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Original Article

Factor Analysis of Metabolic Syndrome Components in a Population-Based Study in the South of Iran (PERSIAN Kharameh Cohort Study)

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Abstract

Background: We aimed to estimate the exploratory factor analysis (EFA) of metabolic syndrome components based on variables including gender, BMI, and age groups in a population-based study with large sample size.

Methods: This study was conducted on 10663 individuals 40-70 yr old in Phase 1 of the Persian Kharameh cohort study conducted in 2014-2017. EFA of the metabolic syndrome components, including waist circumference (WC), systolic blood pressure (SBP), diastolic blood pressure (DBP), triglyceride (TG), high-density lipoprotein (HDL) and fasting blood sugar (FBS), was performed on all participants by gender, BMI (Body Mass Index), and age groups.

Results: EFA results in the whole population based on eigenvalues greater than one showed two factors explaining 56.06% of the total variance. Considering factor loadings higher than 0.3, the first factor included: DBP, SBP, and WC, named as hypertension factor. The second factor also included TG, negative-loaded HDL, FBS, and WC, named as lipid factor. Almost similar patterns were extracted based on subgroups.

Conclusion: MetS is a multi-factorial syndrome. Both blood pressure and lipid had a central role in this study and obesity was an important factor in both ones. Hypertension, having the highest factor loading, can generally be a valuable screening parameter for cardiovascular and metabolic risk assessment.

Keywords: Metabolic syndrome; Factor analysis; Cohort; Iran

Introduction

Metabolic syndrome (MetS) is defined as a branch of risk factors such as central obesity, insulin resistance, dyslipidemia and hypertension which increase the risk of type 2 diabetes mellitus, cardiovascular disease, cancer, and premature death (1). These are the most important health care problems in the world. This syndrome is associated

with twice the risk of heart disease and heart attack and five times the risk of diabetes, so it is a common tool for cardiovascular risk assessment (2). The impact of MetS on mortality has increased over time and even its components are associated with various causes of mortality (3). About 20% to 25% of the adult population in the world suffers from metabolic syndrome disorders (4). In Iran, the prevalence of MetS by IDF (International Diabetes Federation) and ATP III (Adult Treatment Panel III) were 37% and 33.82%, respectively (5). MetS have been a complex issue in health care and seem to have no simple cause. When the components of MetS coexist, these risk factors increase the risk of cardiovascular disease and its associated consequences, including death; and it is beyond what can be expected by a single component (6). Metabolic components are likely to be correlated and have interactions (7).

Factor analysis is an appropriate method to identify the fundamental structure of metabolic syndrome components. The purpose of factor analysis was to reduce the number of variables and discover the underlying latent factors that can justify the structure of related factors and observed changes in metabolic syndrome components in populations, instead of statistical analysis of each component, it would be better to analyze two or multiple latent factors which were not observable but were identified by factor analysis. This method is an epidemiological technique to provide significant insight into the underlying disease process. Understanding how the components of the metabolic syndrome cluster helps physicians and researchers to interpret the pathophysiology of metabolic syndrome and provide effective strategies to identify and prevent potential cardiovascular risks (8).

Regardless of the different diagnostic cutoff points for the syndrome, all definitions include four main characteristics: obesity, glucose intolerance, dyslipidemia, and hypertension (9). In previous studies, factor analysis for components of metabolic syndrome has revealed indecisive and inconsistent results; the different number of factors has been suggested in previous models of exploratory factor analysis, even up to 5 factors (10-17). However, the important mechanisms of the metabolic syndrome, the interaction between regular physiological functions, including the abnormalities involved, and the number of latent factors explaining the pathophysiological process have still been unclear and remained controversial.

Therefore, the purpose of this study was to estimate the exploratory factor analysis to discover underlying latent factors explaining the observed variations and correlations of metabolic syndrome components based on variables including gender, BMI (Body Mass Index), and age groups in a population-based study with large sample size.

Materials and Methods

This cross-sectional, population-based study was conducted on 10.663 individuals aged 40-70 yr in the first phase of the PERSIAN (Prospective Epidemiological Research Studies in Iran) cohort study of Kharameh City from 2014 to 2017. Kharameh study was a subset of the National PERSIAN cohort study which included different geographical, climatic and ethnic groups in eighteen provinces of Iran (18). Kharameh City is located in Fars Province in the southern part of Iran. Its population is 54,864 and the main ethnicity of population is Fars (19). The main inclusion criteria were 40-70 yr of age, living in Kharameh County, and Iranian nationality. The exclusion criteria were: lack of presence in clinics for physical examination, mental retardation, and unwillingness to participate in the study. All questionnaires were completed by using online survey through dedicated platform.

The data used in this study were demographic, age and gender questions. Anthropometric indices also included weight (kg), height and waist circumference (cm). BMI was calculated by a standard formula and the subjects were divided into the groups of normal weight (BMI<25 kg/m2), overweight (BMI=25–29.9 kg/m2) and obese (BMI ≥30 kg / m2). These blood biochemical parameters data were used as components of the metabolic syndrome in exploratory factor analysis: FPG, TG, and HDL. Blood pressure was also

measured twice with 15 min intervals and the data was recorded based on blood pressure on the right and left arms.

Ethical approval was obtained from the research ethics committee of Shiraz University of Medical Sciences (IR.SUMS.REC.1398.445).

Exploratory Factor Analysis for Metabolic Syndrome Components

In this study, Exploratory factor analysis was performed using Principal Component Analysis and Orthogonal Rotated Varimax from Metabolic Syndrome Components including; WC, SBP, DBP, TG, HDL and FBS to reduce the number of original variables to fewer latent factors. The sum of the variances for each observed variable was estimated with other variables in the constructed factor and the amount of Eigenvalue (sum of squared loading factor) greater or equal to one was used as the criterion for the inclusion of an additional factor in the model. The KMO (kaiser-meyer-olkin) was measured to determine the correlation between the data suitable for factor analysis. Moreover, the Bartlett test result was significant, which indicates that there is a relationship between the variables. Finally, based on factor analysis, factor loadings equal to or greater than 0.3 were considered acceptable.

Descriptive characteristics of patients were presented with statistical, mean (standard deviation) and frequency (relative frequency) markers. Independent t-test was used to compare two-way equality between qualitative variables. One-way ANOVA was used to compare mean equality in more than two qualitative variables. Pearson correlation coefficient was used to examine the correlation between quantitative variables. Data were analyzed by SPSS software (ver. 22, Chicago, IL, USA). *P*-values less than 0.05 were considered statistically significant.

Results

Of the 10.663 participants in the Kharameh cohort study: in terms of gender, 44.3% were male (4719) and 55.7% were female (5944). In terms of BMI, 3.9% (411), 36.4% (3882), 41.7% (4451) and 18.0% (1919) were in the low, normal, overweight and obese groups, respectively. The mean age of the subjects was 51.94±8.27 yr and mean BMI was 26.07±4.41.

In examining the difference between the mean metabolic syndrome components by gender, the average waist circumference in women was more than 4 cm on average in comparison to men. Women also had higher levels of FBS and HDL cholesterol of 2.66 and 1.86, respectively. However, there was no difference in high triglycerides and systolic and diastolic blood pressure between genders. The mean of all the metabolic syndrome components was higher in obese than in overweight people and was also higher in overweight people than normal subjects, but this trend was downward from normal people to obese subjects for HDL. The mean WC, FBS, HDL, SBP and DBP were increased by every decade of subjects' age. Although the mean triglyceride level was increased in the age group of 50-59 compared to the age group of 40-49, this was the lowest in the elderly group (60-70 yr) than other three decades of age groups (Table 1). The results of the correlation between the metabolic syndrome components in the whole population showed the highest correlation between SBP and DBP (r=0.83). Then, there was an inverse correlation between HDL and TG. In terms of higher correlation, the correlation between WC with both SBP and DBP, and triglycerides with WC and FBS were the next. In terms of gender, in addition to the strong correlation between the two types of hypertension, the highest correlation was observed between waist circumference and blood pressure in males and there was a reverse correlation between HDL and TG in females (Table 2). In terms of BMI and age groups, in addition to the strong relationship between the two types of hypertension, the highest correlation was a reverse relationship between HDL and TG in the three groups. Thereafter, the highest correlation was found between WC and blood pressure (Data are not showed).

Table 1: Mean and SD of metabolic syndrome components by gender, BMI and age groups (n=10663)

Components	***Total (10663)***	***Sex***			***Body Mass Index (BMI), kg/m2***				***Age group (yr)***			
		Male (4719)	Female (5944)	*P*	Normal (4293)	Overweight (4451)	Obese (1919)	*P*	40-49 (4686)	50-59 (3759)	60-70 (2218)	*P*
WC, cm	95.5±12.0	93.0±11.9	97.5±11.7	<0.001	85.2±8.3	99.1±6.5	110.1±8.4	<0.001	94.7±12.0	96.0±12.0	96.5±12.0	<0.001
FBS, mg/dL	99.4±33.9	98.0±31.4	100.6±35.7	<0.001	97.9±33.1	99.6±33.7	102.4±35.8	0.003	94.1±26.4	101.8±36.9	106.6±40.2	<0.001
TG, mg/dL	130.3±80.8	130.1±80.8	130.5±80.9	0.760	119.9±73.2	135.1±83.2	142.5±88.2	<0.001	129.3±79.5	133.1±86.8	127.9±72.5	0.029
mg/dL HDL,	47.7±12.5	46.6±12.0	48.5±12.9	<0.001	48.5±12.8	47.3±12.2	46.7±12.5	0.029	46.6±12.1	48.0±12.5	49.4±13.3	<0.001
SBP, mm/Hg	115.1±17.7	114.9±16.9	115.2±18.3	0.321	111.5±16.9	116.6±17.4	119.5±18.7	<0.001	112.1±16.5	116.3±18.1	119.4±18.4	<0.001
mm/Hg DBP,	72.3±10.2	72.3±10.1	72.3±10.3	0.788	69.9±9.7	73.3±9.9	75.4±10.9	<0.001	71.4±10.1	72.9±10.4	73.2±10.0	<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: Correlation between the metabolic syndrome components 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
r P-value																		
WC, cm	1						1						1					
FBS, mg/dL	0.0*7<0.001	1					0.0*8<0.001	1					0.06*<0.001	1				
TG, mg/dL	0.1*4<0.001	0.18*<0.001	1				0.18*<0.001	0.18*<0.001	1				0.11*<0.001	0.18*<0.001	1			
mg/dL HDL,	-0.08*	-0.02<0.07<0.001	-0.29*<0.001	1			-0.06*<0.001	-0.03*<0.018	-0.28*<0.001	1			-0.12*<0.001	-0.01<0.416	-0.30*<0.001	1		
SBP, mm/Hg	0.24*<0.001	0.08*<0.001	0.06*<0.001	0.01<0.173	1		0.32*<0.001	0.07*<0.001	0.05*<0.001	-0.02<0.880	1		0.17*<0.001	0.10*<0.001	0.07*<0.001	0.02<0.082	1	
mm/Hg DBP,	0.27*<0.001	0.05*<0.001	0.06*<0.001	0.01<0.908	0.8*3<0.001	1	0.35*<0.001	0.06*<0.001	0.07*<0.001	0.05<0.714	0.8*4<0.001	1	0.21*<0.001	0.04*<0.001	0.06*<0.001	-0.02<0.903	0.8*3<0.001	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, $P<0.05$

The results of exploratory factor analysis for the metabolic syndrome components in the whole population based on eigenvalues greater than one and the scree plot (Data Are not showed) showed two factors explaining 56.06% of the total variance (first factor 33.46% and second factor 22.60%). Based on factor loadings above 0.3, the first factor included DBP, SBP and WC, named the hypertension factor. The second factor also included TG, negative-loaded HDL, FBS, and WC, named lipid factor. An almost similar pattern was observed in both genders and it was explained 57.45% and 55.45% of the variance in males and females, respectively (Table 3).

Table 3: Factor loadings for metabolic syndrome components in exploratory factor analysis using varimax rotation by gender

Components	***Total***		***Male***		***Female***	
	Factor 1	Factor 2	Factor 1	Factor 2	Factor 1	Factor 2
SBP, mm/Hg	0.933	-0.012	0.927	-0.030	0.941	0.026
DBP, mm/Hg	0.938	-0.014	0.933	-0.028	0.943	0.031
WC, cm	0.477	0.314	0.563	0.277	0.333	0.376
TG, mg/dL	0.055	0.798	0.075	0.797	0.020	0.785
HDL, mg/dL	0.069	-0.706	0.054	-0.700	0.097	-0.720
FBS, mg/dL	0.106	0.403	0.093	0.428	0.099	0.380
Eigen values	2.00	1.35	2.09	1.34	1.95	1.37
Variance explained	33.46	22.60	34.98	22.47	32.57	22.88
Cumulative variance	56.06		57.45		55.45	

Abbreviations: WC, waist circumference; FBS, fasting blood sugar; TG; Triglyceride; HDL, high density lipoprotein; SBP, systolic blood pressure; DBP, diastolic blood pressure.
Factor loads higher than 0.3 are bolded

In addition, the results of the exploratory factor analysis based on BMI in the normal weight group identified two factors that account for 55.96% of the total variance. Here the first factor also included SBP, DBP and WC, and the second factor included high TG, HDL, and FBS. In the overweight group, two factors with the same pattern were identified explaining 53.73% of the variance. However, in the obese group, three factors were identified: the first factor named hypertension included SBP and DBP, the second factor named lipid included TG and HDL, and the third factor named glucose included FBS explaining 70.83% of the total variance in this group. A similar pattern was also extracted by age groups (Table 4)

Discussion

This population-based study showed the mean metabolic syndrome components in the whole population, based on gender, age and BMI variables. The results of EFA limited the metabolic syndrome components in the whole population to two factors named as hypertension and lipid. Abdominal obesity was also important in both factors. Subsequently, similar patterns were extracted according to the subgroups of the studied variables.

The metabolic syndrome components are correlated; in this study, the highest correlation was found between SBP and DBP, followed by an inverse correlation between HDL and TG. WC was also correlated with both types of blood pressure. In the Hanley study, except for the relationship between SBP and DBP, all variables were significantly correlated with WC (20). In another study, TG and HDL cholesterol were inversely correlated (8). There was epidemiological evidence of a direct effect of WC on blood pressure (21). All of these results emphasize that all the metabolic syndrome components overlap.

In this study, the first identified factor in the whole population in both genders included DBP, SBP and WC, named Hypertension; the second factor included TG, Negative-loaded HDL-C, FBS and WC named as lipid factor explaining 56.06% of the total variance. Based on the results, obesity is common in all factors. In our study, all subgroups of SBP and DBP were loaded in one factor as well as TG and HDL-C in another factor. So, because of the importance of blood pressure measurement, it should be considered as a suitable tool for screening people at risk for MetS in populations. There was no major pathological process for metabolic syndrome. This evidence is consistent with previous studies on other populations with at least 2 factors observed in both genders (9, 12-15, 17).

Table 4: Factor loadings for metabolic syndrome components in exploratory factor analysis using varimax rotation by BMI and age groups

Components	***Body Mass Index (BMI), kg/m2***							***Age group (yr)***					
	Normal		Overweight		Obese			40-49		50-59		60-70	
	Factor 1	Factor 2	Factor 1	Factor 2	Factor 1	Factor 2	Factor 3	Factor 1	Factor 2	Factor 1	Factor 2	Factor 1	Factor 2
SBP, mm/Hg	**0.939**	0.016	**0.944**	-0.018	**0.946**	0.020	0.113	**0.940**	-0.021	**0.935**	-0.019	**0.926**	-0.013
mm/Hg DBP,	**0.937**	0.018	**0.942**	-0.018	**0.956**	-0.004	0.062	**0.943**	-0.025	**0.943**	-0.011	**0.935**	-0.003
WC, cm	**0.380**	**0.397**	**0.275**	**0.221**	**0.196**	-0.07	**0.441**	**0.488**	**0.302**	**0.433**	**0.290**	**0.346**	**0.367**
TG, mg/dL	0.018	**0.802**	0.040	**0.786**	0.018	**0.799**	**0.187**	0.067	**0.803**	0.054	**0.795**	0.057	**0.769**
mg/dL HDL,	0.116	-0.689	0.050	-0.693	0.009	-0.818	**0.167**	0.040	-0.732	0.035	-0.701	0.058	-0.646
FBS, mg/dL	0.127	**0.385**	0.079	0.461	-0.074	0.116	**0.893**	0.065	**0.344**	0.093	0.445	0.031	**0.525**
Eigen values	1.98	1.37	1.87	1.35	1.89	1.34	1.004	2.05	1.35	2.00	1.36	1.89	1.38
Variance explained	33.05	22.91	31.18	22.55	31.63	22.48	16.72	34.25	22.62	33.42	22.74	31.60	23.02
Cumulative variance	55.96		53.73		70.83			56.87		56.16		54.62	

Abbreviations: WC, waist circumference; FBS, fasting blood sugar; TG; Triglyceride; HDL, high-density lipoprotein; SBP, systolic blood pressure; DBP, diastolic blood pressure
Factor loads higher than 0.3 are bolded

Besides, in a study on the Iranian population, factor analysis identified three factors (blood pressure, lipids, and glycemia). In males, the first factor was identified by WC, SBP and DBP and the second factor was by positive loading for WC and TG and negative loading for HDL-C. The third factor was only FBS. In women, the variables of the first factor were similar to the first factor in men. The second factor in women identified by TG and negative-loaded HDL-C and the third factor by WC and FBS. The components explained 75.71% and 75.93% of the variances in males and females, respectively (12). Blood pressure and lipids were predominant in this study and waist circumference

were common in all three factors. In a study conducted on the whole population, the first factor was blood pressure (systolic and diastolic) and the second factor was triglyceride (HDL-C and TG) explaining 55.4% of the total variance (15); these results are consistent with the present study.

In the northern part of Iran, three factors were extracted by EFA in both genders. In men, hypertension included systolic and diastolic blood pressure, obesity and WC, and lipid/glucose factor included TG, HDL, and FBS. Together, these three factors accounted for 65.3% of the variance observed in men and 66.8% in women (13). In this study, BMI and WC were considered together for obesity. In this study, the first factor was hypertension, which was in line with our study and the obesity factor was next. In rural areas of India for both genders, three factors were identified in the measured variables explaining 71% of the variance. WC, TG, and LDL and HDL-C negative loading which had the highest explained variance. The second factor was cholesterol explaining about 20% of the variance (total cholesterol and low-density lipoprotein), but hypertension was the third factor in this study (14). In this study, dyslipidemia was the predominant factor correlated with waist circumference and other lipid factors. Generally, these inconsistencies in these studies can be related to the selection of criteria such as the target group, the number of factors, the extraction or rotation methods, the threshold chosen for loading factors, and the cut points for the selection of factors.

Central obesity, as defined by the International Diabetes Federation, is a major component of MetS (4). Obesity is related to all causes of death, especially cardiovascular mortality (22). In our study, abdominal obesity was loaded in both factors and had a higher factor load in women. This suggests that general obesity and abdominal obesity are the most sensitive markers of metabolic syndrome for women than men; therefore, women are more susceptible to metabolic abnormalities (23). As expected, body fat is a driving factor behind most of the factors and traits involved in the development of MetS and metabolic diseases (9). Central obesity appears to play an important role in linking other risk factors together in MetS. As an anthropometric measure, WC could be considered a suitable tool for screening individuals at risk for MetS.

Because of the large sample size, the population-based nature of the study, and because the information is based on a cohort study, more accurate data has been collected for research purposes. Moreover, exploratory factor analysis based on several variables including gender, age groups and BMI are the most important advantages of this study.

The cross-sectional nature of the study limited the possibility of examining causal relationships. This study also evaluated only the relationship between routine components in the definition of MetS and major risk factors and other non-routine risk factors have not been measured, addressed in future studies. Therefore, it is recommended to carry out these evaluations in different groups. Definitely, the results of subsequent phases of this cohort study could further help to understand the pathogenesis of MetS in this population.

Conclusion

MetS is a multi-factorial syndrome and some common causal patterns can be considered for the components of the syndrome. Two factors of blood pressure and lipid had a critical role, obesity was an important variable in both factors and blood pressure had the highest factor loading. Since the risk of cardiovascular disease is constantly increasing by higher blood pressure, it is important to identify these high-risk individuals. As a simple measurement, blood pressure can be a good tool for screening people at risk for MetS in populations.

Ethical considerations

Ethical issues (Including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, redundancy, etc.) have been completely observed by the authors.

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Data availability

Additional information is available. All readers may contact the corresponding author to provide all supplementary and additional data.

Conflict of interest

The authors declare that they have no competing interests.

References

1. O'Neill S, O'Driscoll L (2015). Metabolic syndrome: a closer look at the growing epidemic and its associated pathologies. *Obes Rev*, 16(1):1-12.
2. Mente A, Yusuf S, Islam S, et al (2010). Metabolic syndrome and risk of acute myocardial infarction a case-control study of 26,903 subjects from 52 countries. *J Am Coll Cardiol*, 55(21):2390-8.
3. Ghaem Maralani H, Tai BC, Wong TY, et al (2013). Metabolic syndrome and mortality in the elderly: a time-dependent association. *Diabetes Res Clin Pract*, 99(2):209-16.
4. Alberti KG, Zimmet P, Shaw J (2006). Metabolic syndrome--a new world-wide definition. A Consensus Statement from the International Diabetes Federation. *Diabet Med*, 23(5):469-80.
5. Nikbakht H-A, Rezaianzadeh A, Seif M, et al (2020). Prevalence of metabolic syndrome and its components among a population-based study in south of Iran, PERSIAN Kharameh cohort study. *Clinical Epidemiology and Global Health*, 8(3):478-83.
6. Ford ES (2005). Risks for all-cause mortality, cardiovascular disease, and diabetes associated with the metabolic syndrome: a summary of the evidence. *Diabetes Care*, 28(7):1769-78.
7. Hwang LC, Bai CH, You SL, et al (2013). Description and prediction of the development of metabolic syndrome: a longitudinal analysis using a markov model approach. *PLoS One*, 8(6):e67436.
8. Lafortuna CL, Adorni F, Agosti F, et al (2008). Factor analysis of metabolic syndrome components in obese women. *Nutr Metab Cardiovasc Dis*, 18(3):233-41.
9. Karns R, Succop P, Zhang G, et al (2013). Modeling metabolic syndrome through structural equations of metabolic traits, comorbid diseases, and GWAS variants. *Obesity (Silver Spring)*, 21(12):E745-54.
10. Shen BJ, Todaro JF, Niaura R, et al (2003). Are metabolic risk factors one unified syndrome? Modeling the structure of the metabolic syndrome X. *Am J Epidemiol*, 157(8):701-11.
11. Shen BJ, Goldberg RB, Llabre MM, et al (2006). Is the factor structure of the metabolic syndrome comparable between men and women and across three ethnic groups: the Miami Community Health Study. *Ann Epidemiol*, 16(2):131-7.
12. Ayubi E, Khalili D, Delpisheh A, et al (2015). Factor analysis of metabolic syndrome components and predicting type 2 diabetes: Results of 10-year follow-up in a Middle Eastern population. *J Diabetes,* 7(6):830-8.
13. Hajian-Tilaki K (2018). Factor Analysis of Metabolic Syndrome Components in an Iranian Non-Diabetic Adult Population: A Population-Based Study from the North of Iran. *Int J Endocrinol Metab,* 16(2):e14159.
14. Deshmukh PR, Kamble P, Goswami K, et al (2013). Metabolic syndrome in the rural population of wardha, central India: an exploratory factor analysis. *Indian J Community Med*, 38(1):33-8.
15. Nasila Sungwacha J, Tyler J, Longo-Mbenza B, et al (2013). Assessing clustering of metabolic syndrome components available at primary care for Bantu Africans using factor analysis in the general population. *BMC Res Notes*, 6:228.
16. Hong TK, Trang NH, Dibley MJ (2012). Prevalence of metabolic syndrome and factor analysis of cardiovascular risk clustering among adolescents in Ho Chi Minh City, Vietnam. *Prev Med,* 55(5):409-11.

17. Esteghamati A, Zandieh A, Khalilzadeh O, et al (2010). Clustering of leptin and physical activity with components of metabolic syndrome in Iranian population: an exploratory factor analysis. *Endocrine,* 38(2):206-13.
18. Poustchi H, Eghtesad S, Kamangar F, et al (2018). Prospective Epidemiological Research Studies in Iran (the PERSIAN Cohort Study): Rationale, Objectives, and Design. *Am J Epidemiol,* 187(4):647-55.
19. Wikipedia. Fars Province& Kharameh_County. Available from: *https://en.wikipedia.org/wiki/Fars_Province&Kharameh_County 2018*.
20. Hanley AJ, Karter AJ, Festa A, et al (2002). Factor analysis of metabolic syndrome using directly measured insulin sensitivity: The Insulin Resistance Atherosclerosis Study. *Diabetes,* 51(8):2642-7.
21. Poirier P, Lemieux I, Mauriege P, et al (2005). Impact of waist circumference on the relationship between blood pressure and insulin: the Quebec Health Survey. *Hypertension* ,45(3):363-7.
22. Ghaem Maralani H, Tai BC, Wong TY, et al (2014). The prognostic role of body mass index on mortality amongst the middle-aged and elderly: a competing risk analysis. *Diabetes Res Clin Pract* , 103(1):42-50.
23. Shah S, Novak S, Stapleton LM (2006). Evaluation and comparison of models of metabolic syndrome using confirmatory factor analysis. *Eur J Epidemiol,* 21(5):343-9.