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Factor Analysis of Anthropometric, Physiometric and Metabolic Risk Traits Associated with Cardiovascular Diseases in North Indian Punjabi Adults

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Abstract: The aim of the present study was to identify the clusters of risk factors of cardiovascular diseases among north Indian Punjabi population in India. The clustering of variables was evaluated by Principal Component Factor Analysis (PCFA) with varimax rotation on 616 individuals (350 males and 266 females) from north Indian Punjabi population in Punjab (a north Indian state). Principal component factor analysis was performed to extract orthogonal factors from 13 cardiovascular risk factors. A total of 6 and 5 principal factors accounting for 87 and 84% of the total variance were derived among males and females, respectively. Factor 1 was loaded with glucose and lipids for males; glucose and blood pressures for females. Factor 2 was loaded with obesity in males; glucose and lipid in females. Factor 3 was loaded with blood pressure in males and obesity in females. Therefore, principal component factor analysis has identified a number of cardiovascular risk factors in Punjabi population in north India. This finding indicated the importance of principal component factor analysis to identify the cluster of risk factors for chronic disease like cardiovascular disease.

Key words: PCFA, obesity, lipids, blood pressures, cardiovascular disease

INTRODUCTION

Cardiovascular disease is a significant and a leading cause of mortality and morbidity in present India and worldwide (Reddy, 1993; Mackay and Mensah, 2004; Tassaduqe *et al*., 2004;Yusuf *et al*., 2004; Cox *et al*., 2009; Latiffah and Hanachi, 2008). The risk of developing cardiovascular disease is influenced by smoking, alcohol drinking, physical inactivity, unhealthy diet, obesity, dyslipidemia, hypertension and genetic factors. However, hyperglycemia, dyslipidemia and higher blood pressure are often clustered together which is mostly identified as metabolic syndrome. It is also believed that Body Mass Index (BMI), Waist to Hip Ratio (WHR) or abdominal adiposity are significantly associated to produce metabolic syndrome. Although several studies have been done to demonstrate the increased waist circumference with the association dyslipidemia would be a good predictor of cardiovascular diseases (Han *et al*., 1995; Enas, 2000; Afridi *et al*., 2003; Kraja *et al*., 2005; Das *et al*., 2008; Mahajan *et al*., 2009; Odenigbo *et al*., 2011). However, all measures of adiposity (BMI, WC and WHR), blood pressures and lipid profile are correlated with each other and with incidence of cardiovascular disease. Therefore, large amount of environmental variables are available to understand the actual pathophysiology of cardiovascular disease which still remains unclear. Different approaches have been applied to characterize the significant risk factors for cardiovascular disease. Recently, a multivariate data reduction technique such as Principal Component Factor Analysis (PCFA) has received special attention to extract independent factors from large amount of intercorrelated factors (Bellis *et al*., 2005; Goodman *et al*., 2005; Sundaram *et al*., 2010). PCFA method is able to identify the clusters of variables for cardiovascular disease indicators.

In the present study we tested the different variables primarily responsible for metabolic syndrome such as Body Mass Index (BMI), Waist Circumference (WC), Systolic and Diastolic Blood Pressure (SBP and DBP), Pulse Pressure and Pulse Rate (PP and PR), fasting Glucose Level (GLU), Total Cholesterol (TC), High Density Lipoprotein (HDL), Triglyceride (TG), Low Density Lipoprotein (LDL) and Very Low Density Lipoprotein (VLDL). Therefore, the objective of the present study was to identify the clusters of factors of cardiovascular diseases among north Indian Punjabi population in India. The clustering of variables was evaluated by PCFA with varimax rotation. All the data were grouped by gender. To date no such study has been available in this Indo-Aryan ethnic group incorporating the anthropometric, physiometric, metabolic and blood glucose simultaneously to identify the risk components of cardiovascular diseases.

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MATERIALS AND METHODS

Study population: A total of 616 individuals (350 males and 266 females) within the age group 18-75 years were randomly recruited to participate in the present community based cross-sectional study. Written consent was obtained from all subjects prior to their participation. The data were collected from Punjabi population in urban and semi urban areas of three districts such as Amritsar, Gurdaspur and Ludhiana. The entire selected populations have relatively homogeneous life style due to their same ethnicity, food habit and community based culture. The present study was approved by the Guru Nanak Dev University appropriate research ethics committee in the year 2009.

Anthropometric measurements: The anthropometric measurements taken were height (cm), weight (kg), waist circumference (cm) and hip circumference (cm). All the anthropometric measurements were taken on each individual using standard anthropometric technique (Singh and Bhasin, 1968; Weiner and Lourie, 1981). The age of the individuals was determined directly from their reported date of birth. The height was measured using anthropometric rod with the subject standing erect position with the head in the ear-eye plane. The reading was then, recorded to the nearest 0.1 cm. The weight of the subject was measured in kilograms by making him stand on a weighing machine with minimal clothing. Weight was recorded with an allowance deducted for clothing to the nearest 0.5 kg. Waist circumference was measured using a steel tape. The measurement is taken mid-way between the inferior margin of the last rib and the crest of the ilium in a horizontal plane with relaxed abdomens. The tape was fitted snuggly without compressing the soft tissue. Hip circumference of the subject was taken with steel tape fitted around the pelvis at the point of maximal protrusion of buttocks while the subject was standing with his feet close to each other. The readings were recorded for WC and HC to the nearest 0.1 cm. The values for BMI expressed as the ratio of body weight divided by body height squared (in kg m^{-2}) and WHR defined as waist circumference divided by hip circumference.

Measurement of physiometric variables: The physiometric variables included measurement of Systolic Blood Pressure (SBP), Diastolic Blood Pressure (DBP) and pulse rate. Two consecutive readings were recorded for each of SBP and DBP and the averages were used. The measurements were taken with the help of mercury sphygmomanometer in a sitting position with the right forearm placed horizontal on the table. The recordings were taken as recommended by the American Heart Association (Kirkendall *et al*., 1981). An appropriate sized cuff was fitted on the arm of the subject and was inflated to about 20 mmHg above the point at which the radial pulse disappeared. The pressure within the cuff was then, released at a rate of approximately 2 mmHg sec^{-1} and while osculating with a stethoscope placed over the brachial artery. The onset of sound (Korotkoff- phase I) was taken as indicative of systolic blood pressure and the disappearance of sound (Korotkoff- phase V) was taken as indicative of diastolic blood pressure. All efforts were made to minimize the factors which might affect blood pressure like anxiety, fear, stress, laughing and recent activity (Badaruddoza and Afzal, 1999). The radial artery at the wrist is most commonly used to feel the pulse. It was counted over one minute. Pulse pressure is calculated through SBP and DBP using the following formula: Pulse pressure = SBP- DBP.

Metabolic and glucose measurements: Fasting time for glucose and biochemical measurement was defined as >12 h before blood draw. From each individual 3.5 mL of blood was drawn by venipuncture and stored in tubes containing 500 μL (0.5 M) EDTA as an anticoagulant. Tubes were serially (labeled properly) numbered and then transferred on ice to the laboratory. The samples were centrifuged at 2500-3000 rpm for 10 min. Plasma appeared as supernatant and was separated for further analysis. The absorbance of the standard and each test sample was read against the blank at 505 nm or 505/670 nm on the Erba Mannhiem biochromatic analyzer. The metabolic variables included were Total Cholesterol (TC) Triglycerides (TG) and High and Low Density Lipoproteins (HDL, LDL and VLDL). All biochemical traits were estimated in mg dL^{-1} unit.

Statistical analysis: Data were calculated using SPSS version 17.0. Principal Components Factor Analysis (PCFA) was used to extract orthogonal factors from anthropometric, physiometric and metabolic variables. PCFA is generally used when variables are highly inter-correlated and this statistical tool able to reduce a large number of inter-correlated variables to a smaller number of principal components which account most of the variance in the data (Suhr, 2005; Badaruddoza *et al*., 2010a). Obesity related phenotypes included Body Mass Index (BMI) calculated as kg m^{-2}, waist circumference and waist to hip ratio calculated as waist circumferences (cm)/hip circumferences (cm). Cardiovascular related traits included systolic and diastolic blood pressure, lipids (total cholesterol and triglycerides), lipoprotein

levels (HDL, LDL and VLDL) and other variables which have significant impact on cardiovascular disease such as pulse pressure (SBP-DBP), pulse rate (counted over one minute) and fasting level of glucose have also been included in the analysis. Factors were identified by orthogonal rotation (varimax) to minimize the independence of the clusters of the variables for loading to factors. The first factor (factor1) has explained maximum variance and subsequent factors were explained progressively smaller portions of the total variance. The components with eigenvalues greater or equal to 1 were retained for analysis. The correlations between the factors are explained by factor loadings which were considered greater than or equal to 0.4 for significant contribution of an original variables to a factors.

The measurements greater than or equal to 4 standard deviations from the mean were excluded from the analysis. Variables with high kurtosis and skewness were log transformed otherwise, kurtosis and skewness less than 0.6 were assumed to be normally distributed. A p value<0.05 (two tailed) was considered as significant.

RESULTS AND DISCUSSION

Sex-specific descriptive statistics such as mean, standard deviations, kurtosis and skewness of original measurements used in the PCFA for north Indian Punjabi population are presented in Table 1. The data used in this study consisted of 350 males and 266 females. The mean age of both male and female were 38.13±4.35 and 38.27±5.12 years, respectively. All the phenotypes except pulse rate, total cholesterol and VLDL indicated significant ($p<0.001$) sex-specific differences in the mean variance. Males were observed to have significantly higher values for WHR, DBP, pulse rate, total cholesterol, HDL and LDL compared to females. Female had significantly higher values of BMI, waist circumference, SBP, pulse pressure, fasting glucose, total triglycerides and VLDL than men. Analysis of BMI indicated that Punjabi females were an average overweight (BMI = 26.67). The accepted range for BMI for overweight is 25-29 kg m^{-2}. Waist circumference is another significant indicator for abdominal obesity. With the reference of WHO data it is assumed that waist circumference increase the risk of cardiovascular disease in males and females with measurements exceeding 101 and 89 cm, respectively. The average waist circumference of male (90.46 cm) was within the recommended range, however, females have significantly higher waist circumference (95.86 cm) than recommended range. The average systolic and diastolic blood pressure for males (132.08, 81.35) and females (134.53, 76.73) were within expected normal ranges which is classified as SBP≥140 mmHg and DBP≥90 mmHg considered being hypertensive. Lipid analysis was compared with WHO guidelines. Mean total cholesterol, triglyceride and lipoproteins (HDL and LDL) are within normal recommended limits for both males and females. Kurtosis after adjustments varied from 0.102 (DBP) to 0.601 (glucose) in males and 0.09 (DBP) to 0.816 (glucose) in females. Skewness after adjustment varied from 0.143 (DBP) to 0.604 (glucose) in males and 0.102 (DBP) to 0.754 (SBP) in females. These demonstrate normal distribution for the traits in the study for performing PCFA.

Pearson correlations among the 13 normally distributed variables are presented in Table 2. The upper triangle correlations correspond to the males whereas; the lower triangle refers to the females. In both groups strong correlations were observed among BMI, WC, WHR, SBP, DBP and glucose. Almost all important variables are significantly inter-correlated which demonstrate the structure of the factors. However, the positive and

Table 1: Descriptive statistics of the variables included in factor analysis

	Male (n = 350)				Female (n = 266)				Combined sex (n = 616)			
Variables	Kurtosis	Skewness	Mean	SD	Kurtosis	Skewness	Mean	SD	Kurtosis	Skewness	Mean	SD
BMI (kg m^{-2})	0.437	0.403	23.09	4.23	0.556	0.326	26.67**	4.85	0.443	0.394	24.84	4.85
WC (cm)	0.158	0.392	90.46	11.41	0.544	0.664	95.86**	10.23	0.113	0.143	92.55	13.13
WHR	0.403	0.425	0.948	0.08	0.396	0.583	0.925**	0.08	0.516	0.294	0.926	0.08
SBP (mmHg)	0.330	0.582	132.08	10.57	0.365	0.754	134.53**	11.20	0.150	0.483	129.44	12.43
DBP (mmHg)	0.102	0.143	81.35	11.18	0.09	0.102	76.73**	8.31	0.043	0.127	75.86	9.21
PP (mmHg)	0.575	0.490	50.72	8.54	0.584	0.603	57.73**	9.23	0.533	0.519	53.53	10.44
PR (Count min^{-1})	0.591	0.596	80.69	11.65	0.396	0.152	79.13	11.56	0.178	0.359	79.91	10.97
GLU (mg dL^{-1})	0.601	0.604	98.57	10.45	0.816	0.133	99.42**	15.93	0.323	0.846	98.85	20.13
TC(mg dL^{-1})	0.334	0.432	166.55	25.44	0.780	0.441	157.15	18.23	0.225	0.367	163.42	23.50
TG (mg dL^{-1})	0.275	0.566	100.23	36.40	0.602	0.230	110.32**	30.45	0.554	0.446	103.58	33.43
HDL (mg dL^{-1})	0.538	0.151	53.94	11.07	0.290	0.650	48.97**	12.41	0.032	0.248	52.28	11.28
LDL (mg dL^{-1})	0.297	0.186	92.57	23.37	0.234	0.325	68.36**	19.36	0.176	0.150	90.50	22.09
VLDL (mg dL^{-1})	0.278	0.445	20.04	7.28	0.643	0.241	22.12	12.08	0.445	0.334	20.73	9.07

BMI: Body Mass Index,WC: Waist circumference; SBP: Systolic blood pressure, DBP: Diastolic blood pressure, PP: Pulse pressure, PR: Pulse rate; GLU: Glucose, TC: Total cholesterol, TG: Triglyceride, HDL: High density lipoprotein, LDL: Low density lipoprotein, VLDL: Very low density lipoprotein, SD: Standard deviation. **Significant at the 0.001 level (2-tailed). *Significant at the 0.01 level (2-tailed)

Table 2: Correlation matrix of the variables included in factor analysis

	BMI	WC	WHR	SBP	DBP	PP	PR	GLU	TC	TG	HDL	LDL	VLDL
BMI		0.807**	0.499**	0.257**	0.221**	0.07	0.104	0.01	0.169	0.157	0.011	0.228**	0.157
WC	0.872**		0.791**	0.214**	0.188**	0.066	0.114*	0.082	0.104	0.157	0.154	0.235**	0.155
WHR	0.444**	0.729**		0.120*	0.101	0.042	0.064	0.232**	0.022	0.055	0.318**	0.166	0.052
SBP	0.223**	0.308**	0.250**		0.387**	0.703**	0.013	0.211**	0.223**	0.208**	0.113	0.088	0..095
DBP	0.264**	0.235**	0.131	0.495**		0.373**	0.073	0.096	0.208**	0.223**	0.056	0.200**	0.078
PP	0.053	0.172*	0.183*	0.766**	0.188*		0.023	0.164	0.102	0.098	0.076	0.115	0.098
PR	0.023	0.073	0.064	0.074	0.011	0.081		0.022	0.101	0.232**	0.299**	0.180*	0.232**
GLU	0.130	0.017	0.216**	0.262**	0.014	0.239**	0.198**		0.242**	0.317**	0.410**	0.023	0.317**
TC	0.167*	0.170*	0.126	0.336**	0.223**	0.401**	0.309**	0.418**		0.614**	0.087	0.855**	0.614**
TG	0.032**	0.337**	0.322**	0.423**	0.095	0.423**	0.052	0.206**	0,232**		0.054	0.354**	0.665**
HDL	0.253**	0.374**	0.350**	0.206**	0.151	0.249**	0.425**	0.056	0.302**	0.094		0.378**	0.054
LDL	0.295**	0.178*	0.093	0.075	0.067	0.032	0.592**	0.293**	0.632**	0.415**	0.264**		0.354**
VLDL	0.023	0.322**	0.334**	0.429**	0.101	0.426**	0.042	0.204*	0.163	0.655**	0.085	0.425**	

Upper triangle correlations for males and lower triangle correlations for females. **Correlation is significant at the 0.001 level (2-tailed). *Correlation is significant at the 0.01 level (2-tailed)

Table 3: Coefficients and variances of factors satisfying the eigenvalue≥1 criterion for cardiovascular risk traits

	Factor 1		Factor 2		Factor 3		Factor 4		Factor 5		Factor 6	
Variables	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
BMI	0.204	0.144	0.727*	0.244	0.165	0.722*	0.317	0.938*	0.219	0.213	0.381	-
WC	0.128	0.171	0.941*	0.145	0.178	0.784*	0.158	0.925*	0.225	0.188	0.137	-
WHR	0.134	0.170	0.829*	0.316	0.254	0.696*	0.261	0.124	0.246	0.254	0.419*	-
SBP	0.234	0.798*	0.103	0.109	0.931*	0.431*	0.256	0.198	0.213	0.456*	0.414*	-
DBP	0.134	0.445*	0.109	0.210	0.515*	0.456*	0.156	0.176	0.124	0.966*	0.882*	-
PP	0.286	0.746*	0.123	0.167	0.931*	0.372	0.109	0.171	0.213	0.314	0.231	-
PR	0.250	0.142	0.234	0.900*	0.566	0.278	0.486*	0.256	0.656*	0.280	0.119	-
GLU	0.649*	0.455*	0.294	0.573*	0.262	0.736*	0.486*	0.228	0.116	0.267	0.213	-
TC	0.483*	0.283	0.222	0.647*	0.332	0.449*	0.832*	0.184	0.386	0.156	0.147	-
TG	0.896*	0.881*	0.125	0.518*	0.245	0.304	0.298	0.218	0.275	0.243	0.241	-
HDL	0.190	0.233	0.152	0.233	0.106	0.209	0.273	0.134	0.116	0.187	0.345	-
LDL	0.771*	0.336	0.183	0.855*	0.471*	0.156	0.817*	0.229	0.878*	0.388	0.167	-
VLDL	0.896*	0.883*	0.245	0.515*	0.278	0.299	0.281	0.180	0.201	0.243	0.210	-
Eigen value	3.146	3.192	2.896	2.677	1.834	2.515	1.563	1.442	1.476	1.057	1.240	-
Total variance	22.468	24.554	20.686	20.590	13.097	19.346	11.166	11.095	10.541	8.133	8.857	-
Cumulative variance	22.468	24.554	43.155	45.144	56.251	64.490	67.418	75.585	77.959	83.718	86.816	-

*Loadings≥0.4. BMI: Body mass index, WC: Waist circumference, WHR: Waist to hip ratio, SBP: Systolic blood pressure, DBPL: Diastolic blood pressure, PP: Pulse pressure, PR: Pulse rate, GLU: Fasting glucose, TC: Total cholesterol, TG: Triglyceride, HDL: High density lipoprotein, LDL: Low density lipoprotein, VLDL: Very low density lipoprotein

significant association between increased BMI, WC, WHR and lipids with the development of cardiovascular diseases among Punjabi population has been reported by Alhamdan (2008), Owiredu *et al.* (2008), Latiffah *et al.* (2008), Badaruddoza and Kumar (2009), Badaruddoza and Sawhney (2009), Badaruddoza *et al.* (2010a, b) and Afoakwah and Owusu (2011).

Punjabi populations are unique in India with respect to prosperity, culture, urbanized lifestyle and rich food habit. Therefore, this population has a great importance to the study of complex disorders such as type 2 diabetes and cardiovascular origin which is deeply involved with lifestyle factors. Hence, the current study focused on Punjabi population to dissect the anthropometric, physiometric and metabolic variables underlying cardiovascular disease risk. We performed PCFA with orthogonal rotation to reduce 13 intercorelated variables into groups of uncorrelated factors. The result of analysis has been compared with males and females. To date, no study is available in Punjabi population with PCFA of quantitative traits responsible for cardiovascular risk. The detailed characteristics of Principal Component Factor Analysis (PCFA) are presented in Table 3. The PCFA extracted 6 and 5 factors for males and females, respectively which explained nearly 87 and 84% of the total variations of the 13 original quantitative traits for males and females, respectively. Factor 1 for males has maximum loadings of the traits that reflect lipid particularly total cholesterol, triglycerides, low density lipoproteins (LDL and VLDL) and glucose and explained the largest portion of the total variance (22%). Factor 1 for females is also predominantly with SBP, DBP, PP, glucose, triglycerides and VLDL and explained 25% of the total variance. Factor 1 is a strong indicator of atherosclerosis for both sexes, especially, for females. Factor 2 for males is loaded for obesity mainly for BMI, WC and WHR and this factor explained nearly 21% of the total variance. Factor 2 for females again identified mostly for lipids (total cholesterol, triglycerides, LDL and VLDL), pulse rate and glucose and this factor explained 21% of the total

variance. Therefore, factor 2 is associated with obesity for males and atherogenic dyslipidaemia and type 2 diabetes. Factor 3 for males is loaded with SBP, DBP, pulse rate and pulse pressure which is the strong predictor of hypertension. Factor 3 for females is predominantly loaded with obesity (BMI, WC and WHR) and blood pressures (SBP and DBP). Comparably, factor 4 for males is loaded with pulse rate, glucose, total cholesterol and LDL which is also a strong indicator of ischemic stroke and risk of heart attack. Factor 4 for females is again loaded for central obesity which is a strong indicator of cardiovascular diseases. Factor 5 for males is loaded for pulse rate and LDL. While, in females it is loaded with blood pressure (SBP and DBP) which reflects the risk of essential hypertension. Factor 6 for males is blood pressure (SBP and DBP) and WHR. Therefore, the present results such as high loadings for lipids, obesity and blood pressure are consistent with other factor analysis studies (Shmulewitz *et al*., 2001; Bellis *et al*., 2005; Goodman *et al*., 2005; Badaruddoza *et al*., 2010c; Chang *et al*., 2010).

CONCLUSION

The clustering of risk variables is the results of multiple factors such as lipids, obesity, glucose level and blood pressures. Between genders, the factors loaded are not in a similar fashion. Factor 1 is identified as lipids in males and blood pressures in females. Similarly, factor 2 is identified as obesity in males and lipids in females. Factor 3 is identified as blood pressures in males and obesity in females. Therefore, lipids and obesity had statistically different loadings in males and females. SBP, DBP and glucose were associated with 3 factors in females and are contributing major risk for cardiovascular diseases. BMI, WC and cholesterol were associated with two factors in males and females and are contributing considerable risk. Low density lipoproteins have associated with three factors in males and are contributing major risk for cardiovascular diseases. Hence, it seems from the present analysis that principal component factor analysis is attractive and better predictors for quantitative traits analysis to identify the cluster of risk factors for cardiovascular diseases.

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