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Factor analysis of traditional cardiovascular risk traits in Punjabi adolescents in India

Badaruddoza^{*}, Sandeep Kaur Brar

Department of Human Genetics, Guru Nanak Dev University, Amritsar 143005, Punjab, India

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ABSTRACT

The accuracy of different anthropometric indices to predict cardiovascular diseases is still debated in adolescent age groups and few data are available in state of Punjab in India. We compared the factor loadings of different anthropometric cardiovascular risk factors. A total of 1530 boys and 1530 girls, adolescents aged 10–18 years were recruited for the present study to identify cardiovascular risk factors. Principal component factor analysis (PCFA) was applied to extract orthogonal components from anthropometric and physiometric variables. Association between components were explained by factor loadings. PCFA reduced 14 risk factors to 4 uncorrelated components that explained 84.06% and 83.15% of total variance among boys, girls and combined subjects respectively. Factor 1 has high loading of the traits that reflects thickness of skinfolds. Comparably, factor 2 is loaded with SBP, DBP and pulse rate. Factor analysis reduced 14 inter-correlated cardiovascular risk factors to 4 newly defined factors. These uncorrelated factors can be interpreted to represent a distinct risk factor for cardiovascular disease in Punjabi adolescents aged 10–18 years.

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1. Introduction

The cardiovascular diseases (CVD) have grown significantly over the last two decades. The prevalence of CVD in India is known to be very high. However, not many data are available related cardiovascular disease in Indian adolescents, although consistent evidences are found from epidemiological studies on cardiovascular risk factors among adolescent in worldwide study [1–5]. The increasing prevalence of adolescent obesity is one of the major causes to be hypertensive in adulthood. It has also been suggested that the recessive gene or genes could be held responsible for higher BP in children [6]. Several studies

have found a strong linear relationship of body mass index (BMI), waist circumference (WC) and skinfold thickness with hypertension, dyslipidemia, and ischemic heart disease in Indian population [7–12]. Ethnic differences in the different risk factors for hypertension have been well documented in different studies in adults and childhood populations [1,13,14]. Body mass index (BMI) and waist circumference (WC) were widely used to predict the risk of cardiovascular diseases. Some have also advocated waist to hip ratio (WHR), waist to height ratio and skinfold thickness indices for adverse cardio-metabolic risk profile in adolescents [15–21]. However, various statistical methods have been applied to examine the performance of anthropometric indices for the identification of

^{*} Corresponding author.

E-mail address: doza13@yahoo.co.in (Badaruddoza).

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Table 1 – Clinical Characteristics (mean \pm standard deviation) according to sex among adolescents in Punjab.

Variables	Boys (n = 1530)		Girls (n = 1530)		Pooled (n = 3060)		P value
	Mean	SD	Mean	SD	Mean	SD	Boys vs girls
Height (cm)	155.41	14.46	151.21	10.07	153.31	12.63	<0.001
Weight (kg)	46.10	15.15	43.78	11.74	45.39	13.64	<0.001
Waist circumference (cm)	69.36	11.91	68.17	11.21	68.76	11.58	<0.004
Hip circumference (cm)	81.29	11.24	82.31	10.64	81.80	10.95	<0.01
Biceps skinfold (mm)	7.84	4.49	9.39	4.57	8.61	4.59	<0.001
Triceps skinfold (mm)	12.61	6.97	15.09	7.04	13.85	7.11	<0.001
Sub scapular skinfold (mm)	13.74	7.98	16.29	8.24	15.02	8.21	<0.007
Waist–hip ratio	0.85	0.06	0.83	0.07	0.84	0.07	<0.001
Body mass index (kg/m ²)	19.01	3.97	18.93	3.87	18.97	3.92	0.573
Systolic blood pressure (mmHg)	123.81	14.04	122.10	13.89	122.96	13.98	<0.001
Diastolic blood pressure (mmHg)	82.24	11.09	81.63	10.70	81.93	10.86	0.120
Mean blood pressure (mmHg)	96.09	11.43	95.12	11.17	95.61	11.31	<0.018
Pulse rate (counts/min)	77.65	7.54	77.32	7.34	77.48	7.44	0.220
Pulse pressure (mmHg)	41.58	8.46	40.47	8.46	41.02	8.48	<0.007

adverse cardiovascular risk profile [22–24]. Therefore, to quantify the magnitude of cardiovascular risk in the present study, multivariate data reduction techniques such as principal component factor analysis (PCFA) have been used to extract uncorrelated factors from various inter-correlated variables [24,25]. In the view of above consideration, the present work was undertaken to determine the significant traditional risk factors through principal component factor analysis (PCFA) among population based Punjabi adolescents aged 10–18 years. Punjab is one of the most prosperous states in India.

2. Subjects and methods

The study population included a total of 3060 (1530 boys, 1530 girls) adolescent subjects were recruited for the present study to identify effective traditional cardiovascular risk factors using principal component factor analysis (PCFA). The data were collected from educational institutes from various districts of Punjab. This study was approved by appropriate ethical research committee of Guru Nanak Dev University, Amritsar in year of 2010. This study population included adolescents from 10 to 18 years of age, of both sexes, enrolled in private higher secondary schools. This cross sectional study was carried out through classroom selection process divided into two stages. In the first stage, 25 Government and private schools were selected. The schools were randomly selected with respect to the proportional probability of school in the stratum. In the second stage, classrooms with respect to age group were selected by simple random sampling. The number was proportional to the population of students in each age group (10–18 years). All the selected students from the groups were considered eligible to participate in the present study after their parents had given written consent beyond student's verbal consent. Exclusion criteria were adolescents with orthopedic problems that prevented anthropometric measurements, no parental consent and adolescent pregnancy (if any).

2.1. Measurements

The anthropometric measurements were taken height (cm), weight (kg), waist circumference (WC) (cm), hip circumference

(HC) (cm) and three skinfolds (biceps, triceps and sub scapular). All anthropometric measurements were taken on each individual using standard anthropometric technique [26,27]. The height was measured using anthropometric rod with the standing erect position with the head in 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 them 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 was taken mid-way between the inferior margin of the last rib and crest of the ilium in a horizontal plane with relaxed abdomen. The tape was fitted snugly 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/her feet close to each other. The readings were recorded for waist and hip circumferences to the nearest 0.1 cm. A Lange skinfold calliper was used to measure the skinfolds to the nearest 0.2 mm. Two subsequent measurements were taken and averages were used in the analysis [28]. The body mass index (BMI) expressed as the ratio of the body weight divided by body height squared (in Kg/m²) and waist to hip ratio (WHR) defined as waist circumference divided by hip circumference. The physiometric variables included systolic blood pressure (SBP), diastolic blood pressure (DBP) and pulse rate. The blood pressure was measured with standardized mercury sphygmomanometer and a stethoscope by following the recommendations of American Heart Association [29]. Two consecutive readings were recorded for each SBP and DBP and the average were used. Pulse rate was counted over one minute. Pulse Pressure was calculated as SBP-DBP. The age of the adolescents was determined directly from their reported date of birth in the school records. All the measurements were taken by second author.

3. Statistical analysis

Data was screened using SPSS version 17.0. The comparison of means between males and females were done by using student's t test. Principal Component Analysis was used to

Table 2 – Correlation matrix (bivariate) of cardiovascular risk factors included in PCFA among boys and girls of Punjabi adolescents.

Variables	Height	Weight	WC	HC	BSF	TSF	SSSF	WHR	BMI	SBP	DBP	MBP	PR	PP
Height		0.791*	0.509*	0.704*	0.084*	0.114*	0.242*	–0.131*	0.396*	0.381*	0.337*	0.372*	0.019	0.194*
Weight	0.660*		0.853*	0.924*	0.475*	0.539*	0.664*	0.192*	0.865*	0.551*	0.461*	0.521*	0.095*	0.315*
WC	0.284*	0.791*		0.881*	0.616*	0.707*	0.788*	0.565*	0.886*	0.509*	0.397*	0.463*	0.172*	0.328*
HC	0.569*	0.913*	0.826*		0.537*	0.613*	0.704*	0.114*	0.840*	0.496*	0.412*	0.468*	0.141*	0.288*
BSF	0.178*	0.622*	0.690*	0.669*		0.854*	0.814*	0.357*	0.668*	0.326*	0.253*	0.296*	0.071**	0.212*
TSF	0.165*	0.667*	0.775*	0.711*	0.796*		0.886*	0.412*	0.742*	0.346*	0.253*	0.304*	0.136*	0.245*
SSSF	0.215*	0.716*	0.807*	0.744*	0.764*	0.879*		0.420*	0.820*	0.416*	0.313*	0.372*	0.128*	0.283*
WHR	–0.324*	0.078**	0.570*	0.014	0.259*	0.348*	0.348*		0.395	0.206*	0.120*	0.162*	0.118*	0.186*
BMI	0.265*	0.894*	0.851*	0.846*	0.708*	0.776*	0.812*	0.284*		0.510*	0.413*	0.474*	0.138*	0.309*
SBP	0.214*	0.409*	0.337*	0.366*	0.293*	0.289*	0.286*	0.064	0.400*		0.798*	0.922*	0.249	0.622*
DBP	0.243*	0.369*	0.271*	0.339*	0.222*	0.211*	0.227*	–0.009	0.335*	0.794*		0.969*	0.291	0.024
MBP	0.244*	0.405*	0.313*	0.368*	0.263*	0.254*	0.264*	0.021	0.379*	0.921*	0.968*		0.289	0.270*
PR	0.032	0.082	0.152*	0.086*	0.041	0.108*	0.111*	0.129*	0.093	0.292*	0.316*	0.323*		0.034
PP	0.044	0.205*	0.210*	0.173*	0.201*	0.207*	0.182*	0.117*	0.234*	0.639*	0.038	0.289*	0.081**	

WC = Waist circumference, HC = Hip circumference, BSF = Biceps skinfold, TSF = Triceps skinfold, SSSF= Sub scapular skinfold, WHR = Waist–hip ratio, BMI = Body mass index, SBP = Systolic blood pressure, DBP = Diastolic blood pressure, MBP = Mean arterial blood pressure, PR = Pulse rate, PP = Pulse pressure.
 Upper triangle corresponds for males and lower triangle for females.
 *Correlation is significant at 0.001 level (2-tailed).
 **Correlation is significant at 0.01 level (2-tailed).

extract orthogonal factors from cardiovascular and obesity related measurements. Obesity related traits included BMI, WC, HC, weight, thickness of skinfold. Cardiovascular related traits included SBP, DBP, pulse rate and pulse pressure. Principal Components were simplified by orthogonal rotation (varimax). Relationships between components are explained by factor loadings. The values greater than or equal to 0.4 were used to indicate meaningful correlations between the component and the variable. Principal Components were retained with eigenvalues greater than or equal to 1. The probability values less than or equal (two-tailed) to 0.05 were considered to be significant.

4. Results

Table 1 displayed the sex specific means, standard deviation and comparison of the original measurements which are used in the principal component factor analysis for Punjabi adolescents aged 10–18 years. All studied quantitative phenotypes except body mass index, diastolic blood pressure and pulse rate indicated significant ($P < 0.05$) sex specific differences in the trait variance. Boys were observed to have significantly higher values for height, weight, waist circumference, waist to hip ratio, systolic blood pressure and pulse pressure as compared to girls. Girls had significantly ($P < 0.05$) higher mean values of hip circumference, biceps, triceps and sub scapular skinfolds than boys. It is also revealed that BMI, diastolic blood pressure and pulse rate among boys were slightly higher but statistically not significant.

Pearson's correlations among 14 normally distributed variables are presented in Table 2. The upper triangle correlations correspond to the boys and lower triangle refers to girl adolescents. In both the groups strong correlations were observed among BMI, WC, SBP, DBP and thickness of skinfold. Therefore all the anthropometric variables are significantly inter-

correlated which demonstrate the structure of the factors among male and female Punjabi adolescents.

The characteristics of derived principal components have been given in detail in Table 3 among Punjabi adolescents. The PCFA extracted four factors, which explained 84.21%, 84.06% and 83.15% of the total variance of the 14 original quantitative traits among boys, girls and combined subjects respectively. Factor 1 has high loading of the traits that reflect adiposity such as waist circumference, BMI and skinfolds among both sexes. However, waist circumference and body mass index are the indicator of abdominal obesity which increases the risk of cardiovascular diseases. The loadings of these two traits have been found maximum in girls adolescents (WC = 0.924; BMI = 0.905). Therefore, factor 1 is the strong indicator of atherosclerosis in adolescents. Factor 2 is predominantly loaded with blood pressures and related traits (SBP, DBP, MBP and pulse rate) which reflect the risk of essential hypertension in adolescent girls and combined subjects, whereas, factor 2 loaded with obesity related traits among boys (weight and hip circumferences). Comparably, factor 3 is loaded with blood pressures among boys and with height and WHR among girls, while factor 4 contains high loadings of pulse pressure among boys, girls and combined group of adolescents.

5. Discussion

The current study is focussed to determine the significant traditional factors through Principal Component Factor Analysis (PCFA) among adolescents aged 10–18 years in urban areas of Punjab. The systematic studies of cardiovascular risk factors and prevalence of abdominal adiposity among adolescents in Punjab are very scanty. In the epidemiological studies, anthropometry has been well established method for tracking cardiovascular diseases among adolescents [30–34]. Punjab is one of the economically advanced and prosperous

Table 3 – Coefficients and variances of factors satisfying the eigenvalue ≥ 1 criterion.

Variables	Factor 1			Factor 2			Factor 3			Factor 4		
	Boys	Girls	Combined	Boys	Girls	Combined	Boys	Girls	Combined	Boys	Girls	Combined
Height (cm)	0.063	0.326	0.159	0.921	0.122	0.120	0.121	0.803	0.887	0.096	0.031	0.093
Weight (kg)	0.444	0.846	0.671	0.836	0.195	0.207	0.209	0.414	0.649	0.146	0.080	0.164
WC (cm)	0.731	0.924	0.874	0.538	0.165	0.184	0.200	0.122	0.216	0.163	0.046	0.171
HC (cm)	0.502	0.863	0.739	0.807	0.162	0.173	0.176	0.387	0.590	0.075	0.046	0.074
BSF (mm)	0.853	0.822	0.840	0.131	0.065	0.094	0.104	0.051	0.034	0.029	0.119	0.038
TSF (mm)	0.902	0.891	0.907	0.173	0.078	0.100	0.109	0.124	0.043	0.039	0.082	0.042
SSSF (mm)	0.872	0.911	0.918	0.309	0.091	0.118	0.137	0.082	0.056	0.081	0.046	0.056
WHR	0.656	0.389	0.508	0.263	0.052	0.077	0.114	0.780	0.509	0.210	0.017	0.207
BMI (kg/m ²)	0.739	0.905	0.858	0.524	0.180	0.202	0.208	0.062	0.274	0.124	0.115	0.144
SBP (mmHg)	0.189	0.211	0.202	0.288	0.759	0.747	0.724	0.096	0.185	0.589	0.606	0.594
DBP (mmHg)	0.104	0.161	0.145	0.274	0.929	0.927	0.917	0.171	0.219	0.031	0.038	0.021
MBP (mmHg)	0.145	0.190	0.176	0.294	0.907	0.902	0.885	0.149	0.216	0.261	0.275	0.258
Pulse rate (counts/min)	0.140	0.048	0.094	0.110	0.603	0.580	0.570	0.225	0.182	0.182	0.185	0.143
Pulse pressure (mmHg)	0.179	0.144	0.149	0.121	0.071	0.045	0.008	0.059	0.026	0.937	0.948	0.954
Eigenvalue	7.08	6.63	6.76	2.10	2.43	2.26	1.52	1.63	1.53	1.07	1.06	1.07
Total variance (%)	50.57	47.36	48.31	15.04	17.39	16.16	10.91	11.70	10.97	7.68	7.58	7.70
Accumulative variance (%)	50.57	47.36	48.31	65.62	64.76	64.48	76.53	76.46	75.45	84.21	84.06	83.15

WC = Waist circumference, HC = Hip circumference, BSF = Biceps skinfold, TSF = Triceps skinfold, SSSF = Sub scapular skinfold, WHR = Waist–hip ratio, BMI = Body mass index, SBP = Systolic blood pressure, DBP = Diastolic blood pressure, MBP = Mean arterial blood pressure, PR = Pulse rate, PP = Pulse pressure.

•Factor loadings in bold type are >0.4 .

states in India with western lifestyle. Therefore, this population is unique to study complex multifactorial lifestyle disorders. We performed PCFA with varimax rotation to reduce 14 inter-correlated variables into four independent factors. These four factors explained 83% of total variance among combined adolescent subjects. The present data reduction method identified four distinct components for cardiovascular disease risk in the population. The first factor which is accounted for the largest portion of variance was strongly loaded by the factors relating to obesity which increases the risk for developing cardiovascular disease among girl adolescents than boys. The second largest component, factor 2, reflected traits of hypertension loaded with SBP, DBP and pulse rate among girls and combined subjects. Therefore, increased WC, BMI, SBP and DBP are the indicators of metabolic syndrome and a strong predictor of cardiovascular disease. The factor 3 also reflected the risk of essential hypertension in boys. Therefore, the present analysis has shown that girl adolescents are more susceptible to develop essential hypertension than boys. It is interesting to observe the pattern of variables. The thicknesses of three skinfolds (biceps, triceps and sub scapular) seem to load more than any other traits in both sexes for first factor and explained 50.57%, 47.36% and 48.31% of total variance among males, females and combined subjects, respectively. Therefore, the cluster of three skinfold measurements could be classified as an important indicator for central obesity and this cluster is equally associated with adolescent boys and girls. Hence, it may be concluded that measurement of skinfolds would be good predictor to the occurrence of cardiovascular disease among adolescent age groups. The association of central obesity and hypertension with respect to different biomarkers has been observed in a number of population groups in adult and children group worldwide [22,32,35–42]. Furthermore, in the present study the second factor which are namely blood pressure and pulse rate for girls and combined subjects explained 17.39%, 16.16% of the total variance, respectively. Whereas, in boys the second factor, that is height, weight and hip circumference explained 15.04% of total variance. However, the third factor that is SBP and DBP explained 10.91% of total variance. Therefore, the factors such as blood pressures are more predisposed among adolescent girls than boys due to their sedentary lifestyle.

However, many statistical techniques have been used to examine the association between risk factors and cardiovascular diseases. Principal component factor analysis (PCFA) is one of the most sophisticated statistical methods to identify these associations. Very little work has been so far undertaken in India among adolescent age groups. Hence the present work may be helpful for further studies. The present findings support the hypothesis that clustering of cardiovascular risk factors is more important than to identify any single trait due to its underlying heterogeneous nature of cardiovascular related phenotypes. The present study has some limitations beyond its strength such as (i) some inconsistent loading pattern for different variables has been observed (ii) the study is cross-sectional in nature (iii) it has been observed that certain risk traits have low eigenvalues which were eliminated from the analysis but act as important predictors.

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