REVIEW OF LITERATURE

The antecedents to the recognition and measurement of blood pressure can be traced back at least to ancient Greek medicine over 2000 years ago (Levine, 1971). Recognizing the heart as the center of circulation is attributed to Aristotle. He apparently was the first to describe heartbeat and pulse as normal constant physiological functions. In *Historia Animalium*, Aristotle writes, “The blood in animals pulsates in all the blood vessels throughout (the body) at once” (Von Staden, 1989). Expanding on Aristotle’s theories, Herophilus was the first to discuss the dilation and contraction of the arteries. In description of the pulse, Herophilus was the first to use the term diastole and systole (Von Staden, 1989). “Blood pressure is a dynamic physiological function that varies with each heartbeat” (O’Rourke, 1990; James and Baker, 1995). “Blood pressure is the product of cardiac output and systematic vascular resistance to flow” (Lifton, 1996).

Human biological and epidemiological research on blood pressure has been conducted for many years, focusing on cross-cultural comparison, adaptability to certain environmental conditions, and the influences on blood pressure of various cultural, behavioral and psychological changes concomitant with modernization and migration. Field studies began to appear in the literature in the 1920s, the research illustrated a lack of an age-related increase in blood pressure in certain populations (Donnison, 1929; Stevenson, 1999). The rise of blood pressure levels was believed to be a result of influences of “civilization”, such as high sodium and high fat diets, urban lifestyle and social stresses (Huizinga, 1972; Waldron et al., 1982). Although evidence has been found to support the presence of a genetic risk for hypertension, the effect may be impossible to measure without also examining gene-gene and gene-environment interactions as well as the presence of other anthropometric and behavioral characteristics (Williams et al., 1991; Borecki et al., 1997; Crews and Williams, 1999). High blood pressure is one of the most prevent disorders in the industrialized world. It is estimated that over 150 million individuals in the United States, India and China,
three of the most populous countries in the World, have blood pressures at or above the recommended thresholds (Reddy, 1996). Prevalence rates for high blood pressure have largely decreased in developed countries, whereas rates in developing countries continue to rise (Pearson, 1996). Many studies conducted in rural/village and an urban community of different places highlights how differences in social and material environment within the same country may act to produce widely varying patterns of pressure distributions. The urban sample exhibits nearly 3 times the prevalence of hypertension as the rural group (Mohan et al., 2004; Mitra et al., 2011; Hem latha et al., 2013). High blood pressure is an established risk factor for cardiovascular disease and it contributes substantially to premature mortality (MacMohan et al., 1990; Stamler et al., 1993; Tunstall-Pedoe et al., 1994; Munter et al., 2004). The cardiovascular diseases usually occur during or after the fifth decade of life, but pathophysiological and epidemiological evidences have suggested that essential hypertension and the precursors of cardiovascular disease originate in childhood (Raitakari et al., 2003).

Here, the review of literature has been done on prevalence and risk factors associated with high blood pressure among the adolescents. Wide range of research papers were reviewed through pubmed, epidemiological journals and other reference material searched through worldwide web services. The findings have been cited dated back from 1929 till date (December, 2013), to discuss the various aspects related to the topic.

2.1. Prevalence of Hypertension among Adolescents

High blood pressure in children and adolescents is a growing health problem that is often overlooked by physicians. Normal blood pressure values for children and adolescents are based on age, sex, and height and are available in standardized tables. Prehypertension is defined as a blood pressure in at least the 90th percentile, but less than the 95th percentile, for age, sex and height, or a measurement of 120/80 mmHg or greater. Hypertension is defined as blood pressure in the 95th percentile or greater. A secondary etiology of hypertension is much more likely in children than in adults, with renal parenchymal disease and renovascular disease being the most common. Overweight and obesity are strongly correlated with primary hypertension in children. History and physical examinations are needed for all children with newly diagnosed
hypertension to help to rule out underlying medical disorders. Children with hypertension should also be screened for other risk factors for cardiovascular disease including diabetes mellitus and hyperlipidemias and should be evaluated for target organ damage with a retinal examination and echocardiography. Hypertension in children is treated with lifestyle changes, including weight loss for those who are overweight or obese, a healthy, low-sodium diet, regular physical activity, active lifestyle and avoidance of tobacco and alcohol (Riley and Bluhm, 2012).

Few studies provide comprehensive trends in blood pressure among children and adolescents. A single blood pressure measurement was obtained among children and adolescents aged 6 to 17 years in the National Health and Nutrition Examination Survey (NHANES) during 1963 to 1965, 1966 to 1970, 1971 to 1974 and 1976 to 1980 (Rowland et al., 1982). Among children and adolescents, blood pressure was lower in 1971 to 1974 and 1976 to 1980 than previous periods. After 8 years, two cohorts of children and adolescents, the first examined in 1973 and the second in 1984, were re-examined. Systolic and diastolic blood pressure levels were similar at baseline in both cohorts with the exception that black boys in the 1984 group had slightly lower diastolic blood pressure (2 mmHg) (Giddings et al., 1995). At the 8 years follow-up visits, the 1984 cohort weighed significantly more than the 1973 cohort for all ethnic and sex groups except white girls. Nonetheless, the increase in systolic blood pressure during follow-up was 4 to 6 mmHg less for the 1984-1992 cohort compared with the 1973 to 1981 cohorts. This suggested that factors other than weight were influencing the secular trend. Leupker et al. (1999) compared blood pressure levels from 2 serial cross-sectional surveys of fifth through eighth grade public school children, aged 10 to 14 years, from Minneapolis, Minn, surveyed in 1986 (n=8222) and 1996 (n=10241). During the 10 years period, systolic blood pressure increased by 1.5 mmHg among boys ($P<0.001$) and 0.7 mmHg among girls ($P<0.001$). However, diastolic blood pressure decreased by 1.5 mmHg among boys ($P<0.001$) and 2.1 mmHg among girls ($P<0.001$).

Sharma et al. (1991) determined the blood pressure was determined among 2,453 schoolchildren aged between 7 and 16 years in the northwest Indian town, Chandigarh.
to establish the norms. The percentiles were calculated for each age group in both sexes. Both systolic and diastolic blood pressure had a positive correlation with age, weight, height and body surface area (r=0.112-0.178, p<0.01). There was no difference in the systolic and diastolic pressures of boys compared with girls of corresponding age. The upper limits of normal (90th percentile) systolic/diastolic pressure were 113/74, 119/76 and 126/79 in children aged 7 to 9 years, children aged 10 to 12 years, and adolescents aged 13 to 16 years, respectively. The lower limits of hypertension (95th percentile) for systolic/diastolic pressure were 119/80, 124/81 and 132/82 in each of these groups, respectively. The 99th percentile values indicative of severe hypertension for systolic/diastolic pressure in these groups were 128/88, 135/88 and 149/89, respectively. Authors suggested that the 90th percentile of height and weight shown in the percentile table should be taken into consideration whenever blood pressure exceeds the 90th percentile for age and sex while planning the management of an individual.

Mohan et al. (2004) conducted the study to evaluate the prevalence of sustained hypertension and obesity in apparently healthy school children in rural and urban areas of Ludhiana, India, using standard criteria. A total of 2467 apparently healthy adolescent school children aged between 11 to 17 years from urban area and 859 students from rural area were taken as subjects. Out of total 3326 students, 189 were found to have sustained hypertension. In urban areas, the prevalence of sustained hypertension was 6.69% (n=165) and in rural area it was 2.56% (n=24). Males outnumbered females in both rural and urban areas. The mean systolic and diastolic blood pressure of hypertensive population in both urban and rural population was significantly higher than systolic and diastolic blood pressure in their normotensive counterparts (urban normotensive systolic blood pressure:115.48±22.74 mmHg, urban hypertensive systolic blood pressure:137.59±11.91 mmHg, rural normotensive systolic blood pressure: 106.31±19.86 mmHg, rural hypertensive systolic blood pressure: 131.63±10.13 mmHg, urban normotensive diastolic blood pressure: 74.18±17.41 mmHg, urban hypertensive diastolic blood pressure: 84.58±8.14 mmHg, rural normotensive diastolic blood pressure: 68.84±16.96 mmHg, rural hypertensive diastolic blood pressure: 79.15±7.41 mmHg. Overweight population was significantly higher in
urban area. There were 287 (11.63%) overweight students and 58 (2.35%) obese. In rural population overweight and obese students were 44 (4.7%) and 34 (3.63%), respectively. There was significant increase in prevalence of hypertension in both rural and urban population with increased body mass index in urban students; those with normal body mass index had 4.52% (n=96) prevalence of hypertension, in overweight it was 15.33% (n=44) and in obese it was 43.10% (n=25). In rural area, the overweight students showed prevalence of sustained hypertension in 6.82% (n=3) and 61.76% (n=21) in obese group. None of the students with normal body mass index in rural area was found to be hypertensive. The mean body mass index of hypertensive population in both rural and urban areas was significantly higher than respective normotensive population (mean body mass index in urban normotensive group: 20.34±3.72 kg/m², hypertensive group: 24.91±4.92 kg/m²; mean body mass index in rural normotensive group: 18.41±3.41 kg/m², hypertensive group: 21.37±3.71 kg/m², p<0.01). The authors concluded that the prevalence of sustained hypertension was on the rise in urban area even in younger age groups. Blood pressure was frequently elevated in obese children as compared to lean subjects. This was possibly related to their sedentary lifestyle, altered eating habits, increased fat content of diet and decreased physical activities.

Watkins et al. (2004) examined secular trends in blood pressure over a 10 year period between two representative cohorts of adolescents from Northern Ireland. A total of 1015 adolescents, aged 12 to 15 years were studied between 1989 and 1990 and 2017 adolescents of same age group were studied between 1999 and 2001. The four groups for sex and age showed decreases in both systolic blood pressure (mean decrease 7.7 mmHg to 10.0 mmHg) and diastolic blood pressure (8.8 mmHg to 11.0 mmHg). This was not accounted for by adjustment for potential confounders including age, height, body mass index, smoking, physical activity, aerobic fitness, and stratification of school by education board area and type. The findings were not altered by additional adjustment for social class, pubertal status, birth weight and infant feeding. No evidence was found of systematic variation between observers.

through a survey conducted in 10 secondary schools in the Pitka Ranta area. All ninth grade students (15 years old) in 1995 and in 2004 were included in the survey samples. Systolic blood pressure decreased statistically significantly among boys (from 119 to 116 mmHg). Diastolic blood pressure decreased statistically significantly among both girls (from 64 to 59 mmHg) and boys (62 to 59 mmHg). Total cholesterol levels increased significantly only among girls (3.9 to 4.1 mmol/l). Body mass index did not exhibit any significant changes in both genders. There was significant doubling of daily smoking rate among girls from 7% to 15%.

Saha et al. (2008) conducted a community-based cross-sectional study on 1081 adolescents of aged 10 to 19 years to determine the prevalence of hypertension and variation of blood pressure in an urban slum of Chetla, Kolkata, India. The prevalence of hypertension was 2.9% and highest prevalence (5.6%) was observed in the age group of 18 to 19 years. The mean systolic and diastolic blood pressure was higher in males than females. Among males and females, average increase of mean systolic blood pressure was found to be 2.26 mmHg and 1.95 mmHg per year, respectively. The mean diastolic blood pressure increased by 1.55 mmHg and 1.42 mmHg per year, respectively. The age spurt of rise in mean systolic blood pressure in males was found at 10 to 11, 13 to 14, and 16 to 17 years age groups, whereas in females it was observed in 12 to 13, and 17 to 18 years age groups. The age spurt of rise in mean diastolic blood pressure in males was observed in the age group 16 to 17 years and in females it was noted in the age group 11 to 12 and 17 to 18 years.

Raj et al. (2009) carried out a study to determine blood pressure distribution in school children and to derive population specific reference values appropriate for age, gender and height status. Blood pressure and anthropometric data were collected from 20,263 students of 5 to 16 years age. Three readings of blood pressures of each child were taken by mercury sphygmomanometer and mean was taken for analysis. Blood pressure percentiles in relation to gender, age and height were estimated from a non-overweight population of 18,931 children using polynomial regression models. Children from study population had higher diastolic pressures for both sexes than international standard
across all age groups. For systolic blood pressure, girls showed higher values than the international standard while for boys, the difference appeared to be minimal.

Leung et al. (2011) determined the prevalence, risk factors for and patterns of hypertension in Chinese adolescents based on a territory-wide school based screening programme in Hong Kong. Cross-sectional anthropometric and blood pressure (BP) measurements and lifestyle information were obtained as part of a growth survey of students from randomly selected secondary schools. Those with blood pressure ≥95th centile were screened a second or third time. The independent effects of age, sex, body mass index, high waist circumference (≥85th centile), and sleep duration, family history of hypertension and frequency of exercise on hypertension were explored by multivariate analysis. Among the 6193 students screened, the prevalence of elevated blood pressure on the first, second and third screens were 9.54%, 2.77% and 1.44% respectively. Hypertension was more likely to be systolic. High waist circumference (≥85th centile) was independently associated with a higher risk of hypertension, while exercising twice or more per week was protective.

Freedman et al. (2012) examined whether the secular changes in BMI were accompanied by increases in blood pressure levels. A total of 24,092 examinations were conducted among 11,478 children and adolescents (aged 5 to 17 years) from 1974 to 1993 in the Bogalusa Heart Study (Louisiana). The prevalence of obesity increased from 6% to 17% during this period. In contrast, only small changes were observed in levels of systolic blood pressure (SBP) and diastolic blood pressure (DBP) and neither mean, nor high levels increased over the 20 year period. Within each race–gender group, mean levels of SBP did not change, whereas mean levels of DBP decreased by 2 mmHg (P <0.001 for trend). Levels of BMI were positively associated with levels of SBP and DBP within each of the 7 examinations, and controlling for BMI (along with other covariates) indicated that only ~60% as many children as expected had high levels of blood pressure in 1993.

Kumar et al. (2012) studied the prevalence of hypertension and its determinants among adolescents in rural areas of Wardha. A total 1055 adolescents’ were selected by simple random sampling method. Among sampled adolescents, 990 were interviewed and
examined. The prevalence of hypertension and pre-hypertension was found to be 3.4% and 10.6%, respectively. Bivariate analysis showed significant association (p<0.05) of hypertension and prehypertension with age, education, occupation, type of family, use of smokeless tobacco, amount of salt consumption, nutritional status, education level of mother and blood pressure level of mother and father. On multivariate analysis, the final model by ordinal logistic regression showed significant association of hypertension/prehypertension of adolescents with age, type of family, BMI of adolescent and blood pressure of mother and father.

Sundar et al. (2013) studied the prevalence and determinants of hypertension among urban school children in the age group of 13 to 17 years in Chennai, Tamilnadu. A cross-sectional survey was done among 400 adolescent students including government and private schools in the age group of 13 to 17 years in Chennai. Socio demographic details, food habits, physical activity, anthropometric measurements and family history of hypertension were obtained. The prevalence of adolescent hypertension was 21.5%. MANOVA showed there was significant (p<0.05) effect on gender, class of study, body mass index, waist to hip ratio. Chi-square showed significant association for same variables including parent history of hypertension. The major determinants were found to be increased body mass index and decreased physical activity.

2.2. Risk Factors Associated with Hypertension among Adolescents

2.2.1. Non-modifiable Risk Factors

2.2.1.1. Age and gender: Sorof et al. (2004) carried out a study to describe the current prevalence of pediatric hypertension and the relationships between gender, ethnicity, overweight and blood pressure. School-based screening was performed in 5102 children (13.5±1.7 years) from May through November 2002. Age, gender, ethnicity, weight and height were ascertained and body mass index (BMI) was calculated as weight (kg)/height (m²). Overweight was defined as BMI > or =95th percentile. Students with blood pressure >95th percentile on the first screening underwent a second screening 1 to 2 weeks later, and then a third screening, if blood pressure was >95th percentile at the
second screening. Ethnicity distribution was 44% white, 25% Hispanic, 22% African Americans and 7% Asian. Overall, overweight prevalence was 20%, which varied significantly by ethnicity (31% Hispanic, 20% African American, 15% white, and 11% Asian). The prevalence of elevated blood pressure after first, second and third screenings was 19.4%, 9.5%, and 4.5%, respectively. Elevated blood pressure on first screening was highest among Hispanics (25%) and lowest among Asians (14%). Ethnic differences in the prevalence of hypertension (elevated blood pressure on 3 screenings) were not significant after controlling for overweight. The prevalence of hypertension increased progressively as the BMI percentile increased. After adjustment for gender, ethnicity, overweight, and age, the relative risk of hypertension was significant for gender and overweight.

Soudarssanane et al. (2006) assessed the prevalence of hypertension and the risk factors involved among adolescents through a cross-sectional study carried out including 673 adolescents (351 males, 322 females) in the 15 to 19 years age group from Kuruchikuppam, Pondicherry. Mean SBP and mean DBP were 113.6 and 74.3 mmHg, respectively (114.1 mmHg and 74.6 mmHg in males; 113.1 mmHg and 74.1 mmHg in females). Mean blood pressure (MBP) showed significant correlation with age. MBP and prevalence of hypertension increased with social class, salt intake, parental history of hypertension, weight, height and BMI. Of these, BMI and higher salt intake emerged as independent predictors by multivariate analysis.

Nichols and Cadogan, (2012) determined the effect of growth pattern on blood pressure changes in an adolescent population of African ancestry based on longitudinal data and compared this with estimates derived from cross-sectional data. Participants were measured for weight, height, blood pressure and percentage body fat taken annually using standardized procedures. Annual blood pressure and anthropometry velocities as well as one and three year interval gender specific tracking coefficients were computed. They investigated whether changes in blood pressure could be explained by measures of growth using a multilevel mixed regression approach. The results showed that systolic blood pressure (SBP) increased by 1.27 and 3.09 mmHg per year among females and males, respectively. Similarly, diastolic blood pressure (DBP) increased by 1.16 and
1.92 mmHg per year among females and males, respectively. Multilevel analyses suggested that weight, body mass index, percentage body fat and height were the strongest anthropometric determinants of blood pressure change in this population. The results also suggest that there are gender differences in the relative importance of these anthropometric measures with height playing a minor role in predicting blood pressure changes among adolescent females. With the exception of DBP at 18 years among females, there were no significant differences between mean blood pressure generated from cross-sectional and longitudinal data by age in both males and females. Anthropometric measures are important covariates of age related blood pressure changes and cross-sectional data may provide a more cost-effective and useful proxy for generating age related blood pressure estimates in this population.

2.2.1.2. Ethnicity: According to Bhopal et al. (2002), ethnicity means group of a person belong to a result of mix of culture factors including language, diet, religion and ancestry. There is considerable variation in cardiovascular disease distribution between different ethnic groups especially between traditional and non-traditional societies. This variation of CVD may be due to socio-cultural factors rather than genetic background (Dressler, 1999; Jafar et al., 2003; Kuller, 2004; Dwivedi and Beevers, 2009; Fernandes et al., 2011).

Bhopal et al. (2002) studied the ethnic and socio-economic coronary heart diseases (CHD), diabetes and risk factors in Europeans and South Asian population. The authors concluded that the inequality pattern of CHD, diabetes and risk factors in Europeans was being established in South Asian men and women at different pace in different subgroups. They further suggested that future studies of inequalities should be large and studied in separate populations, such as Indian, Pakistani and Bangladeshi, to track changes over time.

Chaturvedi (2003) studied the ethnic differences in cardiovascular diseases (CVD) between South Asians (mostly from Indian origins), Europeans and Caribbeans. He found that South Asians have increased risk of heart diseases as compared to Europeans and Caribbean’s have low risk of heart diseases as compared to Europeans. He
concluded from his study that these differences are due to increased level of insulin resistance and associated factors such as inflation and endothelial dysfunction, adaptation to western lifestyle and dietary factors like consumption of ghee (unsaturated fats) and raised level of trans fatty acid and lower level of linoleic and linolenic acids in adipose tissue, all of which adversely effect of the risk of CVD.

Sidhu et al. (2005) conducted the study on 2000 adult Punjabi females, from the residential areas of Amritsar, Hoshiarpur, Ludhiana and Pathankot cities of Punjab in India. The information regarding age, occupation, income, education, caste and family history was collected and blood pressure was measured and found that hypertension was maximum in Bania followed by Arora, Jat Sikh and then Sikh Harijan females, respectively. The difference between the four caste groups was statistically significant ($\chi^2 = 34.3$, df = 3, $P<0.01$). The reason for Bania females having higher prevalence of hypertension was higher socio-economic status of this group, sedentary life style, increased level of stress, changes in dietary practices and heredity factors as compared to other groups. Sikh Harijan females have minimum hypertension because they involved in manual labour (physical activity) and less obesogenic diet. The Jat Sikh and Sikh Harijan females both have great physical activity but the hypertension has higher prevalence in Jat Sikh population because of good diet supplements to the Jat Sikh females. Thus, they concluded that the health of Punjabi population has been severely affected by socio-economic and demographic developments.

Holland et al. (2011) studied the prevalence of coronary heart disease (CHD), stroke and peripheral vascular disease (PVD) across Asian-American subgroups (Asian Indian, Chinese, Filipino, Japanese, Korean and Vietnamese) and non-Hispanic white subjects and found that there was a considerable heterogeneity across the Asian subgroups for the prevalence of CHD, stroke and PVD based on the odds ratio. It was found to be higher in Filipino women and men and Asian Indian men and significantly lower among Chinese men and women, when compared with non-Hispanic whites.

2.2.1.3. Genetics and family history: Badaruddoza and Afzal (1999) examined the genetic and inbreeding influences on systolic blood pressure (SBP), diastolic blood pressure (DBP) and mean arterial blood pressure (MBP) among 3015 children (1527
males and 1488 females) from the Aligarh district, Uttar Pradesh in north India. The subjects included offspring of first cousins, first cousins once removed, second cousins and unrelated spouses from the same population. The measurements of the inbred children were compared with those of their non-inbred relatives in at least 80% of the cases (matched controls). Consistent increase in mean values of SBP, DBP and MBP with increasing inbreeding coefficients was observed among all age groups, including both the sexes. The results suggested that the hypothesis for a recessive gene or genes could be held responsible for higher BP. The effects of inbreeding on mean blood pressure among children and adults may not necessarily be in the same direction.

Reis et al. (2006) studied the cardiovascular disease risk in a cohort of children and their parents. Eligible families, consisting of ≥1 child and ≥1 biological parent, were recruited through community and faith based educational and screening programs. In a single, fasted study visit, participants underwent for the assessment of cardiovascular disease risk factors: obesity, hypertension, dyslipidemia, and metabolic syndrome. Associations of cardiovascular disease risk factors between children and their parents were assessed. Data were analyzed from 94 families: 108 parents (mean age: 38.5 ± 7.5 years), 141 children (mean age: 10.5 ± 3.4 years), and 170 child-parent pairs. Child-parent association was strong for many risk factors: BMI, waist circumference, systolic blood pressure, triglycerides and total cholesterol. Several discrete-defined risk factors in children were found to be significant predictors of the presence of the same risk factors in their parents. Parents of children with hypertension, obesity, or hypertriglyceridemia had 15 times, 6 times, or 5 times increased odds, respectively, of having the same risk factors.

Khuschnir and Mendonca (2007) investigated the risk factors associated with essential arterial hypertension in adolescents. The study was a case-control, outpatients based study of adolescents, aged 11 to 19 years. Nutritional status was assessed by means of body mass index. Data were also obtained on waist circumference, height, family history of arterial hypertension, birth weight and pubertal development. The analysis was performed using unconditional logistic regression. The study investigated 91 cases and 182 controls. Body mass index was associated with hypertension. Height had a
positive association with hypertension only among the girls. There was no evidence of an association between pubertal development and birth weight with arterial hypertension in adolescence. In contrast, family history, particularly when both parents had hypertension, exhibited a robust association, both among the boys (OR: 13.32; 95% CI: 2.25-78.94), and the girls (OR: 11.35; 95% CI: 1.42-90.21). The authors concluded that overweight, obesity and family history of hypertension (father and mother with hypertension) were the principal risk factors for arterial hypertension in adolescents.

Badaruddoza and Kumar (2009) studied the cardiovascular risk factors and familial aggregation of blood pressure with respect to anthropometric variables in a scheduled caste population in Punjab. They studied a total of 1096 individuals, constituting 350 families, for blood pressure, pulse rate, pulse pressure and anthropometric variables. They estimated correlation among blood pressure phenotypes with other significant variables and stepwise multiple regression analysis was carried out for both offspring and parent generations. The hypothesis for common household effects was examined by Likelihood Ratio tests. Almost all anthropometric variables were found to be significant with blood pressure between both generations. The percent of variance for regression ($R^2$) was found to be higher for offspring generation than for parent generation. The data indicated strong familial aggregation of blood pressure and anthropometric measurements would be a useful tool for screening cardiovascular risk factors with the elevated blood pressure.

Kumar and Badaruddoza (2010) studied the related familial aggregation and heritability for cardiovascular risk factors in a family based study in Punjab. The study was conducted through house to house family study among three generations such as offspring, parents and grandparents in a scheduled caste community (Ramdasia) in Punjab. A total of 1400 individuals, constituting 380 families were surveyed for blood pressure, pulse rate, pulse pressure and anthropometric measurements to study familial aggregation and heritability for cardiovascular risk factors. The analysis represented a multivariate model which included each individual family data for estimation of familial correlation and heritability. The study showed that all the risk factors had positive familial correlation but magnitudes were different in various pairs of
combination. Correlations generally were higher among genetically close relatives such as brother-sisters or parent-offspring and are lower among spouses. The estimated heritabilities were 22% for systolic and 27% for diastolic blood pressure, 19% for BMI and 17% for WHR. The study concluded that these results indicate a strong familial aggregation of cardiovascular risk factors such as SBP and DBP in this population and also showed that this familial influence can be detected from anthropometric measurements and genetic closeness. Almost all anthropometric variables were found to be significant with blood pressures among three generations.

Badaruddoza and Kaur (2012) studied the related familial aggregation of blood pressure with respect to anthropometric variables among the Lobana (nomadic origin) population in Punjab, a North Indian state. The study was carried out on 505 individuals, constituting 116 families of three generations (offspring, parents and grandparents). The study represented a multivariate model analysis, which included family data with respect to blood pressure phenotypes and other metric measurements such as height, weight, body mass index, waist and hip circumferences, waist-to-hip ratio (WHR), and four skinfold measurements. A higher correlation for almost all sets of anthropometric variables with blood pressure was found among the offspring generation as compared with the parental and grandparental generations. The study confirmed that the familial aggregation of blood pressure with respect to anthropometric measurements was strong in the offspring generation. The findings suggested that sharing a household environment had a significant effect on familial aggregation especially for systolic blood pressure.

Mane et al. (2012) evaluated the incidence of obesity, hypertension and under nutrition in adolescents of Pimpri-Chinchwad Corporation area near Pune, Maharashtra, India. It was a prospective cohort study based on teenage screening questionnaire and clinical examination. Total 200 adolescents including 100 boys and 100 girls of aged 15 to 18 years were included in the study. General demographic data was collected along with family history and dietary information like intake of fast food, bakery items was taken. General examination, blood pressure, anthropometric measurements were taken by using standard techniques. Health Risk Score and Body Mass Index (BMI) were
calculated. Increasing BMI contributed to increase in systolic BP (p<0.000) and DBP (p<0.000). Stress appeared to be significantly correlated to BMI (P<0.023) and SBP (p<0.009). Genetics risk factors are having significant correlation with BMI (p<0.001). Family history of hypertension had a positive correlation with SBP (0.045). Diastolic BP, however, was not significantly affected by family history. Family history of obesity has significant correlation with DBP (p<0.007). Sedentary habits significantly affected DBP (p<0.009). SBP was showing significant gender difference (p<0.041).

2.2.2. Modifiable Risk Factors

2.2.2.1. Obesity: The strong association between BMI and systolic blood pressure among children and adolescents has been widely reported in the literature available (Hara et al., 2002; Adair and Cole, 2003, Graf et al., 2005; Kim et al., 2006; Beck et al., 2011; May et al., 2012; Zhang et al., 2012).

Maffeis et al. (2001) undertook a cross-sectional study to explore the relationship between anthropometric variables, lipid concentrations and blood pressure (BP) in a sample of 818 pre-pubertal children (aged 3 to 11 years) and to assess the clinical relevance of waist circumference in identifying pre-pubertal children with higher cardiovascular risk. Height, weight, triceps and subscapular skinfolds, waist circumference and BP were measured. Plasma levels for triacylglycerol, total cholesterol, high-density lipoprotein (HDL) cholesterol, low-density lipoprotein cholesterol, apolipoprotein A1 (ApoA1) and apolipoprotein B (ApoB) were determined. Females were fatter than males. Males had higher HDL cholesterol and ApoA1/ApoB plasma concentrations than females (p<0.001 and p<0.01, respectively). Waist circumference had a higher correlation with systolic and diastolic BP (r=0.40 and 0.29, respectively; p<0.001) than triceps (r=0.35 and 0.21, respectively; p<0.001) and subscapular (r=0.28 and 0.16, respectively; p<0.001) skinfolds and relative body weight (0.33 and 0.23, respectively; p<0.001). Multivariate linear model analysis showed that ApoA1/ApoB, HDL cholesterol, total cholesterol/HDL cholesterol and systolic as well as diastolic BP were significantly associated with waist circumference and triceps and subscapular skinfolds, independently of age, gender, and body mass index.
Hara et al. (2002) determined the best predictor of cardiovascular disease risk factors among anthropometric indices such as body mass index (BMI), percent body fat (%Fat), waist-to-hip ratio (WHR), waist circumference and waist-to-height ratio (WHtR) in Japanese schoolchildren. This study included 880 children (447 boys and 433 girls), aged 9 to 13 years. Dependent variables were total cholesterol (TC), triglycerides (TG), high-density lipoprotein cholesterol (HDLC), low-density lipoprotein cholesterol (LDLC), atherogenic index (AI), lifestyle related disease prevention score and systolic (SBP) and diastolic (DBP) blood pressure. The strongest correlation was found between WHtR and the score by Pearson's correlation analysis. Multiple regression analysis showed that significant independent correlates for the score included WHtR and %Fat. Among the anthropometric indices, WHtR was the most significant predictor for TC, TG, LDLC, AI and the score. They concluded that WHtR was the best predictor of cardiovascular risk factors in Japanese schoolchildren.

Adair and Cole (2003) used data from 2026 Filipino adolescents to identify periods of growth that matter more for risk of high blood pressure (BP). Subjects were drawn from the Cebu Longitudinal Health and Nutrition Survey, which enrolled pregnant women and followed up their offspring through age 14 to 16 years. After controlling for birth length, current body mass index, age, and height, the odds of high BP in males were significantly decreased with each kilogram increase in birth weight. The highest odds of elevated BP occurred among males who were relatively thin at birth, but, relatively heavy as adolescents. Larger weight increments from birth to 2 years decreased the odds of high BP in boys, whereas larger increments from 8 to 11 and 11 to 16 years increased the odds of high BP. Thinness at birth significantly interacted with growth rate after age 8, such that a high rate of weight gain increased risk only among boys who were in the lower two thirds of the body mass index distribution at birth. Results in girls indicated small or no effects of early growth. The synergistic effect on adolescent BP of rapid weight gain from late childhood into adolescence with thinness at birth further evidenced of fetal programming of BP in males and suggested long term health risks associated with rapid growth, even in the absence of obesity.
Vlajinac et al. (2003) studied the blood pressure and some anthropometric characteristics in children. The study comprised 1651 subjects (809 boys and 842 girls) aged 7 to 14 years, that is, 2.6% of all relevant population. The average levels of systolic and diastolic blood pressures (SBP and DBP) were 113.4/70.3 mmHg in boys and 114.6/71.1 mmHg in girls. High SBP was present in 4.7% of boys and in 5.3% of girls. High DBP was found in 5.6% of boys and in 4.8% of girls. According to multivariate regression analysis, in boys SBP and DBP were significantly associated with age, body mass index (BMI) and subscapular skinfold, SBP was also associated with body weight, and DBP with triceps skinfold. In girls, SBP was significantly related to BMI, suprailiac skinfold and body height, and DBP was significantly associated with BMI, suprailiac and subscapular skinfolds. The results of the study supported the opinion that BMI was a significant predictor of blood pressure in children and pointed out to suprailiac skinfold in girls as a possible predictor of blood pressure.

Katzmarzyk et al. (2004) derived the optimal body mass index (BMI) and waist circumference thresholds for children and adolescents to predict risk factor clustering. A total of 2597 black and white children and adolescents, aged 5 to 18 years, who were examined between 1992 and 1994. The areas under the receiver operating characteristic curves were significantly different from 0.5 for both BMI and waist circumference for all gender/race groups, ranging from 0.73 to 0.82. The optimal BMI thresholds were at the 53rd and 50th percentiles for white and black male subjects, respectively and at the 57th and 51st percentiles for white and black female subjects, respectively. Similarly, the optimal waist circumference thresholds were at the 56th and 50th percentiles for white and black male subjects, respectively, and at the 57th and 52nd percentiles for white and black female subjects, respectively. The sensitivity and specificity at the thresholds were similar for all gender/race groups, ranging from 67% to 75%.

Graf et al. (2005) presented the baseline and final data to prevent overweight and obesity in primary schools. They recorded and calculated from 1689 children, anthropometric data including analyses of bioelectric impedance, waist and hip circumferences, body mass index and its standard deviation and the ratio of waist to hip. Blood pressure was measured after 5 minutes at rest. From the three schools involved in
a programme of intervention, 121 children were invited to take part, and 40 (33.1%) completed the programme. The effect was compared with 155 overweight and obese children identified at the 4 control schools. A total of 830 (49.5%) boys and 848 girls (50.5%) took part. Their mean age was 8.2±1.3 years, their height was 1.31±0.09 m, they weighed 30.0±8.2 kilograms, and their mean index of body mass was 17.1±2.9 Kg/m². Of the children, 7.3% were obese, 10.4% were overweight, 75.7% had normal weights and 6.6% were underweight. Resting hypertension was observed in 2.3% of the children. Increased blood pressure was associated with a higher body weight, body mass index, standard deviation score for body mass index, and waist and hip circumferences (each p<0.001), but not with the ratio of waist to hip. Hypertension at rest was also found in 11.0% of obese children, 4.4% of those who were overweight, 1.2% of those with normal weight and 1.0% of underweight children (p<0.001). After the intervention, the increase of the body mass index tended to be lower in those in whom it had intervened and in these the decrease of the standard deviation score for body mass index was significantly higher (p<0.028). Systolic blood pressure was reduced by about 10 mmHg in those in whom it had intervened (p<0.002), while there were no changes in the control group. Diastolic blood pressure was lowered by 3mmHg, but this was not significant. Thus, obese children had the highest values for systolic and diastolic blood pressure. Increased levels of blood pressure are associated with other parameters of obesity, such as the circumference of the waist and hip. Early preventive measurements in childhood are necessary, and appropriate intervention appears to be effective.

Kim et al. (2006) investigated the association between obesity and CVD risk factors among 2,272 Korean boys and girls aged 10 to 18 years, who participated in the Korean National Health and Nutrition Examination Survey in 1998 and 2001. Obesity was defined by body mass index cutoff points provided by the US Center for Disease Control and Prevention. The prevalence of obesity increased significantly from 5.4% in 1998 to 11.3% in 2001 (p<0.0001). Korean obese children and adolescents in 1998 and 2001 had 4.6 and 4.9 fold increased risks for systolic hypertension, 4.2 and 2.8 fold increased risks for high levels of total cholesterol, 9.4 and 2.7 increased fold risks for high levels of low density lipoprotein cholesterol, 4.1 and 3.7 fold increased risks for
low levels of high density lipoprotein cholesterol and 5.3 and 2.8 fold increased risks for high levels of triglycerides, compared with their normal-weight counterparts (p<0.05 in all). Approximately 60% of Korean obese children and adolescents had at least one CVD risk factor. Their findings suggested that Korean obese children and adolescents had an increased risk of CVD.

Urrutia-Rojas et al. (2006) determined the prevalence of high blood pressure and associated risk factors in school children 8 to 13 years of age. Elementary school children (n=1,066) were examined for the study. Associations between high blood pressure, body mass index (BMI), gender, ethnicity and acanthosis nigricans (AN) were investigated using a school based cross-sectional study. Blood pressure was measured and the 95th percentile was used to determine high blood pressure. Comparisons between children with and without high blood pressure were utilized. The crude and multiple logistic regression adjusted odds ratios were used as measures of association. Females, Hispanics, overweight children and children with AN had an increased likelihood of high blood pressure. Overweight children (BMI ≥ 85th percentile) and those with AN were at least twice as likely to present with high blood pressure after controlling for confounding factors. They concluded that 21% of school children had high blood pressure, especially the prevalence was higher among the overweight and Hispanic group. The association identified here can be used as independent markers for increased likelihood of high blood pressure in children.

Freedman et al. (2007) examined the relation of the BMI for age z-score and waist-to-height ratio to risk factors (lipids, fasting insulin and blood pressures). They also compared the abilities of these 2 indices to identify children with adverse risk factors. Children aged 5 to 17 years (n=2498) in the Bogalusa Heart Study were evaluated. As assessed by the ability of the 2 indices to account for the variability in each risk factor and correctly identify children with adverse values, the predictive abilities of the BMI for age z-score and waist-to-height ratio were similar. They found that waist-to-height ratio was slightly better (0.01–0.02 higher R² values, p<0.05) in predicting concentrations of total to HDL cholesterol ratio and LDL cholesterol, but BMI was slightly better in identifying children with high systolic blood pressure (0.03 higher R²,
p<0.05) in predicting measures of fasting insulin and systolic and diastolic blood pressures. On the basis of an overall index of the 6 risk factors, no difference was observed in the predictive abilities of BMI for age and waist-to-height ratio, with areas under the curves of 0.85 and 0.86 (p<0.30) and multiple R² values of 0.320 and 0.318 (p<0.79). They concluded that BMI-for-age and waist-to-height ratio did not differ in their abilities to identify children with adverse risk factors. Although waist-to-height ratio may be preferred because of its simplicity, additional longitudinal data were needed to examine its relation to disease.

Kelishadi et al. (2007a) assessed the anthropometric indices most closely correlated to cardiovascular disease (CVD) in a large nationally representative sample of children and adolescents to be used as a simple tool for identifying those at risk. A representative sample of 4811 school students (2248 boys and 2563 girls) aged 6 to 18 years, as part of the baseline survey of a National Surveillance System were recruited. Anthropometric indices and CVD risk factors were measured using standard protocols and their correlation was analyzed by using Receiver Operator Characteristic (ROC) curves and partial correlation. The most prevalent CVD risk factors were low HDL-C (28%), followed by hypertriglyceridemia (20.1%), and overweight (17%). The ROC analysis showed that among boys, all anthropometric indices had the same association with CVD risk factors in 6 to 9.9 years age group, while in the 10 to 13.9 and 14 to 18 years age groups, respectively. The waist circumference (WC) and body mass index (BMI) were the best in distinguishing CVD risk factors. Among girls, these indices were respectively BMI and waist to stature ratio (WSR); WC and WSR; and WC. In the partial correlation analysis, in boys, the highest coefficient was found for BMI; BMI and WC; and for WC and WSR; in girls, these indices were BMI; WC and WSR; and BMI, respectively. They concluded in their study that BMI, WC and WSR were the most appropriate in predicting CVD risk.

Raj et al. (2007) examined the time trends in childhood obesity in a representative sample of schoolchildren from Ernakulam District, Kerala and determined the relationship of obesity with blood pressure. Stratified random cluster sampling method
was used to select the children. Anthropometric data were collected from 24,842 students, 5 to 16 years of age, during 2003–04. Blood pressure and anthropometric data were collected from 20,263 students during 2005–06. Overweight and obesity were defined by body mass index for gender and age. Gender, age and height were considered for determining hypertension. The proportion of overweight children increased from 4.94% of the total students in 2003 to 6.57% in 2005 (OR: 1.36; 95% CI: 1.25–1.47; p<0.0001). The increase was significant in both boys and girls. The proportion of overweight children was significantly higher in urban regions and in private schools and the rising trend was limited to private schools. Systolic or diastolic incident hypertension was found in 17.34% of overweight children versus 10.1% of the remaining students (OR: 1.87; 95% CI: 1.60–2.17; p<0.0001). They concluded that childhood obesity showed an increasing trend in a short period of 2 years. Hypertension was common in overweight children. The authors suggested the need for greater public awareness and prevention programmes on childhood obesity and hypertension.

Rosa et al. (2007) evaluated the sensitivity and specificity of anthropometric measurements of body fat in a sample of Brazilian adolescents for the prediction of hypertension. The arterial blood pressure was measured on two visits in a sample of 456 students aged 12 to 17 years, from public and private schools of the Fonseca neighborhood, in Niterói, between 2003 and 2004. Subject was defined as hypertensive if he/she had systolic and diastolic pressures above the 95th percentile for sex, age and height. Body Mass Index (BMI) and waist circumference (WC) measurements were made. A statistically significant correlation was observed between hypertension and the cutoff points considered unfavorable, both for BMI and WC. The greatest association was with the cutoff point proposed for the Brazilian population. The BMI sensitivity used for American Black, White populations and for the Brazilian population, were found to be 52.4%, 57.1% and 52.4%, respectively. And BMI specificity was 69.3%, 70.0% and 80.88%, respectively. The sensitivity found in the sample, relative to the cutoff points for WC proposed for all American ethnic groups, was also low and specificity was a little higher. Existing American WC measurements showed low sensitivity and specificity for hypertension in our population. As to BMI, the available
cutoff points also showed a low level of sensitivity. The authors suggested a need to establish body fat cutoff points that can provide a better prediction of cardiovascular risk.

Nur et al. (2008) conducted a cross-sectional epidemiological study to investigate the prevalence of hypertension among high school students. The study cohort included 1,041 students of six high schools, who were selected from among 14,789 students of 26 high schools in Sivas province of Turkey, using the cluster-sampling method. A questionnaire was used for collecting information from students on age, gender, smoking and whether they or their families have any diseases. Blood pressure, height and weight of the participants were determined by the research group. Students whose systolic or diastolic blood pressures were higher than the 95th percentile were considered to be hypertensive patients. Hypertension was prevalent among 4.4% of the students. There was a significant correlation between prevalence of hypertension and body mass index. No significant correlation was found between prevalence of hypertension and other variables such as smoking, age, gender and family history of diabetes. The results suggested that hypertension was an important public health problem among high school students. The results also showed that the body mass index was an important parameter in hypertension in such a study group.

Zhu et al. (2008) carried out a study to evaluate comprehensively the cardiovascular phenotypes of cardiovascular disease free youths at risk of overweight, in comparison with healthy weight and overweight youths. Casual and ambulatory blood pressure measurements, non-invasive hemodynamic profiles, pulse wave velocity, left ventricular structure and function and overnight sodium excretion were examined in a cohort of US black and white youths (n=972; mean age: 17.6 ±3.3 years). At risk of overweight occurred at ~17% in either black youths or white youths. In white youths, there was a ~2-mmHg increase in casual systolic blood pressure for each increasing step in the 3 BMI categories (healthy weight, 109.5±0.5 mmHg; at risk of overweight, 111.5±0.6 mmHg; overweight, 113.5±1.1 mmHg). Ambulatory systolic blood pressure showed a similar increase with the increase in BMI. A blunted nocturnal decline in ambulatory diastolic blood pressure with the categorical BMI increase was observed in
black youths. In both racial groups, cardiac output and stroke volume were significantly enhanced sequentially from healthy weight to at risk of overweight to overweight. In black youths, both casual and ambulatory heart rate increased significantly with the increase in BMI. Moreover, there was a linear increase of left ventricular mass index from the healthy-weight group to the at risk of overweight group, with the overweight group having the highest value. In white youths, carotid-dorsalis pedis pulse wave velocity increased significantly as the BMI increased. Regardless of race, overnight sodium excretion showed a significant increase from healthy-weight subjects to overweight subjects, with at risk of overweight subjects having intermediate values.

Badaruddoza et al. (2009) studied the age specific relation of blood pressure with anthropometric variables among 19 to 24 years Punjabi female youth of Amritsar city. The study samples included a total of 800 Punjabi urban female youth. The results brought strong positive correlation of age and other anthropometric variables with blood pressures.

Badaruddoza et al. (2010) undertook cross-sectional study to assess the inter-relationship of blood pressures with BMI, WHR and subcutaneous fat among university going Punjabi Sikh and Hindu females. No significant differences of all the measured mean values of the traits have been found between these two groups. Further analysis of the data showed that BMI, WHR and skinfold measurements have significant (p<0.05) effect on blood pressure phenotypes. They concluded that BMI and WHR would be good predictors for the chronic diseases like hypertension.

Cobayashi et al. (2010) studied the association of cardiovascular risk factors in overweight and normal-weight adolescents of both genders aged from 14 to 19 years, attending public schools. Their data was case-control and included 163 overweight and 151 normal-weight adolescents. Multiple logistic regression analysis was used to evaluate the associations between overweight and cardiovascular risk factors (lipid profile, blood pressure and baseline insulin level). Overweight adolescents (body mass index > 85th percentile) presented a higher frequency of cardiovascular risk factors in comparison to the normal-weight group. The cardiovascular risk factors associated with
overweight were HDLc ≤35 mg/dl (OR: 3.41; CI: 1.24-9.38), triglycerides ≥150 mg/dl (OR: 3.04; CI: 1.01-9.13), abnormal baseline insulin levels >15 µU/ml (OR: 8.65; CI: 4.03-18.56) and abnormal blood pressure (OR: 3.69; CI: 1.76-7.72). Among overweight adolescents, 22.09% had more than three risk factors, whereas this percentage dropped to 6.12% among normal-weight adolescents. They suggested that overweight adolescents presented risk factors for cardiovascular diseases.

Abolfotouh et al. (2011) investigated the relationship between high blood pressure (HBP) and obesity in Egyptian adolescents. A cross-sectional study of 1500 adolescents (11 to 19 years) in Alexandria, Egypt, was conducted. Resting BP was measured and measurements were categorized using the 2004 fourth report on blood pressure screening recommendations. Additional measures included height, weight and waist and hip circumferences. Obesity was determined based on BMI, waist circumference (WC) and waist-to-hip ratio (WHR), and waist-to-height ratio (WHtR) indicators. Crude and adjusted odds ratios were used as measures of association between BP and obesity. Prevalence rates of prehypertension and hypertension were 5.7% and 4.0%, respectively. Obesity was seen in 34.6%, 16.1%, 4.5%, and 16.7% according to BMI, WHR, WC and WHtR, respectively. Adjusting for confounders, high blood pressure was significantly associated with overall obesity based on BMI (OR: 2.18; 95% CI: 1.38–3.44) and central obesity based on WC (OR: 3.14; 95% CI: 1.67–5.94). They concluded that both overall obesity and central obesity were significant predictors of high blood pressure in Egyptian adolescents.

Badaruddoza et al. (2011a) studied the principal component factor analysis of anthropometric, physiometric and metabolic risk traits associated with cardiovascular diseases in north Indian Punjabi individuals. The clustering of variables was evaluated by PCFA with varimax rotation on 616 individuals (350 males and 266 females). They derived 6 and 5 principal factors accounting for 87% and 84% of the total variance derived among males and females, respectively. Factor 1 was loaded with glucose and lipids for males, glucose and blood pressure for females. Factor 2 was loaded with obesity in males, glucose and lipids in females. Factor 3 was loaded with blood pressure
in males and obesity in females. This finding indicated the importance of PCFA to identify clusters of risk factors for chronic disease like CVD.

Badaruddoza et al. (2011b) studied the association of anthropometric and metabolic variables with cardiovascular disease among urban and rural Punjabi population. This cross-sectional study was carried out on a total of 400 urban and rural origin Punjabi males (200 each from urban and rural). The anthropometric, physiometric and metabolic assessments taken were through standard procedures. Statistical analysis included descriptive statistics, correlation, multivariate regression analysis and odds ratios. It was observed that males of rural population were at a higher risk to develop cardiovascular diseases compared to their urban counterparts. Rural males had significantly (p<0.001) higher mean values of cardiovascular risk factors with respect to BMI, weight, waist circumference, WHR, fasting glucose, total cholesterol, triglyceride, HDL and CHO-HDL ratio. SBP and DBP had positive association with waist-to-hip ratio, body mass index, waist circumference, skinfolds, pulse pressure, alcohol consumptions, food habit, HDL and triglyceride. They concluded that cardiovascular disease risk is found more in rural male Punjabi population due to consumption of more dairy products and leading of more sedentary lifestyle due to the over use of mechanized substances for agriculture and personal use.

Beck et al. (2011) carried out a cross-sectional study with a sample of 660 adolescents aged 14 to 19 including 51.9% girls. Body mass index (BMI), waist circumference, waist-to-height ratio and conicity index were considered. High blood pressure was characterized by values above the 90th percentile for systolic and/or diastolic blood pressure. To identify predictors of high blood pressure, they adopted the analysis of receiver operating characteristic curves (ROC) with a confidence interval of 95%. Subsequently, they identified the cutoff points with their relevant sensitivities and specificities. The areas under the ROC curves with confidence intervals were: boys - waist circumference (OR: 0.80; 95% CI: 0.72 to 0.89); BMI (OR: 0.79; 95% CI: 0.68 to 0.89), waist-to-height ratio (OR: 0.77; 95% CI: 0.66 to 0.88); conicity index (OR: 0.69; 95% CI: 0.56 to 0.81) and for girls - waist circumference (OR: 0.96; 95% CI: 0.92 to 1.00); BMI (OR: 0.95; 95% CI: 0.87 to 1.00), waist-to-height ratio (OR: 0.93; 95% CI: 0.87 to 1.00).
0.85 to 1.00); conicity index (OR: 0.74; 95% CI: 0.50 to 0.98). The different cutoff points of anthropometric indicators with better predictive power and their relevant sensitivities and specificities were identified. Although the waist-to-height ratio and BMI had shown good areas under the ROC curve, the authors suggested the use of waist circumference to predict high blood pressure.

Christofaro et al. (2011) investigated the association between general and abdominal obesity with high blood pressure and identified the sensitivity and specificity of these indicators to detect high blood pressure in adolescents. They recruited 1,021 adolescents aged 10-17 years. Subjects were classified as normal, overweight/obese, according to BMI measurements, and as non-obese and with abdominal obesity, according to waist circumference (WC) measurements. Systolic (SBP) and diastolic (DBP) blood pressure were assessed using an oscillometric device. Logistic regression and ROC curves were used in the statistical analysis. The overall prevalence of high blood pressure was 11.8% (13.4% in boys and 10.2% in girls). The prevalence of high blood pressure among general overweight/obese boys and girls was 10% and 11.1%, respectively. The prevalence of high blood pressure among boys with abdominal obesity was 28.6%. For both genders, the odds ratio (OR) for high blood pressure was higher in abdominal obesity than in general overweight/obesity (OR: 4.09; 95% CI: 2.57-6.51) versus (OR: 1.83; 95% CI: 1.83-4.30). The OR for high blood pressure was higher when general overweight/obesity and abdominal obesity were clustered (OR: 4.35; 95%CI: 2.68-7.05), when identified by either general overweight/obesity or abdominal obesity alone (OR: 1.32; 95% CI: 0.65-2.68). However, both types of obesity had low predictive power in high blood pressure detection.

Vasan et al. (2011) determined which anthropometric measurement correlates best with the metabolic abnormalities associated with the metabolic syndrome in adolescents and young adults. A total of 1359 adolescents and young adults aged 14 to 25 years were sampled from high schools and universities. The waist circumference (OR: 1.56; 95% CI: 1.0 to 2.43; p<0.01) and the abdominal skin fold thickness (OR: 1.44; 95% CI: 1.02 to 2.04, p<0.01) above the third quintile cut-offs were found to be significantly associated with metabolic abnormalities. The sensitivity of either one of these
measurements in predicting metabolic abnormalities was 66.1% with a negative predictive value of 82.8%. Hyperglycaemia was significantly associated with an abdominal skin fold thickness over the fourth quintile alone (OR: 1.63; 95% CI: 1.24 to 2.1). All the anthropometric measurements correlated well with elevated triglycerides and hypertension. They concluded that in a large community-based cross-sectional survey of subjects aged 14 to 25 years, the waist circumference and the abdominal skin fold thickness were important predictors of the metabolic abnormalities associated with metabolic syndrome.

Kaur et al. (2012) studied the cardiovascular risk factors among females of Brahmin and Jat Sikh population using principal component factor analysis (PCFA). It has been used for seventeen factors including anthropometric, physiometric, metabolic and glucose tolerance. A total of 428 females (199 Brahmin and 229 Jat Sikh) were recruited for the study. Blood samples from 100 (50 Brahmin and 50 Jat Sikh) out of total 428 individuals were obtained. PCFA reduced 16 risk factors to 7 uncorrelated components that explained maximum (87%) of the total variance among the females of both the groups. Factor 1 has high loading of the traits that reflected obesity related traits like body mass index (BMI), waist circumference (WC), hip circumference (HC) and waist to hip ratio (WHR) for both female populations and explained the largest portion of total variance (36% for Brahmin; 34% for Jat Sikh). Factor 2 is loaded predominantly with total cholesterol (TC), high density and low density lipoproteins (HDL & LDL), LDL-HDL ratio and TC-HDL ratio for Brahmin female population. Comparably factor 2 is loaded with SBP, DBP and pulse pressure (PP) among Jat Sikh female population. Therefore, factor 2 is identified as responsible for dyslipidemia for Brahmin and hypertension for Jat Sikh.

May et al. (2012) examined the recent trends in the prevalence of selected biological CVD risk factors and the prevalence of these risk factors by overweight/obesity status among US adolescents. The study sample included 3383 participants aged 12 to 19 years from the 1999 through 2008. Among the US adolescents aged 12 to 19 years, the overall prevalence was 14% for prehypertension/hypertension, 22% for borderline-high/high low-density lipoprotein cholesterol, 6% for low high-density lipoprotein
cholesterol (35 mg/dL), and 15% for prediabetes/diabetes during the survey period from 1999 to 2008. No significant change in the prevalence of prehypertension/hypertension (17% and 13%) and borderline-high/high low-density lipoprotein cholesterol (23% and 19%) was observed from 1999–2000 to 2007–2008, but the prevalence of prediabetes/diabetes increased from 9% to 23%. A consistent dose-response increase in the prevalence of each of these CVD risk factors was observed by weight categories. The estimated 37%, 49%, and 61% of the overweight, obese, and normal-weight adolescents, respectively, had at least one of these CVD risk factors during the 1999 through 2008 study period.

Zhang et al. (2012) carried out a study to identify the prevalence of elevated BP and risk factors among children aged 3 to 18 years from Beijing consisted of 20,780 children. They classified the data into three types of obesity including central obesity, peripheral obesity and combined obesity and the non-obese with combined use of Chinese body mass index and waist circumference criteria. A total of 1907 (9.2%) children (10.0% boys and 8.4% girls) with elevated BP were identified, and their main trait was high systolic BP levels, especially in boys. As the non-obese group reference, odds ratios (95%CI) of elevated BP were 3.00 (2.38~3.77), 4.22 (2.97~5.99) and 9.32 (8.21~10.58) in central obesity, peripheral obesity and combined obesity, respectively. Rural area, male, age, sexual maturation, and parental history of hypertension were also associated with elevated BP. The authors concluded that not only peripheral obesity but also central obesity defined by waist circumference is independently associated with elevated BP.

Burgos et al. (2013) analyzed the association between anthropometry measures and cardiovascular risk factors, investigated the determinants to changes in blood pressure (BP), and proposed a prediction equation to waist circumference (WC) in children and adolescents. They evaluated 1,950 children and adolescents, aged 7 to 18 years. Visceral fat was assessed by WC and waist-hip relationship, BP and body mass index (BMI). In a randomly selected subsample of these volunteers (n=578), total cholesterol, glucose and triglycerides levels were evaluated. They found that WC was positively correlated with BMI (r=0.85; p<0.001) and BP (SBP r=0.45 and DBP=0.37; p<0.001).
Glycaemia and triglycerides showed a weak correlation with WC ($r=0.110; p = 0.008$ and $r=0.201; p<0.001$, respectively). Total cholesterol did not correlate with any of the variables. Age, BMI and WC were significant predictors on the regression models for BP ($p<0.001$). They proposed a WC prediction equation for children and adolescents; boys: $y=17.243 + 0.316$ (height in cm); girls: $y=25.197 + 0.256$ (height in cm).

Brar and Badaruddoza (2013a) determined the better anthropometric predictor for detecting hypertension in North Indian Punjabi Adolescents. They carried out a cross-sectional study with a sample of 1225 (634 boys and 591 girls) adolescents aged 10 to 18 years. The study considered three anthropometric indicators such as body mass index (BMI), waist circumference and waist to height ratio (WHtR). Sensitivity, specificity, likelihood ratio and odds ratios analysis were used to identify better predictor for detecting hypertension. The sensitivities with confidence interval were in boys BMI: 0.754 (0.633-0.846); waist circumference: 0.766 (0.616-0.872); WHtR: 0.640 (0.520-0.745) and for girls BMI: 0.581 (0.422-0.726); waist circumference: 0.656 (0.468-0.808); WHtR: 0.621 (0.424-0.787). The odds ratios were in boys BMI: 4.26 (2.40-7.55); waist circumference: 4.35 (2.17-8.71); WHtR: 2.36 (1.43-3.89) and for girls BMI: 2.17 (1.15-4.06); waist circumference: 2.98 (1.41-6.32); WHtR: 2.52 (1.17-5.44). They suggested that the waist circumference is the better predictor to predict cardiovascular risk factors in adolescent boys as compared to girls.

Brar and Badaruddoza (2013b) studied the blood pressure with respect to some anthropometric characteristics among 1225 adolescents (634 boys and 591 girls) aged 10-18 years. The range of average blood pressure (systolic/diastolic) was 116.33-134.52/78.23-92.62 mmHg in boys and 117.71-128.75/77.97-88.85 mm Hg in girls of 10 to 18 years of age, respectively. They observed that 11 and 12 years of age groups were more susceptible for pre-hypertension (4.49% and 4.24%, respectively). Whereas, 10 years and 14 years age groups were more susceptible for hypertension (6.12% and 4.40%, respectively). According to multivariate regression analysis, systolic and diastolic blood pressure was significantly associated with weight, BMI and waist circumference. They suggested that BMI is a significant predictor of blood pressure in adolescent age groups.
2.2.2.2. Lifestyle risk factors

2.2.2.2.1. Diet: Falkner et al. (2000) determined if blood pressure (BP) level was associated with dietary micronutrients in adolescents at risk for hypertension. Diets were assessed among adolescents aged 14 to 16 years, with BP higher than the 90\textsuperscript{th} percentile on 2 separate measurements in a school setting. A 24-hour intake recall was obtained on 180 students (108 boys and 72 girls). Folic acid intake was used as an index of fruit, vegetable, and whole grain intake; the high folate group had a folate intake greater than the recommended daily allowance and the low folate group had a folate intake less than the recommended daily allowance. Data were analyzed by 2-way analysis of variance. Mean diastolic BP was significantly higher in the low folate vs the high folate group (boys: 72 vs 67 mmHg; girls: 76 vs 73 mmHg; P<0.008). The difference in systolic blood pressure was not significant. There was no difference in body mass index between the diet groups. Sodium intake per 4184 kJ was not different. The low folate group had significantly lower intakes per 4184 kJ of potassium (P<0.002), calcium (P<0.001), magnesium (P<0.001), and total intake of beta carotene, cholecalciferol, vitamin E and all B vitamins. They suggested the dietary benefits on BP observed on diets rich in a combination of nutrients derived from fruits, vegetables and low-fat dairy products could contribute to primary prevention of hypertension when instituted at an early age.

Gidding et al. (2006b) studied children participating in a dietary clinical trial to assess physical activity patterns in boys and girls longitudinally from late childhood through puberty and to determine the association of level of physical activity on systolic blood pressure, low-density lipoprotein cholesterol, and BMI. In the Dietary Intervention Study in Childhood, a randomized clinical trial of a reduced saturated fat and cholesterol diet in 8 to 10 year-olds with elevated low-density lipoprotein, a questionnaire that determined time spent in 5 intensity levels of physical activity was completed at baseline and at 1 and 3 years. An estimated-metabolic-equivalent score was calculated for weekly activity; hours per week were calculated for intense activities. They hypothesized that weekly self-reported physical activity would be
associated with lower systolic blood pressure, low-density lipoprotein, and BMI over 3 years. Longitudinal data analyses were performed for each outcome (systolic blood pressure, low-density lipoprotein and BMI) by using generalized estimating equations with estimated-metabolic-equivalent score per week as the independent variable adjusted for visit, gender, and Tanner stage (BMI was included in models for systolic blood pressure and low-density lipoprotein). The initial study cohort comprised 663 youths (362 boys and 301 girls), of whom 623 (94%) completed the 3-year visit. For every 100 estimated-metabolic-equivalent hours of physical activity, there was a decrease of 1.15 mmHg of systolic blood pressure. There was a 1.28 mg/dL decline in low-density lipoprotein for similar energy expenditure. For BMI, an analysis of intense physical activity showed that for every 10 hours of intense activity, there was a trend toward significance with a 0.2 kg/m² decrease. The authors concluded that children with elevated cholesterol levels who lead a more physically active lifestyle have lower systolic blood pressure and a trend toward lower low-density lipoprotein over a 3-year interval. Long-term participation in intense physical activity may reduce BMI as well.

Savitha et al. (2007) detected the prevalence of essential hypertension in early and mid adolescents and to identify various risk factors. They recorded blood pressure in 503 apparently normal school students in 10 to 16 years of age group as per standard guidelines. Detailed clinical examination was done in all cases. A detailed questionnaire was sent to parents. They found 6.16% of adolescents had high blood pressure at the end of fourth screening. Increased body mass index and reduced consumption of vegetables and fruits were found to be statistically significant risk factors for hypertension. They suggested that multiple blood pressure recordings were essential for accurate diagnosis of hypertension.

Amin et al. (2008) assessed the magnitude of obesity and overweight among male primary school children and tried to find the possible association between obesity/overweight and dietary habits and sociodemographic differentials among them. A cross-sectional descriptive study, including 1139 Saudi male children enrolled in the 5th and 6th grades in public primary schools in Al Hassa, Kingdom of Saudi Arabia (KSA), was conducted. The test included a multistage random sampling technique,
based on interview using Youth and Adolescent Food Frequency Questionnaire, gathered data regarding dietary intake, dietary habits, followed by anthropometric measurements with the calculation of body mass index (BMI), the interpretation of which was based on Cole's tables for the standard definition of overweight and obesity. Socio-demographic data were collected through a parental questionnaire form. The age of the school children ranged from 10 to 14 years. The prevalence of overweight among the subjects was 14.2%, while that of obesity was 9.7%; the prevalence was more in the urban, older age students. The mothers of obese and overweight children were less educated and more working. Missing and or infrequent intake of breakfast at home, frequent consumption of fast foods, low servings per day of fruits, vegetables, milk and dairy products, with frequent consumption of sweets/candy and carbonated drinks were all predictors of obesity and overweight among the schoolchildren studied.

He et al. (2008a,b) studied the relationship between salt intake and blood pressure in children and adolescents. They analysed the data of a large cross-sectional study (the National Diet and Nutrition Survey for Young People), which was carried out in Great Britain in 1997 in a nationally representative sample of children aged between 4 and 18 years. A total of 1658 participants having both salt intake and blood pressure were recorded. Salt intake was assessed by a 7-day dietary record. The average salt intake, which did not include salt added in cooking or at the table, was 4.7±0.2 g/day at the age of 4 years. With increasing age, there was an increase in salt intake and by the age of 18 years, salt intake was 6.8±0.2 g/day. There was a significant association of salt intake with systolic blood pressure as well as with pulse pressure after adjusting for age, sex, body mass index and dietary potassium intake. An increase of 1 g/day in salt intake was related to an increase of 0.4 mmHg in systolic and 0.6 mmHg in pulse pressure.

Zhao et al. (2011) reviewed the impact of dietary factors on BP and hypertension, to compare types and recommended intakes of dietary factors in hypertension management and prevention guidelines from different countries and organizations, and to outline global population-based healthy-diet strategies for hypertension control. Of the 27 dietary factors they evaluated on the basis of specified review criteria, 17 have been proposed to have protective effects against hypertension, six were proposed to be risk
factors for hypertension and the association between BP and the remaining factors were considered inconclusive. Excessive sodium intake was a causal risk factor for hypertension, whereas a diet rich in fruit, vegetables and low-fat dairy products, and low in sodium and saturated fat had been recommended to prevent and reduce hypertension on the basis of strong evidence. Notable differences existed in the recommended types and intakes of dietary factors among available hypertension management and prevention guidelines. Available evidence supported the vigorous implementation of dietary strategies against hypertension through population-based, national action plans.

2.2.2.2. Physical activity: Bouziotas et al. (2004) examined the association between CHD risk factors (HDL-C, LDL-C, HDL-C/TC, triglycerides, systolic and diastolic blood pressure) and lifestyle parameters (fitness, fatness, fat intake, and physical activity) in 210, 12 year old, Greek adolescents. Correcting for the fixed factors of gender and maturation, analyses of covariance (ANCOVA) with backward elimination of the lifestyle covariates revealed significant associations between three CHD risk factors (HDL-C, HDL-C/TC, systolic blood pressure) and physical activity levels. In contrast, the covariates aerobic fitness, fatness and fat intake failed to reach significance with any of the CHD risk factors.

Singh et al. (2006) studied to evaluate the prevalence of lifestyle associated risk factors for non-communicable diseases in apparently healthy school children in an urban school in New Delhi using standard criteria among 510 students of classes 9th to 12th in the age group of 12 to 18 years. The students were surveyed through an age appropriate modified GSHS (Global School Based Student Health Survey) self-administered questionnaire. Their study documented the inappropriate dietary practices (fast food consumption, low fruit consumption), low physical activity, higher level of experimentation with alcohol and to a lesser extent smoking, high prevalence of obesity and hypertension in the school children. The study also showed an association between BMI, systolic and diastolic blood pressures amongst children and other lifestyle factors. They suggested that school based interventions were required to reduce the morbidity associated with non-communicable diseases.
Kelishadi et al. (2007b) determined the association of physical activity and the metabolic syndrome in a large national-representative sample of children. The study was performed on 4,811 school students aged 6 to 18 years, selected by multi-stage random cluster sampling from six provinces in Iran. They assessed the level of physical activity using a standardized questionnaire, and categorized it to the tertiles. The metabolic syndrome was defined based on criteria analogous to those of the Adult Treatment Panel III. The participants comprised 2,248 boys and 2,563 girls with a mean age of 12.07±3.2 years. In all age groups, boys were more physically active than girls. The metabolic syndrome was detected in 14.1% of participants, and its prevalence was higher in those subjects in the 1st, 2nd and 3rd tertiles of physical activity, respectively (15.1 vs.14.2 and 13.1%, respectively, p<0.05). This difference was seen in boys, while no difference was found between girls in the 2nd and 3rd tertiles of physical activity. Physical activity was linked to a cluster of factors consisting of high-density lipoprotein-cholesterol and waist circumference, followed by triglycerides in boys and of triglycerides, waist circumference and blood pressure in girls. In both genders, before and after adjustment for age and body mass index, low levels of physical activity significantly increased the risk of having the metabolic syndrome (in boys: OR: 1.8; 95% CI: 1.1-2.1; and in girls, OR: 1.6; 95% CI: 1.1-1.9).

Leary et al. (2008) recruited children aged 11 to 12 years from the Avon Longitudinal Study of Parents and Children. 5505 had systolic and diastolic BP measurements, plus valid (at least 10 hours for at least 3 days) accelerometer measures of physical activity; total physical activity recorded as average counts per minute (cpm) over the period of valid recording, and minutes per day spent in moderate to vigorous physical activity (MVPA). Data on a number of possible confounders were also available. Small inverse associations were observed; for systolic BP, beta=-0.44 (95% CI: -0.59 to -0.28) mmHg per 100 cpm, and beta=-0.66 (95% CI: -0.92 to -0.39) mmHg per 15 minutes/d MVPA, adjusting for child's age and gender. After adjustment for potential confounders, associations were weakened but remained. When physical activity variables were modeled together, associations with total physical activity were only a little weaker, whereas those with MVPA were substantially reduced; for systolic BP, beta=-0.42
(95% CI: -0.71 to -0.13) mmHg per 100 cpm, and beta=-0.03 (95% CI: -0.54 to 0.48) mmHg per 15 minutes/d MVPA. In conclusion, higher levels of physical activity were associated with lower BP and results suggested that the volume of activity may be more important than the intensity.

Sarrafzadegan et al. (2009) assessed the effects of a comprehensive, integrated community-based lifestyle intervention on diet, physical activity and smoking in two Iranian communities. Within the framework of the Isfahan Healthy Heart Program, a community trial was conducted in two intervention counties (Isfahan and Najaf-Abad) and a control area (Arak). Lifestyle interventions targeted the urban and rural populations in the intervention counties but were not implemented in Arak. In each community, a random sample of adults was selected yearly by multi-stage cluster sampling. Food consumption, physical exercise and smoking behaviours were quantified and scored as 1 (low-risk) or 0 (other) at baseline (year 2000) and annually for 4 years in the intervention areas and for 3 years in the control area. The scores for all behaviours were then added to derive an overall lifestyle score. After 4 years, changes from baseline in mean dietary score differed significantly between the intervention and control areas (+2.1 points versus −1.2 points, respectively; *P*<0.01), as did the change in the percentage of individuals following a healthy diet (+14.9% versus −2.0%, respectively; *P*<0.001). Daily smoking had decreased by 0.9% in the intervention areas and by 2.6% in the control area at the end of the third year, but the difference was not significant. Analysis by gender revealed a significant decreasing trend in smoking among men (*P*<0.05) but not among women. Energy expenditure for total daily physical activities showed a decreasing trend in all areas, but the mean drop from baseline was significantly smaller in the intervention areas than in the control area (−68 metabolic equivalent task (MET) minutes per week versus −114 MET minutes per week, respectively; *P*<0.05). Leisure time devoted to physical activities showed an increasing trend in all areas. A significantly different change from baseline was found between the intervention areas and the control area in mean lifestyle score, even after controlling for age, sex and baseline values.
De Moraes et al. (2013) examined the independent and combined association of physical activity and sedentary behavior on both systolic (SBP) and diastolic blood pressure (DBP) in adolescents from two observational studies. Participants from two cross-sectional studies, one conducted in Europe (n = 3,308) and the other in Brazil (n = 991), were selected by complex sampling. Performing the recommended amount of physical activity attenuated the effect of sedentary behavior on DBP in BRACAH study girls and in boys from both studies. In contrast, physical activity did not attenuate the effects of sedentary behavior on the SBP of girls in the HELENA study. The combination of less than recommended levels of physical activity with 2–4 hour/d of sedentary behavior was found to be associated with increased SBP in boys from both studies. They concluded that meeting their physical activity recommendations could mediate the association between sedentary behavior and DBP in both sexes. In boys, the joint effect of low levels of physical activity and excessive sedentary activity increased SBP levels.

Zhang et al. (2013) examined the difference in body shape and physical activity between adolescents with normotensive and elevated blood pressure in Shandong, China. They carried out a large cross-sectional survey of 28,039 school students (14,084 boys and 13,955 girls) aged 10 to 17 years. Height, weight, waist circumference (WC), BP, triceps and subscapular skinfolds of all subjects were measured and the sum of triceps and subscapular skinfold thickness was applied. Body mass index (BMI) of adolescents was calculated from their height and weight and the prevalence of overweight and obesity were obtained according to the International Obesity Task Force (IOTF) cut-offs. The mean values of BMI, WC and SFT for both boys and girls were all significantly higher in the elevated BP group than in the normal BP group in all age categories (p<0.01). More adolescents with elevated BP were overweight or obese compared with normal BP subjects. Significant differences in physical activity were observed between the elevated and normal BP group, adolescents with elevated BP had poor physical activity attitudes and behaviours compared with normal BP subjects. Adolescents with elevated BP had high levels of BMI, WC, SFT and poor physical activity attitudes and behaviors.
2.2.2.3. Screen time: Watching TV contributes heavily to the obesity as it leads to increased sedentary lifestyle and displacement of more physical pursuits. In addition, it results in unhealthy eating practices learned from both the programming and the advertisements for unhealthy foods, increased snacking behavior while viewing and interference with normal sleep patterns (AAP, 2011). Many longitudinal and correlational studies have been carried out worldwide to detect the association between cardiovascular risk diseases and screen time (Jordan, 2007; Dennison and Edmunds, 2008; Singh et al., 2008; Strasburger et al., 2009).

Martinez-Gomez et al. (2010) examined the independent associations between TV viewing and CVD risk factors in adolescents. They recruited 425 adolescents, aged 13- to 18.5-year-old and determined their body mass index (BMI), waist circumference (WC), glucose, total cholesterol, triglycerides, HDL-cholesterol, LDL-cholesterol, apolipoprotein (apo) A-1, apo B-100 and lipoprotein(a) levels. The CVD risk score was computed based on age, sex, sexual maturation and race standardized triglycerides, HDL-cholesterol, LDL-cholesterol and glucose. TV viewing was self-reported. They found 225 adolescents (53%) who spent >3 hrs/day watching TV were considered as the "high TV viewing" group. Ninety-nine adolescents (23%) from the total sample were classified as overweight according to International age and sex specific BMI values. The high TV viewing group had significantly less favorable values of HDL-cholesterol, glucose, apo A1 and CVD score, independent of age, sex, sexual maturation, race and weight status. There was a significant interaction effect of TV viewing versus weight status (P<0.002) on WC, and the negative influence of TV viewing on WC persisted in the overweight group (P<0.031) but was attenuated in non-overweight adolescents (P<0.05). They concluded that excessive TV viewing seems to be related to an unfavorable CVD risk factors profile in adolescence and thus reducing TV viewing in overweight adolescents might be beneficial to decrease abdominal body fat.

Altenburg et al. (2012) included baseline data of 125 Dutch overweight and obese adolescents (12 to 18 years). Self-reported screen time (Activity Questionnaire for Adolescents and Adults) and clustered and individual cardio-metabolic risk (i.e. body composition, systolic and diastolic blood pressure, low-density (LDL-C), high-density
(HDL-C) and total cholesterol (TC), triglycerides, glucose and insulin) were assessed in all participants. Multiple linear regression analyses were used to assess the association between screen time and cardio-metabolic risk, adjusting for age, gender, pubertal stage, ethnicity and moderate-to-vigorous physical activity. They found no significant relationship between self-reported total screen time and clustered cardio-metabolic risk or individual risk factors in overweight and obese adolescents. Unexpectedly, self-reported computer time, but not TV time, was slightly but significantly inversely associated with TC and LDL-C.

Bauer et al. (2012) examined the adolescent girls' participation in a variety of recreational sedentary behaviors (e.g., talking on the phone and hanging around), and their association with physical activity, dietary behaviors and body mass index. Data were collected from a sample of 283 adolescent girls. Recreational sedentary behavior, physical activity and dietary behaviors were self-reported and girls' height and weight were measured. Over 95% of girls were found to be engaged in at least one recreational sedentary behavior during the recall period. Watching television and hanging around were the most common behaviors. Watching television, using the internet, and hanging around were associated with less physical activity; watching television, hanging around, and talking on the phone were associated with less healthful dietary behaviors. No associations were found with body mass index.

2.2.2.2.4. Sleeping time: Javaheri et al. (2008) assessed that whether insufficient sleep was associated with pre-hypertension in healthy adolescents. A cross-sectional analysis of 238 adolescents, all without sleep apnea or severe comorbidities was recruited for the study. Participants underwent multiple-day wrist actigraphy at home to provide objective estimates of sleep patterns. In a clinical research facility, overnight polysomnography, anthropometry and 9 blood pressure measurements over 2 days were made. Exposures were actigraphy-defined low weekday sleep efficiency, an objective measure of sleep quality (low sleep efficiency <85%), and short sleep duration (<6.5 hours). The main outcome was pre-hypertension (>90th percentile for age, sex, and height), with systolic and diastolic blood pressures as continuous measures as secondary outcomes. Pre-hypertension, low sleep efficiency and short sleep duration occurred in
14%, 26%, and 11% of the sample, respectively. In unadjusted analyses, the odds of pre-hypertension increased 4.5-fold (95% CI: 2.1 to 9.7) in adolescents with low sleep efficiency and 2.8-fold (95% CI: 1.1 to 7.3) in those with short sleep. In analyses adjusted for sex, body mass index percentile, and socioeconomic status, the odds of pre-hypertension increased 3.5-fold (95% CI: 1.5 to 8.0) for low sleep efficiency and 2.5-fold (95% CI: 0.9 to 6.9) for short sleep. Adjusted analyses showed that adolescents with low sleep efficiency had on average a 4.0±1.2-mmHg higher systolic blood pressure than other children (P<0.01).

Mezick et al. (2012) evaluated the associations between actigraphy-assessed time spent asleep and ambulatory blood pressure in adolescents. Participants were 246 black and white adolescents (mean age: 15.7 years) who were free from cardiovascular or kidney disease and were not taking sleep, cardiovascular, or psychiatric medications. Sleep duration and efficiency were assessed with in-home wrist actigraphy and sleep diaries across 1 week; ambulatory blood pressure monitoring was used to obtain 24-hour, sleep, and wake blood pressure as well as sleep: wake blood pressure ratios across 2 full days and nights. Results showed that shorter actigraphy-assessed sleep across 1 week was related to higher 48-hour blood pressure and higher nighttime blood pressure. Shorter sleep was also related to a higher systolic blood pressure sleep: wake ratio. These results were independent of age, race, sex, and body mass index. Follow-up analyses by race revealed that associations between sleep duration and blood pressure were largely present in white, but not black, adolescents.

Narang et al. (2012) obtained the data on adolescents, a population-based cross-sectional study in the Niagara region of Ontario. Participants underwent measurements of cardio-metabolic risk factors, including body mass index (BMI), lipid profile and blood pressure and they completed questionnaires measuring sleeping habits and nutritional status. They assessed sleep disturbance using the sleep disturbance score derived from the Pittsburgh Sleep Quality Index. They explored associations between sleeping habits and cardiovascular risk factors. Among 4104 adolescents (51% male), the mean hours of sleep per night (± standard deviation) were 7.9±1.1 on weeknights and 9.4±1.6 on weekends. In total, 19% of participants reported their sleep quality as
fairly bad or very bad on weeknights and 10% reported it as fairly bad or very bad on
weekends. In the multivariable regression models, a higher sleep disturbance score was
associated with increased odds of being at high cardiovascular risk (OR: 1.43; 95% CI:
1.16–1.77; p<0.001), increased odds of hypertension (OR: 1.44; 95% CI: 1.02–
2.05; p<0.05) and increased odds of elevated non-high density lipoprotein cholesterol
(OR: 1.28; 95% CI: 1.00–1.64; p<0.05). The mean duration of sleep was not associated
with these outcomes.

2.2.2.2.5. Smoking: Raitakari et al. (2003) carried out the study to determine the
relationship between cardiovascular risk factors measured in childhood and adolescence
and common carotid artery intima-media thickness (IMT), a marker of preclinical
atherosclerosis, measured in adulthood. Population-based, prospective cohort study was
conducted in Finland. 2229 white adults aged 24 to 39 years who were examined in
childhood and adolescence at ages 3 to 18 years in 1980 were re-examined 21 years
later. Association between cardiovascular risk variables (levels of low-density lipoprotein cholesterol (LDL-C), high-density lipoprotein cholesterol (HDL-C), and triglycerides; LDL-C/HDL-C ratio; systolic and diastolic blood pressure; body mass index; smoking) measured in childhood and adulthood and common carotid artery IMT measured in adulthood was studied. In multivariable models adjusted for age and sex, IMT in adulthood was significantly associated with childhood LDL-C levels (P<0.001), systolic blood pressure (P<0.001), body mass index (P<0.007) and smoking (P<0.02) and with adult systolic blood pressure (P<0.001), body mass index (P<0.001) and smoking (P<0.004). The number of risk factors measured in 12 to 18 year-old adolescents, including high levels (i.e., extreme age- and sex-specific 80th percentile) of LDL-C, systolic blood pressure, body mass index, and cigarette smoking, were directly related to carotid IMT measured in young adults at ages 33 through 39 years (P<0.001 for both men and women) and remained significant after adjustment for contemporaneous risk variables. The number of risk factors measured at ages 3 to 9 years demonstrated a weak direct relationship with carotid IMT at ages 24 to 30 years in men (P<0.02) but not in women (P<0.63). Risk factor profile assessed in 12 to 18 year-old adolescents predicts adult common carotid artery IMT independently of
contemporaneous risk factors. The findings suggested that exposure to cardiovascular risk factors early in life might induce changes in arteries that contributed to the development of atherosclerosis.

Ezzati et al. (2005) used data from the American Cancer Society’s Cancer Prevention Study II (CPS II) and the World Health Organization Global Burden of Disease mortality database to estimate smoking-attributable deaths from ischemic heart disease, cerebrovascular disease, and a cluster of other cardiovascular diseases for 14 epidemiological subregions of the world by age and sex. They used lung cancer mortality as an indirect marker for accumulated smoking hazard. CPS-II hazards were adjusted for important covariates. In the year 2000, an estimated 1.62 (95% CI: 1.27 to 2.04) million cardiovascular deaths in the world, 11% of total global cardiovascular deaths, were due to smoking. Of these, 1.17 million deaths were among men and 450,000 among women. There were 6,70,000 (95% CI: 4,40,000 to 9,20,000) smoking-attributable cardiovascular deaths in the developing world and 9,60,000 (95% CI: 7,70,000 to 1,20,000) in industrialized regions. Ischemic heart disease accounted for 54% of smoking-attributable cardiovascular mortality, followed by cerebrovascular disease (25%). There was variability across regions in the role of smoking as a cause of various cardiovascular diseases.

Retnakaran et al. (2005) studied the patterns of one such habit, cigarette smoking, among Aboriginal Canadian youths and to assess the associated accrual of cardiovascular risk factors at an early age. Patterns of cigarette smoking were assessed in a population-based, cross-sectional study involving 236 youths aged 10 to 19 (mean 14.9) years in the Oji-Cree community of Sandy lake, in northwestern Ontario. Participants underwent clinical and metabolic evaluation with assessment of cardiovascular risk factors. The prevalence of cigarette smoking among the study participants was considerably higher than age-specific national averages, with fully 50% of the participants overall and 82% of the adolescent participants (aged 15 to 19) being current smokers. Compared with their peers, children smoking 6 or more cigarettes per day had an enhanced cardiovascular risk profile consisting of a higher mean systolic blood pressure (111 v. 107.5 mmHg, p<0.036), a higher mean plasma
homocysteine level (8.7 v. 7.6 mmol/L, p<0.008) and a lower mean serum folate level 
(4.5 v. 5.4 mmol/L, p<0.007), after adjustment for age, sex and body mass index. In 
separate multiple linear regression analyses, current cigarette exposure (number of 
cigarette smoked per day) emerged as an independent determinant of both systolic 
blood pressure and plasma homocysteine level. In this Aboriginal community with 
remarkably high rates of cigarette smoking among its youth, an independent dose–
response relation was found between current smoking exposure and both traditional 
(systolic blood pressure) and nontraditional (homocysteine level) cardiovascular risk 
factors. The association of cigarette smoking with an enhanced cardiovascular risk 
profile at an early age may be a factor contributing to the high prevalence of 
cardiovascular disease in this Aboriginal population.

Simonetti et al. (2011) determined blood pressure and an array of potential 
anthropometric, prenatal, environmental and familial risk factors for high blood 
pressure, including parental smoking habits, as part of a screening project in 4236 
preschool children (age 5.7 ± 0.4 years). Smoking was reported by 28.5% of fathers and 
20.7% of mothers, and by both parents 11.9%. In addition to classic risk factors such as 
body mass index, prematurity, low birth weight, and parental hypertension, both 
systolic (OR: +1.0; 95% CI: +0.5 to +1.5 mmHg; P<0.0001) and diastolic blood 
pressure (OR: +0.5; 95% CI: +0.03 to +0.9 mmHg; P<0.03) were higher in children of 
smoking parents. Parental smoking independently affected systolic blood pressure 
(P<0.001) even after correction for other risk factors, such as body mass index, parental 
hypertension, or birth weight, increasing the likelihood of having a systolic blood 
pressure in the top 15% of the population by 21% (2% to 44%; P<0.02). The authors 
concluded that in healthy preschool children, parental smoking was an independent risk 
factor for higher blood pressure, adding to other familial and environmental risk factors. 
Implementing smoke-free environments at home and in public places might provide a 
long-term cardiovascular benefit even to young children.

2.2.2.2.6. Alcohol consumption: Jerez and Coviello (1998) evaluated the alcohol 
consumption among adolescents from Tucuman, Argentina, and to determine its 
possible relationship with increased levels of blood pressure. Three 356 students aged
13 to 18 years included in the study were asked to answer questionnaires anonymously. Two blood pressures measures were then taken. Differences between both sexes were found in quantity and frequency of alcohol consumption. Enjoyment was determined to be the main reason for drinking. There was an association between frequency and alcohol-related problems and smoking habits. There were also differences in blood pressure among males and females. A weak, but significant relationship between quantity/frequency index and diastolic blood pressure was found. A greater prevalence of hypertension in male heavy drinkers was noted as well. They suggested that because this addiction implies multiple social problems and it also accounted for a hypertension risk factor, the importance of aiming at developing prevention strategies for alcohol abuse among adolescents was stressed.

Galhotra et al. (2009) carried out a study on 866 adolescents aged 11 to 16 years. Multivariate regression analysis was done to see the effect of risk factors on BMI and DBP. They found that 8.2% and 6.3% of boys had smoked and taken alcohol at least once in the last month, respectively; 13.6% of the subjects felt that there were no benefits of eating fruits and vegetables; 81.3% of the study subjects were eating fast food (Samosa, patties, noodles, etc.) in the past 7 days, out of which 5.1% were eating out on all seven days; 36.8% were taking carbonated drink ≥1 time/day.

2.2.2.2.7. Socio-economic status: The growing epidemics of cardiovascular diseases worldwide are due to their rapidly increasing incidence in low/middle income economies, especially India, China and Eastern Europe (Murray and Lopez, 1996). In India, the prevalence of coronary heart disease in urban areas has increased from about 2% in 1960 to 6.5% in 1970, 7.0% in 1980, 9.7% in 1990 and 10.5% in 2000 and in rural areas it increased from 2% in 1970 to 2.5% in 1980, 4% in 1990 and 4.5% in 2000 (Gupta, 2005). The poor are burdened with the risk factors associated with these diseases. A study on a semi-urban population in southern India found that higher socio-economic status was associated with greater prevalence of CVD risk factor (Reddy et al., 2002). In contrast, a study of industrial workers found that risk factors (tobacco use and hypertension) for CVD were concentrated among the lesser educated in both urban and rural areas, however, the prevalence of diabetes and being overweight increased.
with better education (Reddy et al., 2007). Rural northern India has a greater exposure to cardiovascular risk factors such as smoking, increasing incidence of atherosclerotic risk factors (obesity, diabetes, dyslipidemia and hypertension), poor working and living conditions, stress, lower rates of formal education, and reduced access to health care and health education (Berkman and Kawachi, 2000; Levenson et al., 2002; Reddy, 2004; Marmot and Wilkinson, 2006; Joshi et al., 2007; Sugathan et al., 2008; Rao et al., 2011). To understand the interaction of socio-economic conditions and lifecourse perspectives for CVD, a flowchart has been given below (figure 2.1).

Figure 2.1: Socio-economic influences on cardiovascular disease (CVD) from a life course perspective. (adapted and modified from Berkman and Kawachi, 2000)

Cardiovascular risk factors have been studied in the younger population – children, adolescents and youth in the different parts of the world but these studies are nearly done on the high income countries and rare data is available from low income countries. In India some studies have reported a moderate to high prevalence of multiple atherosclerosis risk factors in adolescents and young. Studies from metropolitan cities in
non-governmental schools report a high prevalence of obesity. In low income schools in Indian urban rural areas there is low prevalence of obesity but high prevalence of tobacco use. (Yusuf et al., 2001; Beaglehole and Yach, 2003; Reddy, 2004; Lynch and Smith, 2005; Gupta et al., 2006; Gupta et al., 2009; Divakaran et al., 2010).

Lowry et al. (1996) examined the relationship between socioeconomic status and risk behaviors for chronic disease among a nationally representative sample of 6321 adolescents aged 12 to 17 years in United States. Most adolescents (63%) reported 2 or more of the 5 risk behaviors. Controlling for age, sex, race/ethnicity, and school enrollment status of adolescents, as the educational level of the responsible adult increased, cigarette smoking, sedentary lifestyle and insufficient consumption of fruits and vegetables were less likely among adolescents. Among girls, but not boys, consumption of foods high in fat decreased as education of the responsible adult increased. As family income increased, adolescents were less likely to smoke cigarettes, less likely to be sedentary, and less likely to engage in episodic heavy drinking. They concluded that among adolescents, risk behaviors for chronic disease were common and inversely related to socioeconomic status. Improved community and school based programs to prevent such behaviors among adolescents were needed, especially among socially and economically disadvantaged youth.

Guillaume et al. (1999) found that duration of living in the rural area of the child and parents correlated with diastolic blood pressure, particularly in boys (p<0.01). Housewives (p <0.002) and their children (p<0.002) had higher body mass indexes (BMI) than working mothers and their children. Sons of housewives also had higher blood pressure (systolic, p<0.0007, diastolic, p<0.007). Socio-economic factors of parents (profession, unemployment) played relatively minor roles. Alcohol consumption was related to skinfold thickness in boys (p=0.022), but not in girls. Girls, but not boys, with smoking parents had higher BMI (p<0.014). Multiple regression analyses suggested that psychosocial factors, such as housewives as mothers of large families, might be important for associations with cardiovascular risk factors in their children. There were apparent differences in the findings between girls and boys, suggesting that boys were more vulnerable to the impacts of the factors analyzed.
Wilson et al. (2000) examined the influence of both neighborhood- and family-level socio-economic status (SES) on blood pressure (BP) reactivity in a healthy sample of 76 black adolescents. It was hypothesized that a higher level of parental education and/or income would reduce the elevated BP reactivity associated with living in poorer neighborhoods. Census-derived data were obtained using each participant's address. Neighborhood level of SES was based on percentage of households below the poverty line, female-headed households, owner-occupied housing, percentage vacant housing, and average number of persons per household. Family level of SES was based on self-reported level of parental education and annual family income. Adolescents participated in a competitive video game to establish their BP reactivity scores. Adolescents who lived in poorer neighborhoods had lower DBP if their parents were more (versus less) educated (P<0.05; 7±8 versus 13±6 mmHg). Adolescents who lived in poorer neighborhoods also had significantly lower DBP reactivity (P<0.05) if their family had a higher (versus lower) annual income (7±7 versus 12±8 mmHg).

Kocaoglu et al. (2005) recruited a random sample of 1044 children aged 12 and 13 years old in three major metropolises in Turkey (Istanbul, Ankara and Izmir). After controlling for energy and fat intake, physical activity status and Body Mass Index (BMI), it was found that mostly paternal education level had a significant positive effect for most of the subgroups examined (Lower vs. Higher and Medium vs. Higher) on total cholesterol and HDL-cholesterol and a negative effect on TC/HDL ratio for both genders. Furthermore, both boys and girls with higher paternal education level and maternal education level were found to have higher energy intake derived from fat and protein than their counterparts with medium and lower paternal education level and maternal education level, while the opposite was observed for the percentage of energy derived from carbohydrates.

Ansa et al. (2010) determined the relationship between parental socioeconomic status and casual blood pressure in adolescents. A total of 1008 adolescents attending two secondary schools in Calabar, Nigeria were selected by stratified random sampling. Their blood pressure, weights and heights were taken using standard methods and socio-demographic data were obtained using a pretested semi-structured questionnaire.
The blood pressure was increased with age with males having higher values. The other major determinants of blood pressure were weight, height, body mass index, level of physical activity and parental socioeconomic status (p<0.05). No relationship was established between these determinants as well as dietary habits with parental socioeconomic status (p<0.05). Female adolescents with parents in the lower socioeconomic classes had significantly higher systolic and diastolic blood pressure (p<0.05). In contrast, parental socioeconomic status showed no significant relationship with systolic blood pressure and diastolic blood pressure in males (p<0.05). The prevalence of elevated blood pressure was higher in females than in males. They concluded that low parental socioeconomic status appears to be associated with higher casual blood pressure especially in female coastal Nigerian adolescents. Traditional determinants did not appear to play a significant role. Psychological stress arising from environmental and economic stressors might be responsible.

Aounallah-Skhiri et al. (2011) assessed the dietary intake and association with socio-economic factors and health outcomes among adolescents in Tunisia. They carried out a cross-sectional survey (in 2005) on 1019 subjects aged 15 to 19 years from a clustered random sample. Results indicated that the energy intake levels were quite high, especially for females. The macro-nutrient structure was close to recommendations but only 38% had a satisfactory diet quality. A main traditional to modern dietary gradient, linked to urbanisation and increased economic level, featured an increasing consumption of white bread, dairy products, sugars, added fats and fruits and decreasing consumption of oils, grains, legumes and vegetables; regarding nutrients this modern diet score featured a decreasing relationship with total fat and an increase of calcium intake, but with an increase of energy, sugars and saturated fat, while vitamin C, potassium and fibre decreased. Adjusted for age, energy and physical activity, this modern pattern was associated with increased overweight in males and a higher WC. Adjusting also for BMI and WC, among females, it was associated with decreased prevalence of high blood pressure. They concluded that the dietary intake contrasted among Tunisian adolescents, linked to socio-economic differentials were characteristic of a nutrition transition situation. The observed gradient of modernisation of dietary
intake features associations with several nutrients involving a higher risk of chronic diseases but might have not only negative characteristics regarding health outcomes.

Chen et al. (2011) explored risk factors associated with overweight and high blood pressure in Chinese American children. Students and their parents were recruited from Chinese language schools in the San Francisco Bay area. Data were collected on 67 children and their mothers, and included children’s weight, height, waist and hip circumferences, blood pressure, level of physical activity, dietary intake, usual food choice, knowledge about nutrition and physical activity, and self-efficacy regarding diet and physical activity. Mothers completed questionnaires on demographic data and acculturation. About 46% of children had a body mass index exceeding the 85th percentile. Lower level of maternal acculturation was found to be a risk factor for predictive of high body mass index and high systolic blood pressure, whereas older age and less physical activity in children were predictors of high diastolic blood pressure.

Zaman et al. (2012) investigated the prevalence, screening and knowledge of cardiovascular risk factors (CVRFs) by socio-economic position (SEP) in rural India. An age and sex stratified random sample of 4535 adults were recruited from rural Andhra Pradesh and a questionnaire was administered to assess prevalence, screening and knowledge of CVRFs and record recent attempts to modify behaviour. Education, income and occupation were used to measure socio-economic position. Lower fruit intake and higher tobacco and alcohol use were found in those with lower socio-economic position. Overweight, physical inactivity, diabetes, hypertension, family history of cardiovascular disease (CVD) and previous CVD (men only) were greater in higher socio-economic position participants. Lower socio-economic position participants had less blood pressure, glucose or cholesterol screening and less knowledge of nine CVRFs. Regardless of socio-economic position, participants knowledgeable of the harms of a CVRF were more likely to have attempted to modify behavior. For example, knowledge of benefits of smoking cessation was associated with an increased odds ratio (OR) for attempting to quit: in educated participants (OR: 3.67; 95%CI: 2.10-6.42; in participants with no education OR: 3.9; 95% CI: 2.27-6.97. Some
biological CVRFs were worse in higher SEP participants while some behavioral risk factors were worse in lower SEP participants. Lower SEP participants had less CVRF screening and knowledge of CVRFs. Those with knowledge of CVRFs were more likely to make healthy behavioral changes.

Van den Berg et al. (2013) investigated the association of socioeconomic status with blood pressure and prehypertension in childhood. In a prospective cohort, 3024 five- to six-year-old children had blood pressure measurements and available information on potential explanatory factors, namely birth weight, gestational age, smoking during pregnancy, pregnancy-induced hypertension, familial hypertension, maternal body mass index, breastfeeding duration, domestic tobacco exposure, and body mass index. The systolic and diastolic blood pressures of children from mid-educated women were 1.0-mmHg higher (95% CI: 0.4-1.7) and 0.9-mmHg higher (95% CI: 0.3-1.4), and the blood pressures of children with low-educated women were 2.2-mmHg higher (95% CI: 1.4-3.0) and 1.7-mmHg higher (95% CI: 1.1-2.4) compared with children with high-educated women. Children with mid- (OR: 1.50; 95% CI: 1.18-1.92) or low-educated mothers (OR: 1.80; 95% CI: 1.35-2.42) were more likely to have pre-hypertension compared with children with high-educated mothers. Using path analyses, birth weight, breastfeeding duration, and body mass index were determined as having a role in the association of maternal education with offspring blood pressure and pre-hypertension.

2.2.2.2.8. Dyslipidaemia: Magkos et al. (2005) examined the secular trends in major cardiovascular disease (CVD) risk factors, that is, obesity and dyslipidaemia, among Cretan children during 1982–2002. A total of 528 boys in 1982 and 620 boys in 2002, aged 12.1±0.1 years were randomly selected from urban and rural regions throughout the county of Iraklio, Crete, Greece. Care was taken so that all procedures in 2002 closely matched those in 1982. Mean height, weight, and body mass index (BMI) were 1.1, 9.6, and 8.4% higher, respectively, in 2002 vs 1982 (P<0.001). The prevalence of overweight and obesity had risen by 63 and 202%, respectively, in 2002 vs 1982 (P<0.001). Contemporary children were found to have 3.6% higher total cholesterol (TC), 24.9% lower high-density lipoprotein-cholesterol (HDL-C), 25.3% higher low-density lipoprotein-cholesterol (LDL-C), 19.4% higher triacylglycerol, 36.6% higher TC/HDL-
C ratio, and 60.3% higher LDL-C/HDL-C ratio compared with their peers in 1982 ($P<0.003$). The differences persisted even when adjusting for BMI ($P<0.02$). The authors suggested that the results were indicative of a largely deteriorated CVD risk profile in Cretan children since 1982, and predict an unfavourable CVD morbidity and mortality for this population in the foreseeable future.

Botton et al. (2007) documented the prevalence and levels of cardiovascular risk factors in a general population of French children and assessed separately in boys and girls whether these risk factors were associated with fat mass distribution independently of subcutaneous overall adiposity. A cross-sectional analysis of baseline data from 452 children (235 boys and 217 girls) aged 8 to 17 years included in a 1999 population-based epidemiologic study (the Fleurbaix Laventie Ville Santé II study) was made. Overweight was defined according to the International Obesity Task Force references and the 90th percentiles of the French body mass index curves. The thresholds of parameters defining cardiovascular and metabolic risks were the 95th percentile of the Task Force Report on High Blood Pressure in Children and Adolescents for blood pressure and those of the American Academy of Pediatrics for lipids. Anthropometric and biological parameters were described by sex and according to overweight status. Partial correlations between cardiovascular risk factors and anthropometric measures of adiposity (body mass index, sum of 4 skinfold thicknesses, waist circumference, waist-to-height ratio) were calculated. Then, these correlations were additionally adjusted for the sum of 4 skinfold thicknesses. High plasma triglycerides, high insulin concentration, and low plasma high-density lipoprotein cholesterol (HDL-C) concentration were associated with all measures of adiposity ($r\geq0.20$, $P<0.002$). When obese children were excluded, overweight children already had high triglycerides and low HDL-C levels, respectively, 2 and 20 times more frequently than normal-weight children did. Among overweight children, 7.7% had at least 2 risk factors among high blood pressure, high plasma triglycerides or glucose, and low HDL-C concentration vs 0.25% among normal-weight children ($P<0.002$). After adjusting for the sum of skinfolds, an independent association between the risk factors and waist circumference was found in girls.
Bovet et al. (2012) compared the associations between several indices of obesity and cardiovascular risk factors in late adolescence in the Seychelles. They measured body mass index (BMI), waist circumference, waist/hip ratio (WHiR), waist/height ratio (WHtR) and percent fat mass (by bioimpedance) and 6 cardiovascular risk factors (blood pressure, LDL-cholesterol, HDL-cholesterol, triglycerides, fasting blood glucose and uric acid) in 423 youths aged 19 to 20 years from the general population. The prevalence of overweight/obesity and several cardiovascular risk factors was high, with substantial sex differences. Except for glucose in males and LDL-cholesterol in females, all obesity indices were associated with cardiovascular risk factors. BMI consistently predicted cardiovascular risk factors better than the other indices. Linear regression on BMI had standardized regression coefficients of 0.25-0.36 for most cardiovascular risk factors (p<0.01) and ROC analysis had an AUC between 60%-75% for most cardiovascular risk factors. BMI also predicted well various combinations of cardiovascular risk factors: 36% of male and 16% of female lean subjects had ≥2 cardiovascular risk factors compared to 74% of male and 46% of female overweight subjects (BMI >P90). They concluded that there was an elevated prevalence of obesity and of several cardiovascular risk factors in youths in Seychelles.