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Original article

Exploratory factor analysis of gender-based metabolic syndrome components: Results from the PERSIAN Guilan cohort study (PGCS)

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SUMMARY

Background: One of the important issues related to metabolic syndrome is the underlying factor that remains controversial. The purpose of this study was estimating exploratory factor analysis (EFA) to reveal underlying factors that may explain the observed variants of metabolic syndrome (MetS) components in a population-based study.
Methods: In this cross-sectional study, the target population consisted of 10,520 individuals aged 35–70 years from Phase 1 of the PERSIAN Guilan cohort study conducted between 2014 and 2017. Exploratory factor analysis (EFA) of components of the metabolic syndrome, including waist circumference (WC), systolic (SBP) and diastolic (DBP) blood pressure, triglyceride (TG), high-density lipoprotein (HDL) and fasting blood glucose (f-Glc) was performed across the population as well as by gender.
Results: EFA results in the whole population based on eigen values > 1 showed two factors that explain 55.46% of the total variance. Taking factor loadings above 0.3, the first factor included systolic blood pressure, diastolic blood pressure, and waist circumference – called the blood pressure factor. Also, the second factor included triglycerides, negative-loaded HDL, and fasting blood glucose, which was named as lipid factor. In terms of gender, the first factor was similar to the whole population pattern, but in the second factor, in addition to the two components of blood lipids, waist size for men and in fasting blood glucose for women was launched.
Conclusion: Hypertension and lipids were substantial factors, and obesity is an important factor in this study. Hypertension, having the highest factor load, can generally be a valuable screening parameter for cardiovascular and metabolic risk assessment.

1. Introduction

Metabolic syndrome (MetS) is defined as a subset of risk factors such as central obesity, insulin resistance, dyslipidemia and hypertension that can increase the risk of type 2 diabetes, cardiovascular disease, cancer, and premature death which are the most important health problems in the world [1]. MetS is a complex issue in health care and seem to be multifactorial. The prevalence of MetS has increased worldwide in recent decades and has reached an alarming level as it is a major public and clinical concern [2–5]. Regardless of the different diagnostic cutoff points for the syndrome, all definitions include the four main features; obesity, glucose intolerance, dyslipidemia and hypertension [6,7].

Although visceral obesity and insulin resistance appear to be at the core of MetS development and abdominal obesity is also an independent predictor of new-onset of metabolic syndrome components in longitudinal studies [8], but due to increased number of metabolic risk factors and the complex interaction between different components the pathogenesis of MetS is unknown [9]. To understand the complexity of the MetS mechanism, it is necessary to study the specific contribution of its determinants [9]. Such studies can help clinicians identify the clustering components of the syndrome and identify the most important factors involved in early diagnosis to take preventive and interventional measures for people at risk for cardiovascular disease and type 2 diabetes [10,11].

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One of the important issues related to the MetS is the underlying factors associated with it. Factor analysis is appropriate to identify the underlying structure of MetS components. Studies with EFA show differences in the number of factors extracted and the variable burden per factor [9,12–19]. Thus the underlying mechanisms of the MetS and the number of latent factors that can explain the pathophysiological process remain controversial. The main assumption of factor analysis is that there is a latent variable that can be extracted [20]. Therefore, if only one underlying factor arises from the analysis, this may lead to the interpretation that a single physiological process is responsible for clustering the metabolic variables. On the other hand, the diagnosis of more than one factor may be considered as evidence that more than one physiological process is responsible for the complete expression of the MetS [21].

Collecting data on chronic diseases and their risk factors is essential for planning health services in any community. Identification of the components of the syndrome as one of the most important causes of CHD and their interaction with one another is one of the most important issues. The purpose of this study is to evaluate exploratory factor analysis to uncover underlying factors that may explain the observed variants of MetS components in a population-based, large-sample study.

2. Materials and methods

2.1. Study population

This is a cross-sectional study and its data are part of a Persian cohort study in the Some'e Sara city in Guilan province which includes 10,520 adults between 35 and 70 years. Some'e Sara Cohort is a subset of the National PERSIAN Cohort in Iran [22–25]. Details of Guilan Cohort Profile Previously published with the details [26]. Some'e Sara city is located at Guilan province, north of Iran. The main ethnicities of this region are Gilak.

2.2. Data collection

The data collection at the cohort center consisted of registration procedures, laboratory sampling, anthropometric characterization, and completion of questionnaires, respectively. The following variables were used as components of the metabolic syndrome exploratory factor analysis in this study: fasting plasma glucose (FPG), triglycerides (TG), high-density lipoprotein cholesterol (HDL-C). Patients' blood pressure was also measured twice at 15 min intervals and the blood pressure values of the right and left arm were recorded.

2.3. Factor analysis

Factor analysis is a data aggregation method and consists of three steps: a) extraction of factors to estimate the number of factors using principal component analysis; b) rotation of factors to obtain a simple structure that can be easily interpreted; and, C) designation and interpretation of each factor based on estimated values for operating loads. Several statistical methods can be used to identify the components of MetS. Principal component analysis (PCA) is one of the approaches that group quantitative variables into clusters known as factors based on the correlation between variables. In this study, exploratory factor analysis using principal component analysis and Varimax rotation of components of metabolic syndrome including variables such as systolic and diastolic blood pressure, waist circumference, fasting blood sugar, triglyceride And high-density cholesterol were incorporated in the factor analysis. Scree plot and Eigen Value were used to determine the number of factors. To extract the factors in factor analysis, consider the size of the special digit as one and to extract factors whose variance exceeds the maximum variance explained by each variable. Finally, based on the factor model, the results were interpreted based on factor loadings greater than or equal to 0.3 (and less than or equal to – 0.3).

2.4. Ethical consideration

The study was approved by Ethics Committee of Guilan University of Medical Sciences, Rasht, Iran (IR.GUMS.REC.1397.156).

2.5. Statistical analysis

Descriptive characteristics of patients were presented with a mean (standard deviation) and frequency (relative frequency). An independent t-test was used to compare the means between the qualitative variables and the Pearson correlation coefficient to investigate the correlation of quantitative variables. Data were analyzed by SPSS software (version 22). P values less than 0.05 were considered statistically significant.

3. Results

Of the 10,520 participants in the cohort study, 46.4% (4887) were male. In terms of body mass index, 1.4% (141), 26.0% (2746), 39.9% (4198), and 32.7% (3435) were in the low, normal, overweight and obese groups, respectively. The mean age was 51.52 ± 8.90 years (males 51.73 ± 8.97 and females 51.33 ± 8.85) and mean body mass index was 28.17 ± 5.76, respectively (males 26.08 ± 4.19 and females 29.92 ± 5.11, $P < 0.05$).

The mean waist circumference as a central obesity index was 98.80 ± 12.37 cm in the total population. Examination of the difference between the mean components of metabolic syndrome by gender showed that the waist circumference was about 10 cm higher in women than in men. But for high triglycerides, the relationship was reversed and the males were higher, with more than 10 units in males. Fasting blood glucose and HDL cholesterol were also higher in women (1.7 and 3.42, respectively). Systolic and diastolic blood pressures were 1.18 and 1.75 in males, respectively (Table 1).

The results of the correlation between the components of the metabolic syndrome in the population showed the highest correlation between systolic and diastolic blood pressure ($r = 0.84$). Thereafter there was an inverse correlation between HDL and triglycerides ($r = -0.33$). Waist circumference with both types of hypertension and triglycerides are also correlated with fasting blood glucose. In terms of gender, in addition to the strong association between the two types of blood pressure, both sexes had the highest correlation, an inverse relationship between glyceride and HDL, followed by waist circumference with systolic and diastolic blood pressure, which was similar to the overall population pattern. Besides, there was a higher correlation between waist circumference with the two types of fats (triglyceride and HDL) as well as between triglyceride and fasting blood sugar in males and females, respectively (Table 2).

The results of exploratory factor analysis for the components of the metabolic syndrome in the whole population based on eigenvalues greater than one and the pebble plot showed two factors that explain 55.46% of the total variance (first factor 33.24% and The second factor is 22.21%). Based on factor loadings above 0.3, the first factor included systolic blood pressure, diastolic blood pressure, and waist circumference called the blood pressure factor. Also, the second factor included triglycerides, negative-loaded HDL, and fasting blood sugar, which was named as lipid factor. Factor analysis results identified two factors in both sexes that explained 57.45% and 55.98% of the total variance in men and women, respectively. In both sexes, the results obtained in the

Table 1
Mean and standard deviation of gender-based of metabolic syndrome components.

Components	Total (10,520)	Gender		
		Male (4719)	Female (5944)	*P*-value
WC, cm	98.80 ± 12.37	93.62 ± 10.89	103.29 ± 11.81	<0.001
f-Glc, mg/dL	104.56 ± 37.17	103.65 ± 35.3	105.35 ± 38.68	0.019
TG, mg/dL	160.26 ± 103.27	166.0 ± 111.81	155.28 ± 94.97	<0.001
HDL, mg/dL	48.38 ± 10.97	46.55 ± 10.54	49.97 ± 11.09	<0.001
SBP, mm/Hg	118.26 ± 16.74	118.89 ± 16.53	117.71 ± 16.91	<0.001
DBP, mm/Hg	77.01 ± 11.00	77.94 ± 11.06	76.19 ± 10.89	<0.001

Abbreviations: WC, waist circumference; FBS, fasting blood sugar; TG; Triglyceride; HDL, high density lipoprotein; SBP, systolic blood pressure; DBP, diastolic blood pressure.

Table 2
Pearson correlation coefficient between the components of the metabolic syndrome in the whole population and by gender.

Components	Total						Male						Female					
	WC	FBS	TG	HDL	SBP	DBP	WC	FBS	TG	HDL	SBP	DBP	WC	FBS	TG	HDL	SBP	DBP
WC, cm	1						1						1					
f-Glc, mg/dL	∗0.08	1					∗0.08	1					0.08∗	1				
TG, mg/dL	∗0.10	0.17∗	1				0.19∗	0.14∗	1				0.08∗	0.20∗	1			
HDL, mg/dL	−0.06∗	−0.04∗	−0.33∗	1			−0.19∗	−0.04∗	−0.34∗	1			−0.08∗	−0.06	−0.31∗	1		
SBP, mm/Hg	0.18∗	0.12∗	0.08∗	−0.03∗	1		0.22∗	0.12∗	0.07∗	−0.03∗	1		0.20∗	0.12∗	−0.09∗	−0.02	1	
DBP, mm/Hg	0.18∗	0.09∗	0.10∗	−0.05∗	∗0.84	1	0.24∗	0.10∗	0.09∗	−0.05∗	∗0.84	1	0.22∗	0.09∗	0.10∗	−0.04∗	∗0.84	1

Abbreviations: WC, waist circumference; FBS, fasting blood sugar; TG; Triglyceride; HDL, high density lipoprotein; SBP, systolic blood pressure; DBP, diastolic blood pressure.
∗ Significant correlation, $P < 0.05$.

first factor were similar to the total population pattern but in the second factor in addition to the triglycerides and negative HDL, the waist circumference and fasting blood sugar were loaded in males and females, respectively (Table 3). Scree Plot to identify the number of operating loads in a population show that in supplementary file 1.

4. Discussion

This study showed the mean components of the metabolic syndrome in the whole population and by gender. Results of the components of the metabolic syndrome in the whole population were based on exploratory factor analysis consisting of two factors: blood pressure and lipid. Abdominal obesity is also an important factor in these factors.

The components of metabolic syndrome are interrelated. In this study, the highest correlation was found between systolic and diastolic blood pressure, followed by an inverse correlation between HDL and triglyceride. Waist circumference was also associated with two types of blood pressure. A higher correlation was found between waist circumference and two types of blood lipids (triglyceride and HDL) in men and between triglyceride and fasting blood glucose in women. In the Lafortuna study, waist circumference was strongly correlated with hyperglycemia and insulin resistance [27]. In the Hanley study, except for the association between systolic and diastolic blood pressure, all variables were more correlated with waist circumference than other variables [28]. The results show that the metabolic syndrome components overlap with each other.

In this study, the first identified factor in the general population in both sexes was systolic blood pressure (SBP), diastolic blood pressure (DBP) and waist circumference (WC), which was named as hypertension factor. Also, the second factor in the whole population and females included two blood lipids (TG and HDL with a negative charge) and FBS and in men two lipid factors plus waist circumference (WC) which were named as Lipid Factor.

In the Hajian-Tilaki study in northern Iran, three factors were extracted by EFA in both sexes. These factors in men included hypertension factor (systolic and diastolic blood pressure), obesity factor (BMI and WC), and lipid/glucose factor (TG, HDL, and FBS). These three factors together explained 65.3% of the variance observed in men and 66.8% in women [12]. In this study, body mass index and waist circumference were used together for obesity. Also, the blood pressure factor was in line with our study and obesity was next in line. In the Hong study of Vietnamese adolescents, EFA showed three factors in males (obesity, hypertension, dyslipidemia) with 64.3% and four factors in females (obesity, hypertension, dyslipidemia, and hyperglycemia) that showed 73.6% variance observed Composed of MetS [15]. Obesity also accounted for the most variance in clustering and appears to be more strongly associated with cardiovascular risk than other variables [15].

In the Lafortuna study, principal component analysis reduced ten related physiological variables to four uncorrelated factors (insulin resistance factor, metabolic lipid/glucose factor, Body mass factor, blood pressure factor), which explained 72.2% of the variance in the main parameter [28].

In the Esteghamati study in the Iranian population, factor analysis of components including waist circumference, evaluation of homeostasis model of insulin resistance, systolic blood pressure, triglyceride (TG) and high-density lipoprotein cholesterol (HDL-C) resulted in two factors that explained about 59.0% of the total variance in both sexes. In this study, a single factor was obtained when TG and HDL-C were replaced by TG to HDL-C [18]. In a study of a sample of Korean men and women, four factors were found in men and three in women [29]. Nasila Sungwacha also identified three factors in factor analysis for MetS group: triglyceride-HDL-C (factor 1), BP (factor 2) and abdominal obesity-dysglycemia (factor 3), which accounted for 75.1% of the total variance [14].

In our study, systolic and diastolic blood pressure was assigned to the first factor, called hypertension, indicating significant independence of hypertension from insulin resistance and dyslipidemia. In general, the inconsistency of the findings may be partly due to the explanatory nature of the PCA and the different extraction methods used to record all changes in observed variables, not just the variance in the variables that are shared among the observed variables [30].

Central obesity, as defined by the International Diabetes Federation, is a major component of MetS [31]. In our study, abdominal obesity in factor one was loaded in both sexes. It can be said that obesity can be the center of other syndrome 'factors in both sexes'. In Wang's study, WC was associated with all MetS risk factors [32]. In the Ayubi study, consistent with our study, with minimum factor loadings of 0.3, WC was common to all three factors in both sexes, and the researchers suggested that central obesity could unite other separate factors [13].

4.1. Strengths and limitation of study

High sample size and population-based are the most important advantages of this study. The cross-sectional nature of the study limits the possibility of examining causal relationships. This study also evaluated only the relationship between routine components in the definition of MetS and the main risk factors and other risk factors have not been measured, which should be addressed in future studies. Due to the large ethnic and cultural heterogeneity in the populations, other ethnic groups need to be studied. Therefore, it is recommended to carry out these evaluations in different groups. Conducting surveys of the results in the later phases of this cohort could certainly help in understanding the pathogenesis of MetS.

Table 3
Factor loadings for metabolic syndrome components in exploratory factor analysis by gender.

Components	Total		Male		Female	
	Factor 1	Factor 2	Factor 1	Factor 2	Factor 1	Factor 2
WC, cm	**0.944**	0.019	**0.942**	0.059	**0.939**	0.009
f-Glc, mg/dL	**0.939**	0.034	**0.939**	0.080	**0.940**	0.017
TG, mg/dL	**0.335**	0.223	**0.331**	**0.487**	**0.385**	0.199
HDL, mg/dL	0.059	**0.805**	−0.002	**0.781**	0.071	**0.794**
SBP, mm/Hg	0.035	**−0.748**	0.079	**−0.764**	0.032	**−0.730**
DBP, mm/Hg	0.171	**0.388**	0.168	0.283	0.160	**0.458**
Eigen values	1.99	1.33	2.05	1.37	2.01	1.34
Variance explained	33.24	22.21	34.28	22.93	33.63	22.35
Cumulative variance	55.46		57.45		55.98	

Abbreviations: WC, waist circumference; FBS, fasting blood sugar; TG; Triglyceride; HDL, high density lipoprotein; SBP, systolic blood pressure; DBP, diastolic blood pressure.
Factor loadings ≥0.30 are bolded.

5. Conclusion

MetS is a multi-factorial syndrome. Hypertension and lipid have a central role and obesity is an important factor in both factors and hypertension has the highest factor load. Since the risk of cardiovascular disease is constantly increasing with the rise in blood pressure, identifying these high-risk individuals is very important. Blood pressure, as a simple measurement, can be a good tool for screening people at risk for MetS in populations.

Ethical approval

Ethical approval for all parts of the cohort was obtained from the local ethical committee of Guilan University of Medical Sciences, Rasht, Iran (Ethic code: IR.GUMS.REC.1397.129).

Authorship contribution

Study conception and design: M.A, F.J, M.N and F.M.
Acquisition of data: S.H and M.A.
Statistical analysis: H.N, M.A, M.N and S.H.

All authors approved the final version of the article, including the authorship list.

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Consent for publication

All authors agreed to the submission and approved the final version of the manuscript.

Declaration of competing interest

All authors declare that they do not have any study-related conflicts of interest.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.clnesp.2020.09.011.

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