegas R, Creagh D, Hinchion R, O'Halloran D, Perry IJ. Prevalence and lifestyle determinants of the metabolic syndrome. *Ir Med J* 2004; 97: 300-3.
29 Chen Y-DI, Swami S, Skowronski R, et al. Differences in postprandial lipemia between patients with normal glucose tolerance and non-insulin dependent diabetes mellitus. *J Clin Endo Crinol Metab* 1993; 76: 172-7.
30 Syvanne M, Hilden H, Taskinen MR. Abnormal metabolism of postprandial lipoproteins in patients with non-insulin-dependent diabetes mellitus is not related to coronary artery disease. *J Lipids Res* 1994; 35: 15-26.
31 Shuraishi I, Iwamoto Y, Kuzuya T, et al. Hyperinsulinemia in obesity is not accompanied by an increase in serum proinsulin ratio in groups of human subjects with and without glucose intolerance. *Diabetologia* 1991; 34: 737-41.
32 Levy D, Garrison RJ, Savage DP, et al. Prognostic implications of ecochardiographically determined left ventricular mass in the Framingham Heart Study. *N Engl J Med* 1990; 322: 1561-6.
33 Cosmi F. Echocardiographic analysis of the left ventricular mass in smokers. *Minerva-Med* 1990; 81: 605-10.
34 Majahalme S, Turjanmaa V, Weder A, et al. Blood pressure levels and variability, smoking and left ventricular structure in normotension and in borderline and mild hyperten. *Am J Hypertens* 1996; 9: 1110-8.
35 Laakso M. How good a maker is insulin level for insulin resistance? *Am J Epidemiol* 1993; 137: 959-65.
36 Dahlen GH, Guyton JR, Attar M, et al. Association of levels of lipoprotein-a plasma lipids and other lipoprotein with coronary artery disease documented by angiography. *Circulation* 1986; 74: 758-65.
37 Davies RJ, Crosby J, Prothero A, Stradling JR. Ambulatory blood pressure and left ventricular hypertrophy in subjects with untreated obstructive sleep apnea and snoring, compared with matched control subjects, and their response to treatment. *Clin Sci Colch* 1994; 86: 417-24.