DISCUSSION

The major purpose of the study was three folds; (i) to examine the prevalence of pre-hypertension and hypertension and to provide overall essential baseline data for CVD among the study population (ii) to identify better anthropometric, physiometric and socio-economic lifestyle indicators to predict the CVD and their basic relationship and impact on the occurrence of the disease (iii) to describe the genetic heritability and familial household contribution to the phenotypic variation for cardiovascular risk factors especially for SBP and DBP.

The total objectives were examined in the Ramadasia community. This community was recognized as socially, educationally and economically backward class in Punjab, which was also recognized as scheduled caste population (under article 341(1) (2) of the constitution of India). The Ramadasia communities had traditionally been relegated to the most menial labour with negligible possibility of upward mobility and also subject to social disadvantages and exclusion in comparison to the wider community. Therefore, socio-economic status of the families was rated as far below than average Indian social structure.

All observations have been done through house to house family study with three generations (mean ages were male offspring - 18 years, female offspring - 17.63 years, male parental - 41.19 years, female parental - 38.05 years, male grandparental - 67.52 years, and female grandparental - 62.46 years generations). The present study represented a multivariate model which included the family data with respect to anthropometric measurements (age, height, weight, BMI, waist circumference, hip circumference, WHR, arm circumference, calf circumference, biceps skinfold and triceps skinfold), physiometric phenotypes (SBP, DBP, MBP, pulse rate and pulse pressure), and socioeconomic lifestyle variables (education, occupation, income, food habits, stress, physical activity and exercise). Therefore the present study can be used to derive basic biological relationship between cardiovascular diseases (CVD) and other studied variables. In regard to these objectives, many interesting results have emerged from the study and will be discussed one by one.
5.1. Distribution

Punjabi population is unique in India with respect to prosperity, culture, urbanized and westernized lifestyle and rich food habit. Therefore, this population has a great importance for study of complex disorders such as type 2 diabetes and those of cardiovascular origin which are deeply influenced with lifestyle factors. Therefore, current study focused on a scheduled caste Punjabi population to dissect the anthropometric, physiometric and socio-economic lifestyle variables underlying cardiovascular disease risk. BMI, waist circumference, WHR, education, occupation, income, food habit, physical activity, stress, smoking and alcohol were chosen in the present study for the evaluation of pre-hypertension and hypertension in all three generations. These indicators are also widely used in adults to track the hypertension (Krauss et al., 1998; Lamarche et al., 1998; Daniels et al., 1999; Savva et al., 2000; Virani, 2011). Waist circumference, WHR and WHtR have been validated in adults as useful predictor for cardiovascular risk factor (Pouliot et al., 1994; Hsieh and Yoshinaga, 1995; Badaruddoza et al., 2010). Therefore, BMI, waist circumference and WHR are the simple measurements that most of the physicians can precisely measure, while the same does not apply to skinfold measurement. The results of the present study indicated that prevalence of pre-hypertension with normal BMI has been found to be maximum in male offspring generation (20%) which was followed by male parental (19%) and grandparental (7.45%) generations. The prevalence of hypertension with normal BMI has been found maximum in male grandparental generation (34%) which was followed by male parental (5.69%) and male offspring (1.59%) generation. The highest prevalence of pre-hypertension and hypertension with normal BMI were found in female offspring (13%) and male grandparental (20.71%) generations. Therefore, individuals with normal BMI have significantly higher risk to develop cardiovascular risk in male and female offspring and male grandparental generations as compared to overweight and obesity. However, obese individuals have developed hypertension in male and female parental and female grandparental generations.

Previous studies (Woo et al., 2002; Olinto et al., 2004; Latiffah and Hanachi, 2008; Yadav et al., 2008; Badaruddoza et al., 2010; Kumar and Badaruddoza, 2010; Durrani and Fatima, 2011; Gupta et al., 2011) have found that prehypertension and...
hypertension, as the antecedent for CVD, were associated with the increasing measurements of BMI, waist circumference and WHR. However, the present study was not in accordance with this hypothesis, because maximum pre-hypertension frequencies were found for individuals within the normal range of BMI in every generation except female parental generation. Therefore, the present findings were not consistent with other cross-sectional studies with respect to prevalence of pre-hypertension. Many other cross-sectional studies (Yusuf et al., 2005; Badaruddoza and Hundal, 2009; Pawar et al., 2010; Ulasi et al., 2011) showed cardiovascular risk factors were more prevalent among overweight and obese people. This hypothesis is consistence among male and female generations in the present study. Therefore, this study showed significant association with the incidence of hypertension and pre-hypertension at any stage of life. Our results of parental generation also confirmed the report of previous investigators indicating a relationship between obesity and hypertension (Cox et al., 1998; Adedoyin et al., 2008). Our findings on the risk of development of pre-hypertension and hypertension with respect to different levels of BMI (classification adopted from WHO, 2000) on the basis of different generations. As the present study in generation based, it posed a difficulty in comparison of our results with a previous investigation on relative risk of hypertension. Nevertheless, this study agreed with findings of other previous investigations that have showed that risk of hypertension increased with increasing BMI. However, this was not the case especially in younger generation or offspring generations.

When the subjects were classified into normal, overweight and obese categories with criteria based on waist circumference (adopted from Yalcin et al., 2005) then different picture has been found. The prevalence of pre-hypertension and hypertension with overweight and obese subjects have been found in male and female parental generations and male and female grandparental generations. Whereas, subjects with normal waist circumference range have maximum prevalence of pre-hypertension and hypertension in only male offspring generation. The results of female offspring generation are inconsistent. Waist circumference was the most important anthropometric indicator in men and women for prediction of cardiovascular diseases. This highlights the importance of android obesity in blood pressures. The present study has also observed a
progressive increase in the prevalence of elevated blood pressure with increasing of overweight and obesity based waist circumference criteria.

Also according to WHR measurement cut-off points, the prevalence of pre-hypertension and hypertension have been found maximum with overweight and obese subjects in male and female parental generations and male and female grandparental generations. The maximum prevalence of pre-hypertension and hypertension has been observed with normal range of WHR in male offspring generation. However, the results of female offspring generation are inconsistent. In recent time many prospective and cross-sectional studies have been done using anthropometric indicators such as BMI, waist circumference and WHR to understand the relationship between elevated blood pressure and anthropometric variables (Ghosh and Bandhopadhyay, 2007; Badaruddoza and Kumar, 2009; Wang et al., 2010; Badaruddoza et al., 2011). The results of present study revealed that waist circumference and WHR were slightly better predictors as compared to BMI to understand the relationship between obesity and cardiovascular risk development. Although, BMI is widely used as measure of fatness in epidemiological studies because this index is highly correlated with body fat, some investigators (Bray, 2003; Yalcin et al., 2005; Ghosh and Bandyopadhyay, 2007) reported that waist circumference is the stronger predictor than both BMI and WHR for CVD. As because, waist circumference is the measurement of abdominal fat mass and it is considered as a simple clinical alternative to BMI to detect the possible health risk due to cardiovascular diseases and obesity. The present results also support this suggestion for screening the central obesity with elevated blood pressure.

**Remark:** In the present study, based on BMI it can be concluded that general obesity was quite prevalent in all generations. However, prevalence of central obesity, as observed by waist circumference was higher than general obesity in most of the generations (female offspring, male and female parental and grandparental generations). This may be partly related to the nature of the diet and sedentary lifestyle. This has been also reported in many recent studies (Ketel et al., 2007; Sarkar et al., 2009; Badaruddoza et al., 2011).
The cross-sectional study does not provide information on the sequence of the risk-factor developments and cause and effect relationship cannot be inferred (Latiffah and Hanachi, 2008). Therefore, to establish the prevalence of pre-hypertension and hypertension with respect to BMI and waist circumference in general population more research especially family study with more than two generations should be carried out. These types of studies are lacking in the populations in India as well as in abroad. In general, overweight and obese individuals have a tendency to develop hypertension, however, the prevalence of pre-hypertension and hypertension in general population may not be in accordance with the hypothesis. The prevalence of pre-hypertension and hypertension may be higher in normal BMI as compared to overweight and obese individuals in the general population. It was noticed that the education levels with maximum frequencies lied on secondary/high school for male and female offspring, male parental generation; on primary for female parental and male grandparental generation; on illiterate for female grandparental generation. However, subjects with higher education level such as graduate/ post graduate/ professional had very low prevalence of hypertension. This showed education has relation with the prevalence of hypertension in every generation. In this study low education level or illiteracy was related to CVD in males and females. However, occupation did not show any relation with the prevalence of CVD. The samples were not so educated and maximum engaged in lower class of occupation or did not do anything; the low occupational positions at baseline which is the characteristic of the scheduled caste population in Punjab. The low education and occupation may affect the incidence of CVD and prevalence status inconsistence with other studies. However, education has been proposed as the preferable characteristic as compared to other socio-economic lifestyle indicators for desirable outcome. Many studies from different countries (Winkleby et al., 1992; Smith et al., 1998; Mohan et al., 2008; Jeemon and Reddy, 2010; Braig et al., 2011) showed education level, occupation and socio-economic status have strong association with mortality and morbidity.

The prevalence of pre-hypertension and hypertension have shown to be maximum in lower middle class for male offspring, male and female parental generations and male grandparental generation. In many Indian study (Pais et al., 1996; Rastogi et al., 2004a;
Jeemon and Reddy, 2010) showed significantly higher CVD risk among low socio-economic group compared to high socio-economic group. Similarly, a follow up data of CVD patients from CREATE (Consortium for Research on Educational Access) registry demonstrated significantly higher mortality rate in low socio-economic status as compared to higher socio-economic groups (Xavier et al., 2008).

As the epidemiological transition is taking place in India with the background of economic globalization, therefore, CVD risk factors among Indian poor and middle class is rapidly increasing. Thus, the impact of globalization changed behavioral pattern of middle and poor class people in India. Therefore, higher level of tobacco and alcohol use, obesity, overweight and hypertension are associated with lower levels of education and income in India (Gupta et al., 2003; Gupta, 2006; Reddy et al., 2007). It is obvious that development is socially and regionally uneven in India. Hence, CVD risk factors are also expected to be uneven across the different societies and regions. So, it is important to understand that socio-economic disadvantage is not simply a factor for CVD risk, but, also an indication that an individual may follow in due course of life. Otherwise awareness of cardiovascular and other lifestyle diseases were lowest in low socio-economic groups (Ajay et al., 2008). Many other urban-rural comparison studies also documented very low awareness of CVD risk factors in socio-economically disadvantaged rural population (Chadha et al., 1997; Gupta et al., 2000; Mohan et al., 2001; Reddy et al., 2002; Prabhakaran et al., 2007; Badaruddoza et al., 2011b). These studies also highlighted that inadequate treatment and poor management of risk factors especially hypertension and type-2 diabetes in rural population. However, the present type of study will also be helpful for reducing CVD burden and to understand the etiology of this complex disease in socially, educationally and economically backward Indian population as well.

In the present study two dietary patterns such as vegetarian and non-vegetarian emerged and were observed to have varied associations with CVD risk factors. However, in cross sectional analysis for demographic and lifestyle variables, diet across all parts of India characterized by dairy products, fried snacks and sweets have appeared to be positively associated with abdominal adiposity and hypertension. Conversely, dietary patterns in many parts of India like Kerala, Mumbai, Chennai characterized by intake of vegetables
and pulses were inversely related to hypertension and diabetes (Daniel et al., 2011). Very few studies have been conducted to examine the relationship of food pattern and CVD risk factors in Indian populations as compared to other abroad populations (Rao, 2002; Padmads et al., 2006; Radhika et al., 2008, 2010; Yadav and Krishnan, 2008; Misra et al., 2009). High fat intake in the form of milk and its products like ghee, butter, cheese particularly in Punjab was one of the major indicator to produce CVD and adverse health profile. The result obtained from the present study in respect of food habits was that vegetarians exhibit higher blood pressure (pre-hypertension and hypertension) among female offspring generation (10.34% for pre-hypertension; 1.92% for hypertension), female parental generation (15.92% for pre-hypertension; 13.59% for hypertension) and female grandparental generation (17.14% for pre-hypertension; 46.43% for hypertension). Non-vegetarians have exhibited higher blood pressure among male offspring generation (13.49% for pre-hypertension; 2.12% for hypertension); male parental generation (26.88% for pre-hypertension; 13.21% for hypertension) and male grandparental generation (7.44% for pre-hypertension; 31.91% for hypertension). It is interesting to note that most of the males with pre-hypertension and hypertension were non-vegetarian and they preferably consumed red meat, soft and hard beverages and processed and fast foods with high fats. But, most of the females with pre-hypertension and hypertension were vegetarians. However, previous studies have reported that CVD risk in India is likely to be inversely related with consumption of fruits, vegetables, mustard oil and positively associated with intake of refined carbohydrates and unhealthy fats (Misra et al., 2009; Mohan et al., 2010; Badaruddoza et al., 2011a). The relationship between diet and chronic disease like hypertension and type-2 diabetes are certainly complex and are likely to encounter unfamiliar challenge in Indian diet. As it was found in the present study vegetarians have also significant impact to raise higher blood pressure especially in female population. It is due to the fact that cooking of vegetable (green leafy, starchy, stir fried, boiled, etc) in traditional Indian mix vegetable dishes may alter the preventive property of the foods and also contribute substantially to added fats which enhance the risk of CVD. It has also been suggested from many studies that the diet rich in fruits and vegetables may be associated with lower levels of low density lipids (LDL) and total cholesterol, but, the diet rich in carbohydrates overall
Discussion

may be associated with higher triglycerides and lower high density lipids (HDL) and
enhance chronic disease risk which have great prevalence in India (Gupta and Bains,
2006; Radhika et al., 2008; Daniel et al., 2011).

The present analysis addressed the association of physical activity and CVD risk factors
among three generations. No physical activity or exercises were associated with
significantly increased risk of CVD, independent of sex and generations. The apparent
protective effect with moderate intensity of exercise and physically active lifestyle on
CVD has been observed in all generations. Therefore, the present study provides a
valuable insight into pattern and correlates of physical activity among all generations. In
general, the studied population was physically active with 87% of male offspring, 72%
of female offspring, 66% of male parent, 33% of male grandparent generations.
However, 90% of female parents and 95% of female grandparents were not interested in
moderate or vigorous physical activity but, they spent more time on household
activities. But, both male and female offspring generations showed greater interest in
moderate or vigorous physical activities. Therefore, promotion of physical activity at
younger ages may be an effective approach for increasing participation of exercise in
later stages of life to reduce the CVD mortality in the population. In the present study
walking was the most frequent type of physical activity. Most of the results from the
study regarding the correlates of sedentary/active lifestyle, physical exercise were
similar to other previous research in many countries (Trost et al., 2002; Rastogi et al.,
2004b; Hu et al., 2005a,b; Jurj et al., 2007; Gupta et al., 2011). Existing data regarding
specific correlates of physical activity with cardiovascular diseases which would be
helpful for public health promotion strategies are still insufficient in Indian populations.
The present study has revealed a substantially high rate of non-smokers (90.48% in
general) in this community in all generations among men and women. Therefore, no
specific relationship between this behavioral risk factor and CVD has been found. This
is also due to the fact that the Sikh religion does not permit to smoke in men and
women. However, the picture of alcohol consumption was different. It was found that
94% of male offspring, 51% of male parents and 48% of male grandparents were non-
alcoholics and had never drunk in their lifetime, whereas, 6% of male offspring, 49% of
male parents and 52% of male grandparents consumed alcohol at regular or at some
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point of time. All the females in every generation did not smoke or consume alcohol. These findings clearly indicate that respondents with lower socio-economic background had a higher rate of prevalence of alcohol consumption except in the case of offspring generation due to lower age group and financial constraints. This finding was consistent with the observations in India and other countries also (Gonzalez et al., 1998; Sugathan et al., 2008; Kaur et al., 2011). It was observed that alcohol is the major risk factor among all behavioral risk factors in males. A significant variation in age group for alcohol consumption has also been observed. A higher probability of acquiring the habit of alcohol consumption among males of younger age around 40 years was seen. High prevalence of alcohol consumption was also in accordance with many other communities that reported increasing prevalence of alcohol consumption (Isaac, 1998; Kaur et al., 2011). The manual worker and less educated males in the present study population were more vulnerable group of alcohol consumption. Punjab has a unique scenario for distribution of alcohol and wide range of network of sells outlet of alcohol. This has likely led to increase in alcohol consumption in general population, which also helped to increase the revenue in the state. Therefore, it is a challenge to the government of Punjab to address properly this issue from policy view point. Alcohol consumption is considered to be major risk for CVD, since it might lead to arrhythmias, brain damage, diabetes, cardiomyopathy, ischemic heart disease, increased risk for hypertension, liver cirrhosis, stomach ulcers and gastritis (O’Keefe et al., 2007; Ronksley et al., 2011). Hence, the high prevalence of this risk factor indicated to be a definite likelihood of high morbidity burden in near future of the population.

Remark

The present findings indicated a high prevalence of many socio-economic lifestyle factors such as low education, low socio-economic status, sedentary lifestyle and alcohol consumption among the scheduled caste community (Ramadasia) in Punjab state. Public health remedial measures will therefore be urgently needed in order to reduce future morbidity burden. A strict public health policy and awareness in general specially, low socio-economic community will be needed immediately.
5.2. Correlation

In the context of simple Karl Pearson’s Product moment correlation between anthropometric, socio-economic lifestyle variables with SBP, DBP and MBP among all the generations have shown significant independent relationship of these variables. The data clearly showed that almost all anthropometric traits except WHR and the level of education and stress (physical/psychological/psychosocial) among both males and females have been found to be significantly correlated with SBP, DBP and MBP. All anthropometric variables for both male and female parents, occupation, income and alcohol for only male parents have been found to be significantly correlated with SBP, DBP and MBP. However, strength of correlation has been different for different anthropometric and socio-economic lifestyle factors within different generations. In general, the results of present study support the hypothesis that BMI, WHR and skinfold adiposity, pulse pressure, occupation and alcohol for only males have some significant independent correlation with risk of elevated blood pressures among all generations especially offspring and parental generations. Among the important anthropometric and socio-economic lifestyle indicators, BMI, waist circumference, WHR, biceps skinfold, triceps skinfold and education were strongly associated with SBP and DBP in female parental generation. However, smoking and alcohol were mainly correlated with SBP and DBP in male generations. Almost similar type of observations have been documented from other studies (Lean et al., 1995; Rexrode et al., 2001; Yalcin et al., 2005; Badaruddoza et al., 2010). Many investigators (Pouliot et al., 1994; Esmaillzadeh et al., 2004; Khan et al., 2008) advocated that waist circumference as well as WHR have strongest correlation with the elevation of blood pressure especially in females although age and menopause have significant effect on cardiovascular parameters. This hypothesis has also been supported by many authors (Spencer et al., 1997; Rheeder et al., 2002; Badaruddoza and Hundal, 2009; Badaruddoza et al., 2009). The present study has also indicated that waist circumference, hip circumference and WHR have strongest relationship with elevated SBP and DBP in female parental generations. Therefore, the elevation of SBP and DBP among women can be correlated with waist circumference, hip circumference and WHR which were also most important variables for obesity. Therefore, the study has demonstrated that a predominant accumulation of adipose
tissue in the abdominal region confers an increased risk of cardiovascular risk and morbidity in both male and female generations. Therefore, the present results suggested that irrespective of generations BMI, waist circumference, WHR, skinfold thickness, income and stress have strong positive correlation with blood pressure and these parameters can be used as significant predictors to predict or understand etiology of the chronic diseases like hypertension and obesity regardless the background of the ethnic and genetic composition. Hence, the study also suggested the especially BMI and waist circumference would be simple and significant indicator for the management of moderate or high risk of cardiovascular diseases and regular health care system in the present community.

5.3. Regression Analysis

As regards of blood pressure indices many interesting results with respect to regression analysis have emerged. Across all three blood pressure phenotypes for all three generations; offspring, parental and grandparental, almost all anthropometric and socio-economic lifestyle variables were at least moderately related to blood pressures on the basis of univariate regression analysis. In the linear regression analysis, it has been observed that the main independent contributory risk factors to the total variation of SBP and DBP were as such: age (33% and 20% for SBP and DBP, respectively), waist circumference (32% and 13% for SBP and DBP, respectively), stress (18% for SBP), income (18% for SBP), occupation (14% for SBP) in male offspring generation. However, any of the socio-economic lifestyle variables has no significant contribution to DBP. The contribution of hip circumference (12.8% and 4.8% for SBP and DBP, respectively), weight (10.9% and 5.9% for SBP and DBP, respectively) and education (3.3% and 4.4% for SBP and DBP, respectively) was significant in female offspring generation. The main independent contributions in male parental generations were by pulse rate (8% for SBP), skinfold thickness (6% for DBP), income (4.2% for SBP) and alcohol (71% for DBP). The main independent contribution in female parental generation were pulse pressure (72% for SBP) and waist circumference (7% for DBP). The main contribution in male grandparents were found for pulse pressure (66% for SBP), age (14% for DBP), alcohol (27% for SBP) and exercise (17% for DBP). The main contribution for female grandparent was pulse pressure (83% and 20% for SBP
and BDP, respectively). No socioeconomic variable has significant contribution in female parental and grandparental generations.

The study showed that different predictors have different contribution in different generations. It is difficult to find out a single significant contributory predictor in all generations. Therefore, such type of study would generate valuable information on the nature-nurture interaction involved in the chronic diseases like cardiovascular diseases. Hence, considering the present linear regression analysis, it may be assumed that mostly age, waist circumference, pulse pressure, level of education, different types of stress and alcohol consumption which is only are males were found to be most consistent in explaining the risk factors of CVD. However, very negligible contributions of socioeconomic lifestyle variables have been observed to the total variation of DBP. However, when blood pressures were regressed on the different sets of variables using multiple regression analysis, then fewer variables were found to be statistically significant at 5% level. This suggested that some of the variables among anthropometric and socio-economic lifestyle factors are primary in nature (significant multivariate correlates) while others are secondary (non-significant multivariate correlates) in different generations. BMI, WHR, skinfold thickness, pulse pressure and pulse rate among anthropometric variables, type of occupation, level of education, food habit (veg/non-veg), physical activity (sedentary/active) and stress (physical/psychological/psychosocial) among socio-economic lifestyle factors were the common correlates of SBP and DBP and significant multivariate predictors among all three generations in both sexes. However, certain other variables of anthropometric and socio-economic lifestyle factors did not remain significant in the strict sense of multivariate context and may be considered secondary correlates among all three generations. It is also interesting to note that in multivariate system, cumulative contribution of the maximum total variance ($R^2$) for anthropometric variables were 86% and 33% for SBP and DBP, respectively, among female grandparental generation and lowest contributions ($R^2$) were 50% and 14% for SBP and DBP among female offspring. For socio-economic lifestyle factors the similar results were as follows; 30% and 15% for SBP and DBP among female parental and male offspring generations, respectively and lowest contributions 4% and 1% for SBP and DBP among female offspring and female
parental generation respectively. However, in offspring generations, the cumulative contribution of anthropometric risk factors to the total variations were 56.9% and 50% for SBP and 22.9% and 13.9% for DBP in male and female offspring, respectively. The similar observation of socioeconomic lifestyle variables were 29% and 3.8% for SBP and 14.6% and 4.3% for DBP in male and female offspring, respectively. The data suggested that a stronger and greater impact of anthropometric and socioeconomic lifestyle variables on SBP as compared to DBP. However, minimum cumulative contributions of socio-economic variables on SBP and DBP have been observed in female offspring generations. In parental generation, the cumulative contribution of anthropometric risk factors to the total variation were 72.9% and 74.7% for SBP; 19.1% and 18.7% for DBP in male and female parental generations. The cumulative contribution of socioeconomic lifestyle factors were 7.9% and 29.5% for SBP and 6.56% and 1.07% for DBP in male and female parental generation, respectively. In grandparental generation, the cumulative contributions of anthropometric risk factors to the total variation were 74.6% and 85.7% for SBP and 28.8% and 33.3% for DBP in male and female grandparental generations, respectively. The cumulative contribution of socio-economic lifestyle variables were 7.51% and 1.40% for SBP and 6.96% and 2.38% for DBP in male and female grandparental generation, respectively.

In the present multivariate analysis, the sample size with 22 parameters are large enough to provide sufficient power for testing of any hypothesis, therefore it may be hypothesized that anthropometric risk factors have comparatively robust effects than socio-economic lifestyle risk factors on SBP and DBP. It is due to the fact that SBP is more environment sensitive as compared to DBP. As the results showed that minimum contribution of socio-economic lifestyle variables to total variance of blood pressure phenotypes (SBP and DBP) in female offspring, male parental and grandparental generations and in only for DBP in female parental generation. It has confirmed that this study population has different risk profile with respect to socioeconomic lifestyle risk factors. On the account of the differences with respect to cumulative contribution to the total variance between anthropometric and socioeconomic lifestyle risk factors strengthened the hypothesis that anthropometric indicators such as BMI, waist circumference, WHR and skinfold adiposity would be recognized best predictors for
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estimating cardiovascular disease risk. The findings of this study corroborates the earlier observations that reported significant positive correlation of anthropometric factors with SBP and DBP (Seidell et al., 1991; Belahsen et al., 2004; Adedoyin et al., 2008; Badaruddoza et al., 2010). Different studies (Perruse et al., 1989; Gus et al., 2004; Badaruddoza et al., 2011a) based on different sets of variables may produce different regression coefficients and associations for different anthropometric and environmental variables.

Another finding regarding blood pressure indices was that age of individual may not be determined the degree of association between blood pressure and particular correlates except for male grandparent for SBP and male offspring and female grandparent for DBP. From previous examples it was noted that relevant obesity measure for SBP and DBP in all generations are BMI, WHR and skinfold thickness. Another example of age dependent associations such as physical activity, stress and food habit appeared to be strongly associated with blood pressure for all the generations. These were able to make the combined association of significant correlates for blood pressures through stepwise regression analysis. All alternative regression models such as five and eight models for all possible subsets among anthropometric and socio-economic lifestyle factors have been used for greater explanatory power for the association of CVD. The selection of predictor variables in the models have been chosen with respect to largest correlation with the criterion variables such as SBP and DBP. The first predictor variables were selected based on the highest partial correlation followed by second, third and other predictor variables based on the respective highest partial correlation in the forward selection. The final model contains all of the independent variables that meet the inclusion criteria. The model used are as such: model 1- age; model 2- age+ BMI; model 3-age+ BMI+ WC; model 4- age+ BMI+ WC+ WHR; model 5- age+ BMI+ WC+ WHR+ pulse rate for anthropometric predictors and for socio-economic lifestyle predictors; model 1- occupation, model 2- occupation+ income; model 3- occupation+ income+ education, model4-occupation+ income+ education+ food habits; model 5-occupation+ income+ education+ food habits+ physical activity; model 6- occupation+ income+ education+ food habits+ physical activity+ exercise; model 7- occupation+ income+ education+ food habits+ physical activity+ exercise+ smoking; model 8-
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occupation+ income+ education+ food habits+ physical activity+ exercise+ smoking+ alcohol. The R is the measure of correlation between observed value and predicted value of the criterion value (SBP and DBP) whereas, R square ($R^2$) is the square of the measure of correlation and indicates the portion of variance in the criterion value (SBP and DBP) which is accounted by the respective model. Overall statistical significance of a regression model is checked by F-statistics. The significance indicates only that the model is not useless. It may or may not be sufficiently good fit. The complement of ‘goodness of fit’ is denoted by also $R^2$. The larger the $R^2$, the better is the fit. $R^2$ is also used to compare one model with another. Model with larger $R^2$ would be better fit. Using stepwise multiple regression analysis, the present study has shown that almost all anthropometric models (1-5) and socio-economic lifestyle models (1-6 for females and 1-8 for males) have significant and pronounced influences on SBP and DBP. The regression coefficients of all models were significant at $p<0.001$. Hence, the increase of such measures of combined risk factors of anthropometric and socioeconomic lifestyle variables also enhanced the occurrence of hypertension and allied measure coronary risk factors. The results of present study were also consistent with many other similar/related studies both in India and abroad (Rao et al., 1984; Perusse et al., 1989; Nath et al., 2002; Ghosh et al., 2003; Deshmukh et al., 2006; Ghosh and Bandhopadhyay, 2007; Gupta et al., 2007; Sarkar et al., 2009). Furthermore, the maximum percent of variance ($R^2$) is explained by model 5 (age+ BMI+ WC+ WHR+ pulse rate) for anthropometric variables and model 8 (occupation+ income+ education+ food habit+ physical activity+ exercise+ smoking+ alcohol) for socio-economic lifestyle factors. Model 5 for anthropometric indicators contribute maximum 28.8% for SBP and 18.3% for DBP whereas, model 8 for socio-economic lifestyle indicators contribute maximum 20.3% for SBP and 4.1% for DBP of total variables among male offspring as compared to other generations. However, the lowest contribution for anthropometric variables was found 11.7% for SBP by model 5 in female grandparent generation and 5.1% for DBP in female offspring. Similarly, for socio-economic lifestyle factors lowest contribution was 3.8% for SBP and 1.1% for DBP among female parents. To evaluate the effect of anthropometric and socioeconomic lifestyle model, one may compare $R^2$. Although the results of $R^2$ may at first seem not very large enough in different
generations, they were quite compatible for SBP and DBP. With respect to F-statistics, all models for SBP and DBP except model 2 for SBP; models 1 and 5 for DBP of socioeconomic lifestyle predictor in female offspring; model 1 for SBP and all models for DBP of socioeconomic lifestyle predictors in female parents; all models for SBP and DBP of socioeconomic lifestyle in female grandparents, have been found significant predictors for cardiovascular diseases. Therefore, the results suggested that anthropometric model was the better fit as compared to socioeconomic lifestyle model to explain the total variation of blood pressure in all the generations. However, the socioeconomic lifestyle variables have not produced high $R^2$ due to the fact that appropriate regressors may not be found out in these situations. It is difficult to choose the appropriate socioeconomic lifestyle predictors on the basis of interpretability and convenience in obtaining the data.

Therefore, to understand the etiology of CVD with respect to different combinations of anthropometric and socio-economic lifestyle factors, future investigations should be undertaken on other Indian populations keeping in mind vast ethnic and cultural heterogeneity in India to determine the relative role of these anthropometric and socio-economic lifestyle factors especially, food habit, occupation and physical activity (active/sedentary) variables in explaining the occurrence risk of CVD. Longitudinal studies to show the interaction between anthropometric and socio-economic lifestyle variables for understanding of etiology of CVD are also needed in future. Furthermore, vast cultural heterogeneity and differences in food consumption habit among different Indian communities across the Indian subcontinent have a potential risk for CVD.

On binary logistic regression analysis, the magnitude and nature of significant association between pre-hypertension/hypertension with anthropometric and socioeconomic lifestyle variables were different in different generations. Logistic regression is useful for the present situation in which the study is able to classify subjects based on values of a set of predictor variables such as anthropometric and socio-economic lifestyle factors. In the present study, the risk of developing pre-hypertension was highest among both the male and female parental generations with respect to WHR (1.5 times) and among female grandparents with respect to sedentary/active lifestyle (2.2 times) as compared to other anthropometric and socio-economic
lifestyle risk factors. Similarly risk of developing hypertension was maximum with respect to WHR (9.9 times higher for male parents and 4.4 times higher for female parents) among parental generation and for socio-economic lifestyle factors, exercise (2.14 times) and education (2.84 times) have greater impact among male offspring and female offspring generations, respectively as compared to other variables. However, overall it was observed that BMI, WHR and waist circumference have almost equal association with development of pre-hypertension and hypertension. For socio-economic lifestyle variables greater influence was found for exercise, education, food habit and physical activity (sedentary/active). It was also observed that male and female generations almost equally tended to have CVD even though, on average women had a higher waist circumference than men, which is a better predictor of CVD. The present findings did not differ from other previous reports showing gender differences in blood pressures with respect to waist circumference and WHR (Wang and Vasan, 2005; Ong et al., 2008; Kumar et al., 2011). NHANES III 1988-1994 study (Ong et al., 2008) showed that males were associated with uncontrolled blood pressures and lack of awareness of hypertension. Although women had higher awareness than men, however, these differences were no longer significant. The present findings showed that female grandparental generation had higher blood pressures as compared to the male counterpart. It has been suggested that sex hormones may contribute to some extent to the gender differences in waist circumference and blood pressures. It is because estrogen is the major contributing factor as compared to androgen and this hormone has significant effect on blood pressure and waist circumference on post-menopausal women. A study (Laughlin et al., 2000) showed that serum testosterone increased with age in women demonstrating that the testosterone may have a physiological role in elderly women. Therefore, higher levels of blood pressures in elderly women, which was found in the present study, was fully justified as because more than 80% of women with diagnosed hypertension were menopausal (Ong et al., 2008; Badaruddoza et al., 2010). As aging is a risk factor for hypertension it is also expected that increasing age may be associated with uncontrolled blood pressures and the incidence of CVD in women increased with age and became higher than in men after menopause. The ovarian age may play a role in increasing waist circumference and fat mass and
decreasing skeletal muscle mass. These changes of body composition may explain the association of increasing age with uncontrolled blood pressure in elderly women (Sowers et al., 2007; Badaruddoza and Kumar, 2009). This hypothesis is also supported by the present analysis.

The slightly higher rate of uncontrolled blood pressure and prevalence of cardiovascular risk factors in present study group (Ramadasia, a socially, economically and educationally backward community) could be because of genetics, culture, social factors, familial aggregation and limited access to care and medications. It has been reported from many epidemiological studies that smoking and alcohol drinking had significant impact on elevated blood pressure and risk of hypertension (Todkar et al., 2009; Brien et al., 2011; Kaur et al., 2011). The present study also confirmed that these two risk factors showed a positive correlation with blood pressure among males, whereas none of the females have been identified as smokers or alcoholics.

The results of binary logistic regression analysis for each anthropometric and socio-economic lifestyle risk factors have showed that the logistic regression coefficient for all these risk factors were not significant among all the generations except male and female parental generations for pre-hypertension and hypertension. However, according to the present result it was found that positive association of all these risk factors with hypertension and these risk factors have some impact on hypertension development in the present study population. Although the prevalence of hypertension varies among different populations worldwide and currently it is treated as a rising health problem. The recent studies on hypertension from developing countries (Gaziano et al., 2006; Badaruddoza and Sawhney, 2009; Ulasi et al., 2011) have shown the prevalence to be equally rising as compared to developed countries. In men, the prevalence is 32% in developing countries and 41% in developed countries and in women, it is 31% in developing countries and 33% in developed countries (Dogan et al., 2012; Pereira et al., 2009). India, as a developing country, is at the risk of an increasing number of hypertensives. In the present study, it has been reported that overall prevalence of pre-hypertension among males as 29.9% and 19.5% among females and of hypertension was 15.2% for males and 17.9% for females. As the present study was semi-urban based with different genetic composition and low level of nutritional features due to
socio-economic reason, the differences of prevalence were large as compared to overall prevalence in India which was reported 25% for urban population and 10% for rural population (Todkar et al., 2009). Therefore, the present results were also in these ranges and it would be higher if the subject considered was in the older age group. In the present study, subjects were of different age groups and generations such as offspring generation (lower age group), parental generation (middle age group) and grandparental generation (older age group). In the present study, it was also observed that prevalence of hypertension was higher in women as compared to men. In many epidemiological studies conducted in different countries have shown that the prevalence of hypertension was higher in women than in men (Turgay et al., 2002; DaCosta et al., 2007; Stein et al., 2008; Yadav et al., 2008; Erem et al., 2009; Todkar et al., 2009; Dogan et al., 2012). However, regarding age and generation factors in offspring the prevalence of hypertension was very low and the prevalence of hypertension was higher in male (2.9%) as compared to females (1.9%), whereas in the older group such as grandparental generation the results were reversed as higher prevalence in women (54%) as compared to males (50%). These variations may be explained by the high prevalence of obesity, sedentary lifestyle (most of the housewives) and the unhealthy diet of women in this region. Prevalence of hypertension was higher in older age group and the differences were very large from 1.9% (offspring) to 53.7% (grandparental generation). Therefore, like in many other studies in the present study age was also a significant risk factor for hypertension (Bener et al., 2004; Yadav et al., 2008; Erem et al., 2009).

The relation of hypertension and obesity related traits have been well known for many decades. In the present study and several other studies it was found that obesity related traits such as BMI, WHR and waist circumference were strong risk factors for the development of hypertension (Manimunda et al., 2011). In this study, obesity was also an important risk factor for hypertension with wide range in every generation. The present families of the community with low socio-economic status consumed more bread and food made up of wheat which increases the weight. In addition to that most of these people live in semi-urban areas and have no regular jobs and not caring for the physical appearances and unwillingness to change their lifestyle which enhances the
risk of obesity and the prevalence of hypertension. On the other hand most of the people with hypertension cannot reach a modern and well equipped health centre for their treatment due to low income.

5.4. Principal Component Factor Analysis

The present 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 on one of the major objective, 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 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 (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 (Badaruddoza et al., 2010; Badaruddoza et al., 2011a; Kaur et al., 2012).

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. (2011a) 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.

Similar type of observation has also been seen in the present analysis. Hence, 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. The association of central obesity, hypertension and dyslipidemia with CVD has been
observed in number of ethnic groups worldwide. Studies across the population demonstrated that these risk factors played important roles for the development of CVD (Ghosh, 2005; Wu et al., 2008; Badaruddoza et al., 2010; Kaur et al., 2012). 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. 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. As far as Indian data is 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. Hence, the present work would be considered as reference baseline 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 have 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 pattern of high loadings for obesity and blood pressure in the present analysis were consistent with other factor analysis studies (Shmulewitz et al., 2001; Bellis et al., 2005; Goodman et al., 2005; Chang et al., 2010). Identification of two important factors from study could suggest at least two patho-physiological processes related important components, obesity and blood pressures, for the occurrence of risk of CVD.

Very few previous studies reporting results of factor analysis have included individuals from three generations with both sexes (Badaruddoza et al., 2010; Badaruddoza et al., 2011a; Kaur et al., 2012). To date knowledge, this is the first investigation to have included all males and females from three generations such as offspring, parental and grandparental.
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.

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

### 5.5. Familial Correlation

Results from this study of extended nuclear families in a scheduled caste community in Punjab clearly demonstrated familial aggregation of CVD risk factors. The brother-sister, father-offspring (male/female), mother-offspring (male/female) correlations were all greater than spouse correlations (brother-sister: 34% for SBP, 31% for DBP, 38% for BMI; father-male offspring: 31% for SBP, 30% for DBP, 21% for BMI; father-female offspring: 21% for SBP, 20% for DBP, 15% for BMI; mother-male offspring: 17% for SBP, 15% for DBP, 23% for BMI; female offspring: 20% for SBP, 18% for DBP, 29% for BMI; spouse: 4% for SBP, 5% for DBP, 9% for BMI). These observations have
suggested that individuals who shared genes tend to be more alike in aggregation of CVD risk factors. The magnitude of these correlations was similar to many previous studies in India and abroad (Knuiman et al., 1996; Badaruddoza and Sawhney, 2009; Kumar and Badaruddoza, 2010; Badaruddoza and Patharia, 2012; Badaruddoza and Kaur, 2010). The magnitudes of these correlations for SBP, DBP and BMI have seen to be lower in grandparent-offspring. Therefore, the higher estimates of correlations among parent-offspring generations and siblings suggested the genetic closeness and those same family environmental factors determine the variations of blood pressure phenotypes. But the correlation between siblings was even larger than correlation between parent-offspring and others. This pattern was also apparent in other several studies (Chow et al., 2007; Di Castelnuovo, 2008; Badaruddoza and Sawhney, 2009; Kumar and Badaruddoza, 2010). These findings suggested that there is greater sharing of environmental determinants or risk factors between siblings than parent-offspring and others, or those dominant as well as additive genetic effects have been involved. It is also interesting to note that a larger correlation for BMI for brother-sister (38%) has been found in the present study. However, several studies have shown greater correlation for same sex siblings than for opposite sex siblings (Tambs et al., 1992; Knuiman et al., 1996; Badaruddoza and Kumar, 2009; Badaruddoza and Patharia, 2012). The lack of significant trend in spouse correlations with SBP, DBP and BMI suggested that observed correlation between spouses of CVD risk factors was primarily due to assortative mating rather than cohabitational effects. This result also agreed with several other studies (Badaruddoza and Sawhney, 2009; Badaruddoza and Kaur, 2012). In this study the estimates of familial correlation of father-male offspring was higher than father-female offspring for blood pressure phenotypes and BMI. The possible reason for this result is that environment is relatively more cordial for male children in Indian society, especially in socio-economically weak community. The present analysis has also showed a significant correlation for blood pressures among sibship, grandfather-offspring. Therefore, the study also strengthens the hypothesis that a substantial fraction of the variation in human blood pressure is determined by both genetics and familial environment. The findings of familial aggregation of blood pressures especially in offspring generations in present population indicated the need
for further investigation into genetic determinants of blood pressure through epidemiologic familial studies. The magnitude of familial effects for SBP were more consistent than DBP. However, familial correlation estimates of SBP were less than those reported from previous studies (Byard et al., 1989; Gu et al., 1998; Rice et al., 2000; Badaruddoza and Sawhney, 2009).

5.6. Heritability
The present study has also examined the cause of familial aggregation of blood pressure and genetic and environmental influences on blood pressure. Familial aggregation of blood pressure is largely due to genes rather than familial environment. Heritability explained by the genetic variation in blood pressure. The study of anthropometry and physiometry have immense importance to quantify the heritable portion of phenotypic variability due to the genetic and environmental factors on their interactions including socio-economic lifestyle risk factors across the different generations. Therefore, the present study has a great potential for the study of quantitative genetic variations within and between the generations. In the present study, as expected age, generation and sex differences were significant for the majority of traits indicating the heterogeneity of the populations. Therefore, estimates of heritabilities through variance-component approach produced a wide range of heritabilities (10%-98.7%) for selected anthropometric and physiometric phenotypes between different combinations of the three generations. However, the general trend of heritability patterns observed in the present study was in agreement with the findings of different previous studies (Devor et al., 1986 a b; Rice et al., 2000; Arya et al., 2002; Badaruddoza and Kumar, 2009).

In this study, the heritability model used included a component for the effect of current sharing the same household (at the time of measurement) but did not take into account the effect of sharing household in the past. However, no such specific data are available on sharing of household in the past. It is most likely characteristic feature of the studied community that all offsprings, parents and grandparents lived in the same household. In this situation, it is not possible to estimate such an effect separately. The omission of such an effect of model leads to overestimation of heritability and the genetic component of variance. Therefore, anthropometric and physiometric phenotypes of Indian community are of particular interest to quantify heritable portion of phenotypic
variability due to the fact that genetic and environmental factors and their interactions including socio-economic variables and food habits across the community group affect the variations in these phenotypes especially SBP, DBP and BMI. Therefore, the present study involved quantitative genetics variations of SBP, DBP, waist circumference, WHR and BMI within and between the generations.

All the heritabilities of anthropometric phenotypes (waist circumference, hip circumference, WHR and BMI) and physiometric phenotypes (SBP, DBP, MBP, pulse rate and pulse pressure) were significant among eight combination of relationship. The maximum heritabilities were found 79% for SBP in male offspring-male parent; 87% for DBP in male offspring-male grandparent; 97% for pulse rate in female offspring-male grandparent; 72% for pulse pressure in female offspring-male parent; 98% for waist circumference in female offspring-male grandparent; 70% for WHR in female offspring-female parent; 86% for BMI in male offspring-male grandparent. Hence, estimates of heritability of SBP, DBP, MBP, pulse rate, pulse pressure, waist circumference, WHR and BMI in studied population were significantly higher in the present study and the present result has also been supported by many other studies in the literature (Devi and Reddy, 1983; Byard et al., 1984; Poosha et al., 1984; Yu et al., 1990; Fagard et al., 1995; Rice et al., 2000; Arya et al., 2002; Fava et al., 2005; Kupper et al., 2005; Owiredu et al., 2008; Odenigbo et al., 2011; Badaruddoza and Patharia, 2012).

However, direct comparison of our result with other studies would be difficult because heritability represented that portion of total phenotypic variations which is attributable to the genetic variations. This would differ from population to population which also differs in distribution of different socio-economic risk factors for all respective traits. Since, generation effects were significant in most of the phenotypes, the magnitude of heritability in inter-generation difference were also more prominent in the present study group. The observed higher heritability of these traits may be attributable to the cohabitation of the majority of subjects leading to similar type of nutrition and environmental effects. The pattern of heritability of parental generation was consistent for all the phenotypes.
Remark: Despite the importance of blood pressure in epidemiological studies, the familial aggregation and the heritability aspect seems to be more important in specific community. Scarcity of Indian data in this respect is unable to compare the present sample with other Indian studies. It is important to emphasize that in present study approximately 89% of the families have 2-4 members. Recent evidence provided by other studies in genetic epidemiology carried out in different populations and different countries support that the genetic factors and familial co-factors have important influences on blood pressure phenotypes (Knuiman et al., 1996; Badaruddoza and Sawhney, 2009; Fermino et al., 2009; Badaruddoza and Patharia, 2012). Among them some studies analyzed nuclear families whereas others assessed extensive pedigree (Perusse et al., 1989; Lin et al., 2005; Fermino et al., 2009). The results found in their studies showed values between 16%-68% and 6%-62% of the accountability of SBP and DBP values, respectively, which can be attributed to genetic factors as compared to our study which showed values between 30%-79% and 60%-87% accountability of SBP and DBP values, respectively. These results are interesting as they demonstrated that both blood pressure phenotypes were strongly influenced by genetic factors which were also influenced by familial correlations. A complementary form to interpret the heritability (h²) is verificationary familial aggregation based on R². The results found in family study were low to moderate, 0.04-0.34 for SBP and 0.05-0.30 for DBP between the degrees of family relationship. Although distinct pattern of similarity between pairs of related individuals such as parent-offspring (0.17≤r≤0.31 for SBP; 0.15≤r≤0.30 for DBP) and siblings (r=for SBP; r=0.31 for DBP) were compared with unrelated individuals (spouses r=0.04 for SBP; r=0.05 for DBP). These values suggested the presence of familial aggregation in blood pressure phenotypes among related individuals. This similarity can be attributed to genetic factors.

The heritability (h²) of male parent-male offspring (79%) and male parent-female offspring (62%) were higher than female parent-male offspring (58%); female parent-female offspring (46%) for SBP. This fact suggested that heritable component for SBP is more dependent on father. In the case of heritability (h²) for DBP, female parent-male offspring (74%) and male parent-female offspring (77%) were found. These values also suggested the heritable portion of DBP for son was dependent on mother and daughter
dependent on father. Similar results were found in different studies (Kumar and Badaruddoza, 2010; Badaruddoza and Patharia, 2012).

5.7. Sensitivity, Specificity and Likelihood Ratio

The cut-off values for different anthropometric and socioeconomic lifestyle indicators for CVD differ in different countries and it is highly race and ethnic dependent. There is no global standard for these indicators (WHO, 1995; Molanus and Seidell, 1998; Doll et al., 2002; Zhu et al., 2005; Lee et al., 2008; Mellati et al., 2009). Therefore, it is important to develop simple and effective anthropometric/socio-economic lifestyle indicators for the screening of CVD risk subjects in different populations until reaching internationally accepted measures. The present study has attempted to evaluate comparative three anthropometric indicators (BMI, waist circumference and WHR) and five socio-economic lifestyle factors (food habits, physical activity, exercise, smoking and alcohol) to identify the most distinctive indicators for pre-hypertension and hypertension for a specific community in Punjab. No such study has been performed in this region based on sensitivity, specificity and likelihood ratio with three generations. Therefore, with the lack of data on this subject unfortunately, the present study was unable to be compared with other studies.

The sensitivity is the proportion of patients for whom outcome is positive that are correctly identified by the test. The specificity is the proportion of the patients for whom the outcome is negative that are correctly identified by the test. Generally, both the sensitivity and specificity of a test indicator need to be known in order to assess its usefulness for diagnosis of discriminating test would have sensitivity and specificity close to 100%. However, a test with high sensitivity may have low specificity and vice-versa. Sensitivity and specificity are usually combined in likelihood ratio (LR). The likelihood ratio of positive test result (LR+) is the ratio of a probability of a positive test result if the outcome is positive (true positive) to the probability of a positive test result if the outcome is negative (false positive). Therefore, LR+ represents the increase in odds favouring the outcome given a positive result. Similarly, LR- is the ratio of probability of a negative test result if the outcome is positive to the probability of a negative test result if the outcome is negative. Therefore, LR- represents the increase in
odds favouring the outcome given negative test result. A high likelihood ratio for a positive result or a low likelihood ratio for a negative test which is close to zero indicates that the test is useful.

It is desirable to choose a test that has high values for both sensitivity and specificity. However, in practice the sensitivity and specificity may not be considered as equally important such as false negative finding may be more critical than a false positive one in which the cut-off with relatively high specificity will be chosen. However, if no judgement is made between the two then Youden’s index \((J)\) may be used to choose appropriate cut-off. The maximum value a Youden’s index can attain is 1 when the test is perfect and the minimum value is zero when the test has no diagnostic value. The results of the present study indicated high sensitivity with respect to physical activity and WHR for pre-hypertension among male offspring and female offspring and for hypertension in male offspring; waist circumference and physical activity for female offspring were better indicators for CVD risk factors in comparison to other anthropometric and socioeconomic lifestyle factors. The values of positive likelihood ratio \((LR^+)\) and Youden’s index were also found to be maximum for BMI, WHR and food habits for these generations. This showed these indicators have significant positive association with the occurrence of CVD risk factors. Although, from the present results it was observed that BMI, waist circumference and WHR clearly have higher sensitivity but, food habit also has significant contribution for the occurrence of CVD in these generations.

Among male parental generation the waist circumference and WHR for pre-hypertension; WHR and exercise for hypertension and waist circumference and BMI for pre-hypertension and hypertension among female parental generation were better indicators to assess CVD risk factors. High sensitivity suggested that waist circumference and BMI performed well in female parental generations. The present findings were consistent with several other studies in India, other south Asian and western countries (Dalton et al., 2005; Zimmet et al., 2005; Hsieh and Muto, 2006; Chehrei et al., 2007; Schneider et al., 2007; Mellati et al., 2009; Gupta and Kapoor, 2012). However, few studies (Dobbelsteyn et al., 2001; Zhu et al., 2005; Lee et al., 2008;) claimed that measure of central obesity such as waist circumference are better
discriminators of CVD risk factors compared to BMI. They also rejected the previous suggestion that combining BMI with waist circumference increased the cardiovascular risk prediction more than either measured alone (Zhu et al., 2004) and supported the use of WHR as sole measure of obesity. However, the present analysis did not support this hypothesis and proposed combined BMI and waist circumference would be the better predictor for both males and females, especially in female generations. BMI, which was most widely used indicator for total adiposity, cannot distinguish visceral fat from muscle mass or peripheral from the central fat and also its limitations were recognized by its change according to age and its dependency on ethnic groups (WHO, 1995; Grinker et al., 2000; Hsieh et al., 2000). Therefore, waist circumference has shown to be highly correlated with the amount of visceral body fat measured by computer tomography (Rankinen et al., 1999; Lee et al., 2008) and majority of the current study suggested that waist circumference is the better indicator for CVD risk factors than BMI and WHR (Ledoux et al., 1997; Mellati et al., 2009; Gupta and Kapoor, 2012). Furthermore, WHO (1995) has suggested that waist circumference is the easiest and most effective anthropometric indicator to be used in population based study because it measures fatness and fat location. However, there is no global standard for this measurement. Some studies measured waist circumference at the level of umbilicusc and some at WHO standard definition which is half way between iliac crest and lower rib. However, waist circumference cut-off values differ between genders and ethnic groups (Molanus and Seidell, 1998; Hsieh and Muto, 2006).

The results of the analysis of present data suggested waist circumference for almost all the generations with average high sensitivity upto 97% and 99% for female parents generation in the prediction of pre-hypertension and hypertension. BMI and WHR may be considered with respect to sensitivity in the second level of best predictor for both pre-hypertension and hypertension. If we compare positive likelihood ratio of the three generations with respect to all the indicators then it was observed that LR+ value of BMI have been consistently higher among all the generations as compared to waist circumference and WHR. Therefore, it has suggested that combination of waist circumference and BMI would be the better predictors to assess CVD risk. Several studies have analyzed the association between CVD risk factors and other anthropometric factors based upon sensitivity, specificity and likelihood ratio analysis.
Most of the studies (Mellati et al., 2009; Gupta and Kapoor, 2012) including present one, supported the idea that waist circumference and BMI are the best anthropometric index of CVD risk factors compared to other indicators. However, due to different reported cut-off values across different ethnic population groups, future research and study would be required until reaching an internationally acceptable simple and appropriate measure that could be easily and efficiently used in the clinical and epidemiological research. It is because none of the three anthropometric indicators (BMI/waist-circumference/WHR) and six socioeconomic lifestyle indicators (food habits/physical activity/exercise/smoking/alcohol) studied here consistently yielded a higher sensitivity or specificity to predict the pre-hypertension and hypertension. Therefore, the other criterion may need to be used to choose the criterion value. This was also supported by the result from the report of Workshop on Use of Anthropometry for Public Health and Primary Health Care (Seidell et al., 2001) emphasize that measurement’s error may be compounded in a ratio such as WHR and BMI and the interpretation of these ratios in patho-physiologic terms is difficult. Sometimes, BMI also criticized because it is calculated by the formula that may be difficult to explain to the patients and even to some clinicians. Despite these facts the reports of that workshop pointed out waist circumference alone could be the reasonable indicator to assess the CVD risk factors. However, the results presented here support the use of combined association of waist circumference and BMI for the prediction of CVD risk.

CONCLUSION
In conclusion, the statistical evidences obtained from the entire hard core analysis of the present work would be sufficient to reject the null hypothesis ($H_0$). However, confirming the evidence that the impact of complex mode of anthropometric and socioeconomic lifestyle variables on SBP and DBP are consistent with major significant effect.

Rejection of hypothesis of no relative roles of hereditary and familial environment in the etiology of SBP and DBP has also been suggested and confirmed significant contributions of familial aggregations and genetic heritability on cardiovascular risk factors in present study population (Ramadasia, a Scheduled caste population).
5.8. **Strengths of the Thesis**

1. The strength of the present study is that this is one of the largest rural/semi-urban family, generation and population based study.
2. This study has been done on a socially, economically and educationally unprivileged community (Ramadasia) in Punjab.
3. The prevalence of risk factors was age, gender and generation specific.
4. It provides base line data that can be used for planning and intervention for control of cardiovascular diseases.
5. The samples were collected from four districts of Punjab with 66 clusters which may be to some extent representative of general backward class population in Punjab.
6. The present findings identified many important socio-economic lifestyle factors for further study and highlighted potential public health intervention for this backward community in Punjab.
7. This is comprehensive population based house-to-house survey investigating patterns and correlation of anthropometric, physiometric and socio-economic lifestyle factors with cardiovascular diseases.
8. The specially designed questionnaire for the study provided comprehensive behavioural pattern.
9. The present analysis of the study showed a strong familial clustering of many cardiovascular risk factors. Therefore, extended nuclear family study should be considered as a point of intervention.
10. Very few previous studies reporting results of principal component factor analysis have included individuals from three generations with both sexes. The findings also added depth to the negligible amount of literature of factor analysis of cardiovascular risk in any Indian ethnic population.
11. This study not only confirmed but extended prior work by developing a cumulative risk scale from factor scores. Till date, such a cumulative and extensive scale has not been used in any Indian studies with individuals of three generations.
12. 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 time to create clinical disease.

13. To support the present result and discussion, a wide range of references from 1942 to 2012 have been used.

5.9. Limitations of the Thesis

1. Due to cross-sectional nature of the data, observed association of different risk factors (anthropometric, physiometric and socio-economic) with cardiovascular diseases cannot be determined as cause and effect relationship.

2. The study was based on maximum self report of respondent especially regarding age and socioeconomic lifestyle factors and it probably may have led to under-estimate true association between social lifestyle and morbidity.

3. No data is available on type of drugs used for the treatment of any kind disease the subjects were suffering from.

4. In principal component factor analysis (PCFA) some inconsistent leading pattern for different variables among the generations have been observed which made the results hard to be interpreted.

5. The limitations of 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.

6. Longitudinal analysis in this and other populations will be required to validate the present hypothesis.

7. As the present study in generation based, it posed a difficulty in comparison of present results with previous investigations on relative risk of hypertension. Nevertheless, this study agrees with findings of other previous investigations that have showed that risk of hypertension increased with increasing BMI. However, this is not the case especially in younger generation or offspring generations.