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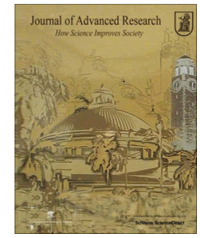

ORIGINAL ARTICLE

Principal component analysis of cardiovascular risk traits in three generations cohort among Indian Punjabi population

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A B S T R A C T

The current study focused to determine significant cardiovascular risk factors through principal component factor analysis (PCFA) among three generations on 1827 individuals in three generations including 911 males (378 from offspring, 439 from parental and 94 from grand-parental generations) and 916 females (261 from offspring, 515 from parental and 140 from grandparental generations). The study performed PCFA with orthogonal rotation to reduce 12 inter-correlated variables into groups of independent factors. The factors have been identified as 2 for male grandparents, 3 for male offspring, female parents and female grandparents each, 4 for male parents and 5 for female offspring. This data reduction method identified these factors that explained 72%, 84%, 79%, 69%, 70% and 73% for male and female offspring, male and female parents and male and female grandparents respectively, of the variations in original quantitative traits. The factor 1 accounting for the largest portion of variations was strongly loaded with factors related to obesity (body mass index (BMI), waist circumference (WC), waist to hip ratio (WHR), and thickness of skinfolds) among all generations with both sexes, which has been known to be an independent predictor for cardiovascular morbidity and mortality. The second largest components, factor 2 and factor 3 for almost all generations reflected traits of blood pressure phenotypes loaded, however, in male offspring generation it was observed that factor 2 was loaded with blood pressure phenotypes as well as obesity. This study not only confirmed but also extended prior work by developing a cumulative risk scale from factor scores. Till today, such a cumulative and extensive scale has not been used in any Indian studies with individuals of three generations. These findings and study highlight the importance of global approach for assessing the risk and need for studies that elucidate how these different cardiovascular risk factors interact with each other over the time to create clinical disease. The findings also added depth to the negligible amount of literature of factor analysis of cardiovascular risk in any Indian ethnic population.

Introduction

Cardiovascular diseases (CVDs) are multifactorial disorders which have strong environmental influences in combination with its polygenic nature. In general, the occurrence of CVD is influenced by genetic and life style factors such as

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obesity, unhealthy diet, physical inactivity, alcohol drinking and smoking. The prevalence of CVD in India is expected to be very high and it has risen many-fold in past two decades [1–4] due to an increase in westernized diets, life styles and the increasing mean age of populations [5]. The risk factors for cardiovascular disease seem to cut across all cultural patterns and geographic regions in India. It is observed that the risk factors of metabolic syndrome like hyperglycemia, dyslipidemia and blood pressures clustered together. On the other hand, body mass index (BMI), waist circumference (WC) and waist to hip ratio (WHR) are significantly associated with metabolic syndrome. Therefore, it is difficult to trace better predictor for CVD. Several studies have reported that increased WC has significant association with dyslipidemia and considered as a good predictor of cardiovascular diseases [6–10]. However, all the anthropometric and physiometric risk factors are inter-correlated with each other and equally responsible to produce CVD. In recent times, a different approach has been applied to identify the better predictor for cardiovascular diseases. Presently, principal component factor analysis (PCFA) has been used to extract independent factors from large amount of inter-correlated factors [1,11,12]. The PCFA is a statistical method of data reduction which has been used in past many years to identify the clustering of risk factors of the metabolic syndrome [1,2,11,13]. All these studies have consistently found multiple factors. The first principal component is a linear combination of the individual variables that are associated with the maximum variance in the data among all possible linear combinations. For complex diseases like CVD the first principal component can be used to indicate the extent to which any individual's CVD risk factors are consistent with having the CVD. However, in Indian context the paucity of family and generations based information and complex etiology of this risk factor made it difficult to uncover the disease pathways. Therefore, the present study involved Ramadasia community of north-west Punjab, India. The Ramadasia community is a unique population to study multifactorial disorders. The combination of social, educational and economical backwardness leads to community sharing a common environment, minimizing differences in lifestyle factors such as diet, exercise, education and stress compared to other populations. Therefore, the homogeneous environment shared by individuals is of great significance in studying complex disorders, especially CVD, which appears to be a threshold effect influenced by lifestyle factors. This community is also of interest in genetic studies as large number of individuals lived in joint families. The current study focused to determine significant cardiovascular risk factors through principal component factor analysis (PCFA) among three generations (offspring, parental and grandparental) in both sexes.

Subjects and methods

Study population

This study used a stratified multistage cluster random sampling design. The present study subjects are supposed to represent Ramdasia community which is a socially and economically backward scheduled caste population, of ages 7 years and above including three generations i.e. offspring, parental and grand-parental generations. All the information such as personal, socio-demographic, medical history, family history of cardiovascular disease, physiometric and anthropometric variables of the subjects was collected through pre-tested self-designed questionnaire. The questionnaire was in English language but before data collection the entire questionnaire was explained in the local Punjabi language to the subjects along with the aims and objectives of the study and the procedure for the data collection. *The present study is ethically approved by the ethical research committee of Guru Nanak Dev University, Amritsar, Punjab, India and an informed consent was signed by the subject taken. In case of the offspring ($\leqslant$18 years) the entire procedure was explained to their parents or any elder person and his/her signature was taken on offspring's questionnaire*. The present data were cross-sectional descriptive study and interview method was adopted to extract the appropriate information from the subjects.

Samples

Total number of samples taken at first visit was 1923, which included 971 males and 952 females. The exclusion of subjects after second visit reduced the total samples studied in three generations to 1827, including 911 males (378 from offspring, 439 from parental and 94 from grand-parental generations) and 916 females (261 from offspring, 515 from parental and 140 from grandparental generations). The age ranges were for offspring from 9.5 to 26.7 years, for parental from 30.5 to 60.7 years and grand parental from 58.2 to 85.6 years. However, the average discriminating age between 3 generations was 26.6 years. The entire study was performed in three years since October, 2008 to December, 2011.

Measurements

The anthropometric measurements taken were height (cm), weight (kg), waist circumference (WC) (cm), hip circumference (HC) (cm), biceps and triceps skinfold (mm). All anthropometric measurements were taken on each individual using standard anthropometric techniques [14,15]. The body mass index (BMI) expressed as the ratio of body weight divided by body height squared (in kg/m^2) and waist to hip ratio (WHR) defined as waist circumference (cm) divided by hip circumference (cm). The physiometric variables included measurements of systolic blood pressure (SBP), diastolic blood pressure (DBP) and pulse rate. Two consecutive readings as recommended by the American Heart Association [16] were recorded for each SBP and DBP and the averages were used. The radial artery at the wrist is most commonly used to feel the pulse. It was counted over one minute. Pulse pressure is calculated as SBP–DBP. The units of blood pressure measurements taken were mmHg.

Inclusion and exclusion criteria

Healthy individuals were selected and only those individuals who had not taken any medication at least 2 weeks prior to the study were chosen. Unwillingness, unavailability in the first and second visits, illness, taken medicine and pregnancy were excluded from the study.

Statistical analysis

Data were calculated using SPSS version 17.0. A p value of < 0.05 was considered significant. Principal Component Factor Analysis (PCFA) was used to extract orthogonal factors from cardiovascular and obesity related measurements. Obesity related phenotypes included body mass index (BMI), waist and hip circumferences, waist to hip ratio, biceps and triceps skinfolds. Cardiovascular related traits included systolic and diastolic blood pressures, pulse rate and pulse pressure. The principal component 1 explained the maximum variance and subsequent factors explained progressively smaller portions of the total variance. Factors were simplified by orthogonal (varimax) which minimized the number of variables with high loadings on each factor (orthogonal rotation to transform the extracted factors into uncorrelated, independent factors to increase the interpretability of the factors). The correlations between the factors were explained by factor loadings, values greater than or equal to 0.4 were used to indicate significant correlations between the component and the variables. The components with eigen values (sum of the squared factor loadings) greater than or equal to 1 were retained for analysis (components with variances less than one produce negligible information than one of the original variables and hence are not worth retains).

Statistical power has a kind of direct relationship with level of significance. It has been decided through statistical power calculation for present study that 1800 plus samples are required to detect specified significant correlation between the variables. Therefore, though number of variable in the correlation matrix is large enough, therefore, the probability for getting significant correlation by chance is < 0.050. Furthermore, significant inter-correlation between the variables indicates the structures of variables are the distinct phenotype underlying CVD risk cannot be interpreted by single variables rather than cluster of variables.

Results

Pearson's correlation matrixes among 12 normally distributed variables are presented in Tables 1–3 among different generations. The upper triangle correlation corresponds to the male whereas lower triangle refers to the female. In offspring and parental generations (Tables 1 and 2), strong correlations were observed among BMI, waist circumference, hip circumference, WHR, biceps and triceps skinfold, SBP and DBP. Almost all important variables significantly inter-correlated which demonstrated the structure of factors among offspring generations. In Table 3, almost all studied anthropometric variables were significantly ($p < 0.05$) inter-correlated with each other for male grandparent generations as compared to female grandparental generation. The overall degree of correlation supported the use of factor analysis.

Coefficients and variances of factors satisfying the eigen values $\geqslant 1$ criterion among offspring generation have presented in Table 4. Among offspring generations, the principal component analysis (PCA) extracted three and five factors which explained 72% and 84% of total variations of 12 original quantitative traits among male and female offspring respectively. Factor 1 has been high loadings of traits that reflect obesity such as weight, BMI, waist circumference, hip

Table 1 Correlation matrix of variables included in factor analysis among offspring generation aged between 9.5 and 26.7 years (n = 639; male = 378; female = 261).

Variables	Age	Weight	BMI	Waist circumference	Hip circumference	WHR	Biceps skinfold	Triceps skinfold	SBP	DBP	Pulse rate	Pulse pressure
Age		**0.808****	**0.634****	**0.736****	**0.727****	**0.131***	**0.254****	**0.346****	**0.461****	**0.390****	**0.165***	0.359**
Weight	**0.707****		0.885	**0.900****	**0.869****	**0.167***	**0.463****	**0.566****	**0.548****	**0.395****	**0.132***	0.451**
BMI	**0.268****	0.294*		**0.849****	**0.756****	**0.267****	**0.562****	**0.657****	**0.485****	**0.327****	0.058	0.410**
Waist circumference	**0.667****	0.888**	0.335**		**0.844****	**0.398****	**0.562****	**0.629****	**0.482****	**0.362****	0.048	0.411**
Hip circumference	0.733	0.934	0.276	0.870		0.054	**0.423****	**0.511****	*0.497***	**0.351****	**0.108***	0.414**
WHR	0.002	0.100	0.168*	**0.431****	0.046		**0.306****	**0.255****	0.054	0.061	**0.112***	0.085*
Biceps skinfold	**0.389****	**0.664****	0.178*	**0.651***	**0.651****	**0.142***		**0.816****	**0.257****	**0.223****	**0.167****	0.200**
Triceps skinfold	**0.471****	**0.765****	0.262*	**0.747****	**0.747****	**0.160***	**0.848****		**0.337****	**0.281****	0.072	0.217**
SBP	**0.231****	**0.338****	0.124*	**0.287****	**0.358****	0.057	**0.235****	**0.244****		**0.544****	**0.113***	0.577**
DBP	**0.177****	**0.211****	0.070	**0.171****	**0.218****	0.036	**0.177****	**0.115***	**0.581****		0.063	0.051
Pulse rate	0.070	0.007	0.059	0.077	0.004	**0.186***	**0.160****	0.108	0.036	0.059		**−0.174****
Pulse pressure	**0.145***	**0.230****	0.087	**0.211****	**0.246****	0.021	**0.134****	**0.187***	**0.662****	**−0.178****	0.111	

Upper triangle corresponds to correlation for male offspring and lower triangle corresponds to correlation for female offspring.
** Correlation is significant at 0.001 (two-tailed).
* Correlation is significant at 0.05 level (two-tailed).

Table 2 Correlation matrix of variables included in factor analysis among parental generation aged between 30.5 and 60.7 years (n = 954; male = 439; female = 515).

Variables	Age	Weight	BMI	Waist circumference	Hip circumference	WHR	Biceps skinfold	Triceps skinfold	SBP	DBP	Pulse rate	Pulse pressure
Age		0.067	0.066	0.058	0.114**	0.223**	0.069	0.071	0.177**	0.088*	0.041	0.192**
Weight	0.232**		0.899**	0.847**	0.826**	0.463**	0.670**	0.636	0.274**	0.241**	0.190**	0.173**
BMI	0.278**	0.914**		0.831**	0.762**	0.745**	0.702**	0.661**	0.264**	0.209**	0.178**	0.183**
Waist circumference	0.394**	0.840**	0.837**		0.817**	0.648**	0.675**	0.731**	0.265**	0.240**	0.243**	0.169**
Hip circumference	0.193**	0.756**	0.698**	0.641**		0.215**	0.613**	0.590**	0.250**	0.191**	0.233**	0.174**
WHR	0.045	0.003	0.010	0.011	0.120		0.423**	0.405**	0.154**	0.180**	0.133**	0.084*
Biceps skinfold	0.204**	0.721**	0.738**	0.668*	0.559**	0.027		0.770**	0.239**	0.247**	0.136*	0.126*
Triceps skinfold	0.197**	0.678**	0.691**	0.634**	0.554**	0.054	0.754**		0.281**	0.252**	0.125*	0.180**
SBP	0.362**	0.308**	0.347**	0.354**	0.247**	0.007	0.255**	0.222**		0.663**	0.291**	0.828**
DBP	0.194**	0.247**	0.276**	0.261**	0.226**	0.007	0.254**	0.209**	0.748**		0.330**	0.159**
Pulse rate	0.034	0.045	0.277**	0.055	0.021	0.016	0.157*	0.158	0.171*	0.212**		0.131*
Pulse pressure	0.371**	0.238**	0.277**	0.307**	0.172**	0.016	0.157*	0.158**	0.847**	0.307**	0.076*	

Upper triangle corresponds to correlation for male parents and lower triangle corresponds to correlation for female parents.

** Correlation is significant at 0.001 (two-tailed).

* Correlation is significant at 0.05 level (two-tailed).

Table 3 Correlation matrix of variables included in factor analysis among grandparental generation aged between 58.2 and 85.6 years (n = 234; male = 94; female = 146).

Variables	Age	Weight	BMI	Waist circumference	Hip circumference	WHR	Biceps skinfold	Triceps skinfold	SBP	DBP	Pulse rate	Pulse pressure
Age		0.511**	0.529**	0.392**	0.457**	0.154	0.422**	0.435**	0.216*	0.120	0.050	0.296**
Weight	0.354**		0.915**	0.904**	0.896**	0.572**	0.784	0.800**	0.182	0.354**	0.232	0.400
BMI	0.216**	0.869**		0.866**	0.779**	0.644**	0.807**	0.784**	0.179	0.340**	0.172	0.200
Waist circumference	0.287**	0.870**	0.816**		0.826**	0.791**	0.772**	0.752**	0.152	0.307**	0.164	0.058
Hip circumference	0.278**	0.821**	0.708**	0.785**		0.341**	0.698**	0.721**	0.166*	0.306**	0.226*	0.008
WHR	0.082	0.265**	0.269**	0.393**	0.002		0.572**	0.515**	0.135	0.225*	0.045	0.036
Biceps skinfold	0.412**	0.715**	0.646**	0.702**	0.660**	0.234**		0.815**	0.063	0.280**	0.159	0.131
Triceps skinfold	0.489**	0.740**	0.702**	0.751**	0.707**	0.253**	0.852**		0.172	0.276**	0.121	0.018
SBP	0.267**	0.027	0.066	0.082	0.190	0.170	0.054	0.058		0.694**	0.284**	0.815**
DBP	0.147*	0.064	0.047	0.139*	0.002	0.192*	0.100	0.052	0.753**		0.347**	0.265**
Pulse rate	0.043	0.062	0.109	0.037	0.143	0.047	0.159	0.173	0.046	0.187*		0.150
Pulse pressure	0.288**	0.002	0.061	0.029	0.015	0.110	0.022	0.062	0.912**	0.439**	0.052	

Upper triangle corresponds to correlation for male grandparents and lower triangle corresponds to correlation for female grandparents.

** Correlation is significant at 0.001 (two-tailed).

* Correlation is significant at 0.05 level (two-tailed).

Table 4 Coefficients and variances of factors satisfying the eigen values > 1 criterion for cardiovascular risk factors among offspring generation.

Variables	Male offspring (n = 378)				Female offspring (n = 261)					
	Factor 1	Factor 2	Factor 3	Communalities	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Communalities
Age (years)	0.252	**0.705**	0.356	0.688	**0.733**	0.018	0.181	0.289	0.126	0.670
Weight (kg)	**0.477**	**0.740**	0.349	0.462	**0.938**	0.043	0.093	0.123	0.030	**0.907**
BMI (kg/m^2)	**0.628**	**0.604**	0.257	**0.825**	**0.378**	0.073	0.145	0.129	**0.629**	0.666
Waist circumference (cm)	**0.643**	**0.630**	0.264	**0.880**	**0.926**	0.216	0.020	0.106	0.091	0.924
Hip circumference (cm)	**0.408**	**0.702**	0.342	**0.780**	**0.930**	0.027	0.113	0.209	0.090	**0.924**
WHR	**0.570**	0.011	0.178	0.357	0.180	**0.492**	0.197	**0.623**	0.357	**0.828**
Biceps skinfold (mm)	**0.864**	0.063	0.154	**0.773**	**0.778**	0.202	0.117	0.008	0.288	**0.744**
Triceps skinfold (mm)	**0.834**	0.187	0.213	**0.776**	**0.853**	0.202	0.009	0.021	0.211	**0.813**
SBP (mm Hg)	0.077	**0.524**	**0.621**	0.666	**0.466**	**0.781**	0.299	0.265	0.033	**0.987**
DBP (mm Hg)	0.094	0.084	**0.894**	**0.814**	0.287	0.382	**0.760**	0.306	0.277	**0.976**
Pulse rate (counts/min)	0.304	**0.608**	0.315	0.562	0.050	0.366	**0.586**	0.284	0.365	0.693
Pulse pressure	0.080	**0.674**	0.042	0.462	0.319	**0.604**	0.336	**0.603**	0.201	**0.983**
Eigen value	6.575	1.667	1.070		5.051	1.633	1.251	1.168	1.020	
Total variance (%)	50.576	12.822	8.231		42.089	13.605	10.428	9.730	8.497	
Accumulative variance (%)	50.576	63.397	71.629		42.089	55.694	66.123	75.853	84.350	
SS loading	3.755	3.584	1.973		4.605	1.575	1.432	1.2888	1.223	

Factors loading in bold type are >0.4; communalities are bold >0.7.

circumference, WHR, biceps skinfold and triceps skinfold and explained the largest portion of the total variances (51% and 42%) among male and female offspring respectively. Factor 2 has been loaded predominantly with SBP, pulse rate and pulse pressure and obesity factors and explained 13% of total variances among male offspring, whereas among female offspring, factor 2 has been loaded only with WHR, SBP and pulse pressure and has explained 14% of total variances. Comparably factor 3 has been loaded with blood pressures such as SBP and DBP and explained 8% of total variances among male offspring. In female offspring, factor 3 was identified as DBP and pulse rate and explained 10% total of variance. Therefore, factor 3 has been identified as strong predictor of CVD. Among female offspring, factor 4 contained high loading of WHR and pulse pressure and factor 5 contained BMI. Therefore, factor 1 would be a strong indicator of obesity related traits; factor 2 has also been identified as obesity clustered with cardiovascular risk. Factor 3 has been identified only as indicator of essential hypertension among male offspring. In female offspring, factor 1 has been identified mostly for obesity traits, factor 2 and 3 would be associated with cardiovascular risk and factors 4 and 5 would be associated with obesity.

Communality is the variance in observed variables accounted by common factors. The estimates of communality may be interpreted as the reliability of indicators. If an indicator scored a low communality then factor model is not working for that indicator and possibly it should be removed from the model. A communality of 0.75 seems to be high and below 0.5 is to be considered low communality. Therefore, the common greater communality estimates (>0.7) has been identified in the present analysis on BMI, waist circumference, hip circumference, biceps skinfold, triceps skinfold and DBP among male offspring; weight, waist circumference, hip circumference, WHR, biceps skinfold, triceps skinfold, SBP, DBP and pulse pressure for female offspring.

Coefficients and variances of factors satisfying the eigen values ⩾ 1 criterion among parental generation have been presented in Table 5. Among parental generation principal component analysis extracted four and three factors which explained 79% and 69% of total variance among male and female parents respectively. Factor 1 reflected obesity related traits such as weight, BMI, waist circumference, hip circumference, WHR, biceps skinfold and triceps skinfold which explained largest portion of total variances (47% and 43%) in males and females, respectively. Factor 2 has been heavily loaded with blood pressure traits such as SBP and DBP in male parents that explained 16% of total variances. However, in female parents, factor 2 has been loaded with age, DBP and pulse pressure and explained 16% of total variances. Factor 3 has been heavily loaded with age in both male and female parents and explained 9% of total variances in both the groups. Factor 4 in male parents has been loaded with DBP, pulse rate and pulse pressure. Thus, factor 1 has shown to be a strong indicator of obesity related traits in both the groups, but has been clustered with blood pressure in male offspring. Factor 2 has shown to be associated with cardiovascular risk trait among both the groups. Greater communality estimates were found on age, weight, BMI, waist circumference, hip circumference, WHR, biceps skinfold, SBP, pulse rate and pulse pressure among male parents and on weight, BMI, waist circumference, biceps skinfold, SBP and pulse pressure among female parents.

Coefficients and variances of factors satisfying the eigen values ⩾ 1 criterion among grandparental generation have been presented in Table 6. Among grandparent generation principal component analysis extracted two and three factors which explained 70% and 73% of total variance among male and female grandparents, respectively. Factor 1 has been heavily loaded with obesity traits like age, weight, BMI, waist circumference, hip circumference, WHR, biceps skinfold and triceps skinfold and explained maximum variance (52% and 42%) among male and female grandparents, respectively. Factor 2 has been loaded with blood pressure traits such as SBP, DBP, pulse rate and pulse pressure explained 18% of total variances among males. In females, it has been loaded with age, SBP, DBP and pulse pressure and explained 22% of total variances. Factor 3 in females has been loaded with WHR and

Table 5 Coefficients and variances of factors satisfying the eigen values > 1 criterion for cardiovascular risk factors among parental generation.

Variables	Male parent (n = 439)					Female parent (n = 515)			
	Factor 1	Factor 2	Factor 3	Factor 4	Communalities	Factor 1	Factor 2	Factor 3	Communalities
Age (years)	0.005	0.042	0.775	0.018	**0.761**	0.226	**0.496**	**0.474**	0.522
Weight (kg)	**0.896**	0.157	0.044	0.022	**0.830**	**0.928**	0.142	0.013	**0.822**
BMI (kg/m^2)	**0.898**	0.171	0.002	0.049	**0.839**	**0.915**	0.192	0.024	**0.875**
Waist circumference (cm)	**0.917**	0.127	0.210	0.069	**0.906**	**0.857**	0.248	0.099	**0.806**
Hip circumference (cm)	**0.816**	0.150	0.227	0.028	**0.741**	**0.795**	0.098	0.008	0.642
WHR	**0.595**	0.042	**0.621**	0.147	**0.763**	0.017	0.044	0.358	0.130
Biceps skinfold (mm)	**0.823**	0.166	0.057	0.061	**0.712**	**0.845**	0.093	0.111	**0.736**
Triceps skinfold (mm)	**0.810**	0.115	0.080	0.116	0.689	**0.822**	0.067	0.035	0.681
SBP (mm Hg)	**0.446**	**0.852**	0.155	0.155	**0.973**	0.175	0.960	0.070	**0.957**
DBP (mm Hg)	0.385	**0.573**	0.162	**0.416**	0.676	0.175	**0.703**	0.338	0.640
Pulse rate (counts/min)	0.289	0.350	0.148	**0.699**	**0.716**	0.034	0.208	0.769	0.636
Pulse pressure	0.300	0.724	0.062	**0.522**	**0.890**	0.107	**0.842**	0.170	**0.749**
Eigen value	6.068	2.018	1.170	1.010		5.163	1.980	1.113	
Total variance (%)	46.680	15.525	9.003	7.772		43.029	16.498	9.272	
Accumulative variance (%)	46.680	62.205	71.209	78.981		43.029	59.527	68.799	
SS loading	5.628	1.867	1.490	1.283		4.582	2.558	1.116	

Factors loading in bold type are >0.4; communalities are bold >0.7.

Table 6 Coefficients and variances of factors satisfying the eigen values > 1 criterion for cardiovascular risk factors among grandparental generation.

Variables	Male grandparent (n = 94)			Female grandparent (n = 140)			
	Factor 1	Factor 2	Communalities	Factor 1	Factor 2	Factor 3	Communalities
Age (years)	**0.594**	0.306	0.447	**0.433**	0.423	0.145	0.388
Weight (kg)	**0.942**	0.153	**0.911**	**0.929**	0.018	0.094	**0.873**
BMI (kg/m^2)	**0.931**	0.138	**0.886**	**0.875**	0.083	0.035	**0.773**
Waist circumference (cm)	**0.925**	0.128	**0.872**	**0.912**	0.079	0.189	**0.874**
Hip circumference (cm)	**0.846**	0.150	0.739	**0.858**	0.010	0.146	**0.758**
WHR	**0.662**	0.111	0.450	**0.298**	0.162	**0.556**	0.424
Biceps skinfold (mm)	**0.886**	0.038	**0.787**	**0.858**	0.096	0.040	**0.746**
Triceps skinfold (mm)	**0.870**	0.125	**0.772**	**0.897**	0.109	0.006	**0.816**
SBP (mm Hg)	0.045	**0.965**	**0.933**	0.021	**0.977**	0.089	**0.962**
DBP (mm Hg)	0.292	**0.700**	0.575	0.018	**0.736**	0.380	0.686
Pulse rate (counts/min)	0.132	**0.461**	0.230	0.191	0.042	**0.800**	0.679
Pulse pressure	0.173	**0.818**	0.699	0.015	**0.904**	0.114	**0.831**
Eigen value	6.736	2.371		5.065	2.610	1.135	
Total variance (%)	51.815	18.235		42.205	21.748	9.454	
Accumulative variance (%)	51.815	70.050		42.205	63.953	73.407	
SS loading	6.597	2.510		5.050	2.554	1.205	

Factors loading in bold type are >0.4; communalities are bold >0.7.

pulse rate and explained 9% of total variances. Factor 1 has thus a strong indicator of obesity related traits among both the groups. Factor 2 is an indicator of cardiovascular risk in male grandparents. In females, factor 2 has been clustered with obesity and cardiovascular risk factors. Greater communality estimates were found on weight, BMI, waist circumference, biceps skinfold, triceps skinfold and SBP among the male and female grandparents and on hip circumference and pulse pressure also among female grandparents.

Discussion

The current study focused on to determine significant cardiovascular risk factors through principal component factor analysis (PCFA) among three generations in both sexes. The study performed PCFA with orthogonal rotation to reduce 12 intercorrelated variables into groups of independent factors. The factors have been identified as 2 for male grandparents, 3 for male offspring, female parents and female grandparents each, 4 for male parents and 5 for female offspring. This data reduction method identified these factors that explained 72%, 84%, 79%, 69%, 70% and 73% for male and female offspring, male and female parents and male and female grandparents respectively, of the variations in original quantitative traits. The factor 1 accounting for the largest portion of variations was strongly loaded with factors related to obesity (BMI, waist circumference, WHR and thickness of skinfolds) among all generations with both sexes, which has been known to be an independent predictor for cardiovascular morbidity and mortality. The second largest components, factor 2 and factor 3, for almost all generations reflected traits of blood pressure phenotypes loaded; however, in male offspring generation, it was observed that factor 2 was loaded with blood pressure phenotypes as well as obesity. Therefore, in the present study, factor analysis has been applied to investigate the clustering of variables that are thought to be important components of CVD. Hence, the analysis yielded only two clusters of factors such as obesity and elevated blood pressure with pulse pressure and pulse rate which is also not unusual in the literature. The majority of the studies have reported to these factors [1,2,17,18]. In addition, obesity factor was found to be stronger correlate of the cardiovascular risk in both genders.

The present model suggested that clustering of variables in obesity and blood pressure was a result of multiple factors in which centripetal fat and blood pressure (SBP and DBP) played key roles. Moreover, all the loaded risk variables (anthropometric and physiometric) are modifiable in nature. Therefore, it seems reasonable to argue that early prevention and proper intervention strategies to promote healthy lifestyle to reduce the burden of CVD in this population.

Badaruddoza et al. [1] observed that between genders the factors loaded were not in similar fashion. Factor 1 was identified as lipid in males and blood pressure in females. Similarly, factor 2 was identified as obesity in males and lipids in females. Factor 3 was identified as blood pressure in males and obesity in females. Therefore, lipids and obesity have statistically different loading in males and females. Blood pressure was associated with three factors in females and contributing major risk for CVD. BMI and waist circumference were associated with 2 factors in males and females and contributing considerable risk. Goodman et al. [11] have also reported that central obesity factor predicted the highest (26%) variance for cardiovascular risk in a study with White, Black and Hispanic Americans. Significant association of central obesity, hypertension and dyslipidemia with coronary artery diseases has been reported in numbers of ethnic population worldwide and demonstrated that these multiple risk factors have played a positive role to develop the cardiovascular diseases [2,17,19–23].

Hence, various statistical techniques could examine the association between risk factors and CVDs. Principal Component Factor Analysis (PCFA) is one such important approach to identify these associations and it seems that PCFA is attractive and better predictor for quantitative trait analysis to identify the cluster of risk factors for cardiovascular diseases. Therefore, the present findings have made two major contributions to the literature: (i) obesity risk components such as BMI, WHR and waist circumference are the core predictors for CVD and these core factors (obesity) were equally distributed among all generations in both sexes, (ii) physiometric risk components (SBP, DBP, pulse pressure and pulse rate) for CVD have been identified as second important core factors among different generations. It is interesting to observe the pattern of clustering of variables. BMI, waist circumference, hip circumference, WHR and thickness of skinfold seem to load more than blood pressure. Therefore, it may be concluded that BMI, WHR, waist circumference and skinfold thickness have played more important role to the occurrence of CVD. Therefore, identification of the components of phenotypes of cardiovascular risk factors and how its phenotypic expression differs across the generations/ethnic/community and caste groups could be helpful in understanding the etiology of CVD [2]. As far as Indian data are concerned, very little work so far has been undertaken to identify the underlying factors/components among different generations. However, no such work at all has been undertaken in Ramadasia community (backward community) of Punjab and the present work would be considered as reference base line data for further research work. In this analysis, some inconsistent loading pattern for different variables such as skinfold thickness, pulse rate, pulse pressure and WHR has been observed in all the generations which made the results difficult to be interpreted. Further limitation of the factor analysis is that the investigator is forced to retain the number of factors with respect to eigen values (> 1). However, it has been observed that some risk traits have low eigen values but act as important predictors.

The factor analysis of this study demonstrated that obesity factors is the pre-dominant and significant correlate of cardiovascular risk among the individuals of this community regardless that risk is defined in the terms of individual physiological variables on a cumulative risk scale. BMI and obesity were associated with high risk for CVD. The magnitude of loadings of these obesity factors have been found maximum and consistent in parent generation as compared to other generations. However, this also found consistent in other generations but in a lesser degree. It was also found that the loading patterns of blood pressure were consistent in all the generations, but it was in higher degree in grand-parental generations. Thus, the inter-relationship between these anthropometric and physiometric variables appeared to be established may be early in the life course. Whether high factors score on any of these particular factors will predict development of CVD in adulthood remains to be determined through longitudinal analysis.

Conclusion and clinical implication

The present factor analysis of cardiovascular risk clustering in Indian Punjabi population suggested that multiple risk factors have accounted for CVD. Obesity factors have shown for maximum variance in clustering the risk factors and appeared strong correlate of cardiovascular risk in three generations. This study not only confirmed but also extended prior work by developing a cumulative risk scale from factor scores. Till today, such a cumulative and extensive scale has not been used in any Indian studies with individuals of three generations. These findings and study highlighted the importance of global approach for assessing the risk and need for studies that elucidate how these different cardiovascular risk factors interact with each other over the time to create clinical disease. In further conclusion, the present study demonstrated that the nature of clustering of cardiovascular risk factors is different in different generations. Between generations and genders, the factors loaded are not in similar fashion. However, obesity risk components such as BMI, WHR and waist circumference are the core predictors for cardiovascular diseases and these core factors (obesity) were equally distributed among all generations in both sexes.

Therefore, early identification with the help of present cumulative and extensive scale especially in the younger generation can be prevented the increasing risk of coronary artery disease and type 2 diabetes mellitus in latter stage of life.

The findings also added depth to the negligible amount of literature of factor analysis of cardiovascular risk in any Indian ethnic population.

Conflict of interest

The authors have declared no conflict of interest.

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