CHAPTER IV

DISCUSSION
Available data on overweight/obesity and its association with hypertension and hyperglycemia in Indian populations, particularly in Chittoor district of Andhra Pradesh is inadequate. Hence, the present work is carried out to understand the association of body mass index with blood pressure and blood glucose levels in urban and rural adult populations of Chittoor district, Andhra Pradesh. The results are discussed with the available literature on various other population groups too.

A total of 1520 adults are screened for the present study. Among the sample, 802 adults (Male: 421; Female: 381) are drawn from urban settings and 718 adults (Male: 382; Female: 336) are drawn from rural settings. The age range in the present study is 30-65 years. Furthermore, the subjects are divided into different age groups like 30-40 yrs, 40-50 yrs, 50-60 yrs and >60 yrs for comparison between sexes and groups. The study delineates the levels of anthropometry, blood pressure, blood glucose and their prevalence in urban and rural population groups. It is anticipated that the outcome of the work may lead to formulate suitable strategies and implement developmental programmes for the well being of the population groups.

In the present study urban and rural variation in anthropometry, blood pressure and blood glucose levels are clearly visualized. Urban population is characterized by elevated levels of anthropometry, blood pressure and blood glucose levels than rural population. Previous reports have clearly identified the rural urban differences in anthropometry, blood pressure and blood glucose levels (Shukla et al., 2002; Naidu and Rao, 1994). However the mean levels of anthropometry, blood pressure and blood glucose levels are comparatively lower in Indian population than western population. The findings are in good agreement with other published works (Bose and Chaudhuri 2001; Agyemang and Bhopal 2001; Rurik et al., 2004; Turconi et al., 2006; Atallah et al., 2007; Ghosh and Bandyopadhyay 2007; Sung et al., 2007; Christofaro et al., 2007).
Thus the relative risk exerted by the risk factors is low in Indian populations (Reddy et al., 2013).

Prospective studies over the last two decades have ascertained the importance of elevation in anthropometric indicators in developing various metabolic disorders (Yong et al., 2011; Priya, 2012). The mean values of anthropometric and physiological variables in the present study are comparatively lower to many western studies (Jackson et al., 2005; Wrighta et al., 2005) and in good agreement with studies from South Asia (Ni Mhurchu et al., 2004). The increasing prevalence of various metabolic diseases even at lower anthropometric indicators in Indian populations is a serious concern to explore and fix the cut offs to assess the risk towards metabolic disorders (Deshmukh et al., 2006; Reddy et al., 2010).

Several studies have indicated that age is a confounder when using anthropometric indicators to predict the risk of hypertension and diabetes (Molarius et al., 2000). Age has been differently categorized by different scientists; however, relationships between anthropometric indicators with hypertension and diabetes are consistent across the age groups (Daniel et al., 1999). In contrary some studies have shown that age is not a confounder when assessing the relationship between anthropometric indicators with hypertension and diabetes (Mato, 2009). It is assumed that a larger sample size in each age group might increase the statistical power to eliminate age as the confounder.

Blood pressure, an important physiological marker, attained great etiological significance in the epidemiology of CVD. In the present study, the rise in blood pressure with age is moderate among urban and rural populations. There is a general tendency of systolic and diastolic levels of blood pressure to increase with advancing age in both urban and rural populations. The observations of the difference of systolic, diastolic and mean pulse rate in the urban and rural areas have been found to be statistically significant (p<0.05).
A consistent increasing trend of systolic, diastolic and mean pulse rate has been found in urban. This suggests that environmental differences, lifestyle, dietary habits, stress and strain have a positive effect to increase the blood pressure. Therefore, the present study is consistent with the findings reported by several studies (Sidhu et al., 2004; Riikka Mattila, 2009; Ann Blomstrand, 2014). Whereas, Passos et al., (2007) studied the Brazilian population and reported that residence in a more modernized community is associated with higher blood pressure. Tesfaye et al., (2007) reported the elevation of BP along the socioeconomic gradient across the three countries in Africa and Asia.

Numerous epidemiological and clinical surveys during the last three decades have identified a series of risk factors which are significantly associated with the occurrence of noncommunicable diseases. The major and minor risk factors so far identified suggest that NCDs are multi-factorial conditions whose probability of occurrence is controlled by genetic, metabolic and environmental factors. Several demographic variables like age, sex, occupation, economic status, rural and urban differences etc., are known to influence the incidence of NCDs. Prospective studies have clearly demonstrated that the urban population is more prone to develop NCDs like hypertension, diabetes, cancer etc than the rural population (Nissinen et al., 1988; Milan Gupta et al., 2006).

Research reports have convincingly highlighted the importance of overweight/obesity, hypertension, and diabetes mellitus in predisposing the subjects towards developing NCDs. Recently several studies on free living populations are instituted to discern the factors associated with the occurrence of NCDs and how the disease evolves and terminates in the general population. Personal habits like excess use of tobacco, lack of physical exercise and nutritional habits have also shown a striking correlation with the occurrence of NCDs. (WHO, 2010; Mattias Oberg et al., 2011).
Cross examination of the data indicates that the age standardized prevalence rates are significantly higher in urban population than rural population. While the age standardized prevalence of obesity, hypertension and hyperglycemia in the study population are higher than those observed in the Framingham study (Castelli, 1992); they are not as high as those reported in studies of migrant South Asian and other Indian populations (Ramaiya et al., 1991; Fernando et al., 1994; Agyemang and Bhopal, 2002; Ezzati et al., 2002; Harding et al., 2006; Anoop Misra and Usha Shrivastava, 2013). The prevalence rates observed in the present study are: overweight (urban males: 27%; urban females: 29% and rural males: 20%; rural females: 26%), obesity (urban males: 22%; urban females: 19% and rural males: 12%; rural females, 8%), hypertension (urban males: 17%; urban females: 16% and rural males and females: 10%), hyperglycemia (urban males: 17%; urban females: 15% and rural males: 10%; rural females: 7%) respectively.

Among North Indian urban population, there is a greater prevalence of higher profile NCD risk factors, for example 58% are hypertensive and 33% are obese (Dwivedi et al., 1999; Devi et al., 2003; Sachdev et al., 2005; Thakur et al., 2011). This high rate has been attributed to changes in diet and food habits, as well as increases in leisure time physical inactivity (WHO, 2009). In contrast, recent findings from an affluent tribal population in South India showed that this population had lower NCD risk factor prevalence rates than urban and other rural communities in India (Reddy et al., 1998; 1999; 2012). The authors suggested that balanced nutritional status and optimum physical activity kept the tribal community’s prevalence rates low.

Several studies in developing countries suggest that NCD risk factors may be related to socioeconomic status and urbanization (Singh et al., 1997; Gwatkin and Heuveline, 1997; Meyer et al., 2001; Resnikoff et al., 2004; Jeon et al., 2008; WHO, 2010). For example, the prevalence of CHD, diabetes, hypertension and obesity has increased 10-fold among urban dwellers in India (Reddy et al., 1994; Enas and Senthilkumar, 2001; Kanala et al., 2002; Swami et al., 2005; Mohan et al., 2007; Krishnan, 2012). Studies from rural areas have shown a lower prevalence of CHD risk
factors such as obesity, hypertension and diabetes compared to urban areas, but an increasing trend is seen among them as well (Gupta and Gupta, 1998; Gupta, 2003; 2010).

The findings of the present study indicate that increased prevalence of NCD risk factors among middle and high-income groups of both urban and rural populations. The effect of socioeconomic status on the prevalence of risk factors in both urban and rural groups is thoroughly investigated in the present study. Prospective studies carried out in various parts of the country have clearly shown an increasing prevalence of NCD risk factors with increase in the socioeconomic status (Reddy et al., 2006; WHO, 2008).

The findings of this study showed that coronary risk factors such as hypertension, hyperglycemia, obesity and sedentary lifestyle are more prevalent among higher SES groups of both urban and rural populations. Men in the higher socioeconomic groups had higher prevalence of hypertension and obesity than women. Recent reports on the prevalence of NCD risk factors among the Indian social classes has shown similar results (Singh et al., 1999; WHO, 2010; IARC, 2011; Anwar Basha et al., 2014). However, these findings differ from those seen in developed countries (Wang et al., 2001; Olshansky et al., 2005; Wang et al., 2010), where coronary risk factors and deaths due to NCDs have been more common in the lower social classes (Gwatkin and Heuveline, 1997; Rhonda BeLue et al., 2009; Lim et al., 2012; WHO, 2011; Subramanian et al., 2013). These differences may be due to different dietary and living patterns.

A higher percentage of men and women in the higher social classes have more sedentary habits, which may increase their risk of NCDs. In his analysis of the global burden of disease, Christopher (1996) has shown that NCDs caused 34% of deaths among the poor and up to 85% of deaths among the richest sections of the population and the same reported by WHO (2013) as low and middle income countries, a higher proportion (48%) of all NCD deaths are estimated to occur in people under the age of 70, compared with high income countries (26%). The transition from poverty to
affluence is likely to lead a decline in communicable diseases compared to NCDs like CHD, obesity, hypertension, hyperglycemia, cancer etc (WHO, 2010). In many countries, this transition tends to favor the adoption of atherogenic diets and physical inactivity, which are considered to be major NCD risk factors (Enas, 1998; WHO, 2004; Rachel Nugent, 2008; WHO, 2009; Shenglan Tang et al., 2013; Sukumar et al., 2013).

National Nutrition Survey in India indicates that dietary fat intake is much higher in high and middle income urban populations compared to low income groups (ICMR, 1990). 17% of rural social class-V subjects do not consume any edible fat, whereas about 5% of higher social class subjects consume 40% of available dietary fat. These diet and lifestyle changes have been associated with a modest increase in overweight and hypertension (ICMR, 1990; Kanala et al., 2002; Rajeev Gupta and Soneil Guptha, 2010; Justin et al., 2014). In the present study, hypertension and obesity are found to be positively associated with SES in men only. It has been observed that increases in the prevalence of obesity and hypertension are not invariable accompaniments of lifestyle changes though they are often present.

The findings of this study add to the body of evidence that suggests higher social classes in developing countries may have greater NCD risk than lower social classes. Rapid growth in industrialization and urbanization may have led to changes in dietary patterns and a reduction in physical activity as noticed in the study population, as has been the case in other Indian populations (Bhatnagar, 1998; Singh et al., 1998; WHO, 2002; Rachel Nugent, 2008; Bernard et al., 2010; Reddy et al., 2010; 2012; Anwar Basha et al., 2012). NCD mortality rates are likely to increase among the higher social groups in urban areas. This epidemic may be halted through the promotion of healthier lifestyles (Dhawan and Petkar, 1998; Parkin, 2006; Helen and Marita, 2008; WHO, 2010; Reddy et al., 2012) and the support of environmental and policy changes. Perhaps restoration of some family aspects such as joint families, good education, yoga practice, increases in work and leisure time physical activity and traditional food consumption patterns would help to mitigate this burden.
From this study it is found that elevated BMI is associated with higher educational attainment in both sexes of urban and rural populations. From the 26 populations studied in the MONICA study (Molarius et al., 2000), no significant association is found between education and BMI in men from 18 countries and an inverse association is found in six countries and education level and BMI are positively associated only in men from Moscow and Poland (Flegal et al., 1998). Education-BMI association is not static but changes over time and with the epidemiological transition (Gutierrez-Fisac et al., 2002; Cutler and Lleras-Muney, 2007; Reddy et al., 2007; Perez et al., 2014). In countries in transition, where less educated people are labour intensive occupations and people with higher education are living a more sedentary life (Shukla et al., 2002; Fong et al., 2007), a positive association between education and BMI will be seen, as in this study.

Smoking is associated with increased levels of NCD risk factors in many studies (WHO, 2010; Mattias Oberg et al., 2011) but not all (Aulikki Nissinen et al., 2001). In the present study, though smoking could not find significant difference in both urban and rural populations, but the differences are greater especially a significant reduction is persisted with body mass index in rural smokers, which in turn is connected with higher physical activity at work. Alcohol intake is a lifestyle factor often thought to offer health benefits as well as hazards. Among the hypothetical health benefits, there is a well-established positive correlation between alcohol intake and elevation of body mass index (Corrao G et al., 2004; Bagnardi et al., 2008; WHO, 2009; Mukamal et al., 2010; Rehm et al., 2010; Roerecke and Rehm, 2010; Ronksley et al., 2011; WHO, 2011), whereby alcohol may increase CHD risk. However, relatively little information is available on the relationship of body mass index to alcohol intake. In the present study, alcohol consumption did not find any significant differences in body mass index, blood pressure and blood glucose levels in both urban and rural populations.

There is overwhelming evidence that one of the most significant risk factor for NCD is a high level of obesity (McMurray et al., 2000; Wang, 2001; Ezzati et al., 2002; van Lenthe et al., 2004; WCRF, 2009; WHO, 2009; Finucane et al., 2011; Lalu Naik et
In the present study, BMI seems to be a better needle when compared to other anthropometric indicators in assessing the risk of hypertension and diabetes as noticed in Chinese (Linn et al., 2006), Japanese (Sakurai et al., 2006), Mauritanian (Nyamdorj et al., 2008), and reports by WHO (2010). These findings are contrary to some of the observations from Taiwanese population (Chien-Hsiang et al., 2010), where BMI largely identified as a predominant risk factor in developing metabolic disorders (Finucane et al., 2011). Excess body weight and obesity are well recognized to be important risk factors for hypertension, whereas abdominal fat plays a more important role in increasing the release of fatty acid in the portal blood vessels, leading to the development of hypertension (Siani et al., 2002; WHO, 2010).

Body mass index is determined from weight and height measurements, presenting the general measure of obesity rather than body fat distribution. Probably this could one of the important reasons why some prospective studies have indicated that central obesity (WC or WHR) has a stronger association with the risk of hypertension (Feldstein et al., 2005; Jyoti Ratan and Arup Ratan, 2013). However, in the present study it is noticed that the effect of BMI remained significant in assessing the risk of hypertension and diabetes in both urban and rural populations. Indian population had relatively smaller WC compared with Whites; therefore, total body fat (BMI) may also play a significant role in accordance with abdominal fat (WC) in predicting hypertension (Fuchs et al., 2005; Sushma et al., 2010; Chandrasekharan et al., 2012).

Systolic and diastolic blood pressures and blood glucose levels are positively correlated with age in both urban and rural populations. A significant correlation between SBP and DBP with age is also reported (Chobanian et al., 2003; Williams et al., 2004; WCRF, 2009; Lalu Naik et al., 2012). Similarly a strong association of overall and abdominal obesity with blood pressure is also noticed in both urban and rural populations (Debolina Sarkar et al., 2009). In the present study overweight/obesity identified as significant determinants of hypertension and diabetes. Similar findings have been reported in other studies. It is probable presumed that economic transition
towards affluence might have increased the risk of hypertension and diabetes. It is thus demonstrated that BMI is closely associated with BP and blood glucose levels in populations who are at different stages of socioeconomic transition (Brown et al., 2009; Reddy et al., 2010).

Importance of body mass index has been recognized for estimating CVD risk factors, particularly due to their positive association with hypertension and diabetes (Pis-Sunyer, 1993; Whitworth, 2003; WHO, 2009; Danaei et al., 2011). In the present study, mean values of all these anthropometric indicators are significantly higher in hypertensives than in normotensive population in both the genders. The findings are similar to many studies (Gryglewska et al., 1998; Wilsgaard et al., 2000; Doll et al., 2002; Fang and Nie, 2003; Zhao et al., 2003; Deshmukh et al., 2006; Al-Sharbatti et al., 2011; Anwar Basha et al., 2012; Zahra Bostani et al., 2012; Reddy et al., 2013;). The study also finds significant positive correlation between all these anthropometric indicators and systolic and diastolic blood pressure except for WHR and diastolic blood pressure.

Elevated body mass index is equally associated with an increased risk of hypertension in the presence of higher abdominal obesity in both urban and rural populations. These findings are in good agreement with other studies, supporting a stable relationship between body mass with blood pressure (Kaufman et al., 1996; Reddy et al., 1997; Hilal Yildiran et al., 2011; Keshav Kashya, 2012; Lalu Naik et al., 2012; Bum Ju Lee and Jong Yeol Kim, 2014). The presence of insignificant differences in the relationship of BP with adiposity in male gender provides substantial argument against a lower hypertensive effect of obesity than female gender.

The above evidence presented supports a common general physiopathological mechanism linking the excessive fat deposition to elevated BP independently of genetic and environmental background. The mechanism of obesity associated hypertension appears to be an inadequate vasodilatation in the face of the increased blood volume and cardiac output, which are the natural consequences of an increased body mass. This
defect in control of vascular resistance has been attributed to increased activity of the sympathetic nervous system, abnormal renin-angiotension aldosterone relations, and insulin resistance (Dustan 1990; Theodore Kotchen, 2010; 2014).

Obesity seems to accentuate the development of a cluster of metabolic disorders (including hypertension and hyperglycemia) among the subjects presenting the syndrome X, referred to as the insulin resistance syndrome (Schmidt et al., 1996; Srinivas et al., 2000; Suhrcke et al., 2007; Sánchez-Chaparro et al., 2008; Global risks 2010). Correlation coefficients for each of the adiposity and blood pressure markers indicate that females dominate males, suggesting a greater female responsiveness of BP to gain in overall weight. Significant correlation of BMI with SBP and DBP, in men and women, is reported by other studies (Kadiri et al., 1999; Njelekela et al., 2001; van Lenthe et al., 2004; WCRF, 2009). Lower correlations between adiposity and blood pressure are documented in female subjects of Ethiopia origin (Tesfaye et al., 2007). The relationship of BP to cardiovascular mortality has been found to be similar among different countries, continuous and linear, even at the lower range of BP, i.e. below the cut-off points (140/90 or 160/95 mmHg) generally used to define hypertension (Van den Hoogen et al., 2000; Obesity, 2004; Finucane et al., 2011). Therefore, changes in BP corresponding to define gains in adiposity, which can directly be converted into their effect on the relative risk of death from CVDs.

In the present population, a constant increase in mean SBP, DBP and adiposity is observed with age in both sexes. Thus, when BP increased with age, the BMI and WHR also increased. A significant correlation between blood pressure and age is also reported in an Indian population (Singh et al., 1997; Reddy et al., 2013). The age-specific prevalence of hypertension increased consistently with increasing age (group), in both genders of urban and rural populations. A similar pattern has been reported in other studies (Bovet et al., 2002; Boden-Albala et al., 2008; Finucane et al., 2011). The prevalence of hypertension at different BMI categories revealed a steep rise at obesity in both males and females of urban and rural populations. Significant associations
between BMI and BP have also been documented in various populations elsewhere (Hu et al., 2000; Mufunda et al., 2006; Danaei et al., 2011; Lalu Naik et al., 2012).

Urban and rural populations showed a high BP and hyperglycaemia prevalence rates increased linearly with overweight and obesity. This trend showed that hyperglycaemia and high BP increased linearly with overweight, and more so in urban population than rural population (Tazeen et al., 2006; Lei Zhang et al., 2010). Pappachan et al., (2011) reported that overweight individuals are at high risk of diabetes and hypertension in an Indian population. Other studies that are conducted in North India indicated that age can be a risk factor for obesity, hypertension and diabetes (Mohan, et al., 2007; Rajeev Gupta and Anoop Misra, 2007; Ravikumar et al., 2011). In the same studies, obesity and hypertension are reported to be possible risk factors for diabetes and both hypertension and diabetes are common in obese individuals. The WHO (2003; 2010) indicated that 90% of type 2 diabetes is overweight. A linear relationship is also observed in both populations of the present study between the degree of obesity and high BP and hyperglycaemia.

Many investigators have earlier reported significant positive correlation of body mass index with systolic and diastolic blood pressure (Seidell et al., 1991; Hsieh et al., 2000; Gus et al., 2004; Nguyen et al., 2009; Viswanathan Mohan et al., 2013). Significant positive correlation between WHR and systolic and diastolic blood pressure has been reported earlier (Shahbazpour, 2003; Anwar Basha et al., 2012; Youssef et al., 2014). However, in the present study, the correlation between WHR and DBP is insignificant. Woo et al., (2002) reported that waist-hip ratio is not a useful predictor of health outcome while Dalton et al., (2003) found that BMI, WC and WHR are equally related with hypertension.

In the present study, results indicate that BMI as the significant predictor of both systolic and diastolic blood pressure. Independent association between BMI and systolic/diastolic blood pressure; and between WHR and systolic/diastolic blood pressure has been reported earlier (Anwar Basha et al., 2012; Lalu Naik et al., 2012).
Sayeed et al., (2003) reported that waist-height ratio is a better obesity index than body mass index and waist-hip ratio for predicting hypertension. Lin et al., (2002) also reported that waist-height ratio may be better indicator for screening obesity related CVD risk factors including blood pressure than BMI, waist circumference and waist-hip ratio.

Prospective studies have repeatedly emphasized the importance of obesity in the development of NCDs (Sobal and Stunkard, 1989; Martinez et al., 1999; van Lenthe et al., 2004; Finucane et al., 2011). The findings of the present study reveals that the prevalence of hypertension and obesity indicates that the risk of CVDs is more in urban than rural populations. The results are consistent with the previous observations among selected industrial population wherein increased prevalence of obesity and hypertension are found to be major contributors of NCD (Reddy et al., 2010). Increased prevalence of high fasting glucose levels in urban environment than rural indicating the increased CHD risk in urban environment. Coronary Artery Disease in Indians (CADI) studies (Enas 2001; Joshi et al., 2001) reported that the prevalence of diabetes is to be three to six times higher among South Asians than Europeans, Americans and other Asians. Thus the high prevalence of obesity, hypertension and hyperglycemia in urban setting is a cause of concern. It have been observed that in comparison with western population, a relatively lower levels of blood glucose and blood pressure levels appears to predispose Indians to Coronary artery disease (CAD) (ADA, 2008).

The multiple linear regression analysis shows that there are similarities in the relationships of lifestyle and sociodemographic variables to NCD risk factors in both urban and rural populations. BMI is the strongest predictor of blood pressure and blood glucose levels. The regression coefficients suggest a differed magnitude of association between the groups.

Obesity is often associated with resistance to insulin-mediated glucose uptake and hyperinsulinaemia (Michael et al., 2008). Peripheral insulin resistance leads, among other consequences, to a decrease of HDLC concentration and an increase of
triglyceride and LDLC concentrations through the mechanism of enhanced lipolysis and increased release of free fatty acids from adipose tissue (Gerald. 2008). Obesity, which is also associated with hypertension and type 2 diabetics, is a common problem in industrialized societies. Prospective studies have clearly shown that obesity is a major contributor to a continued high prevalence of NCD and premature deaths (Stamler, 1993; Kumanyika et al., 2002; WHO, 2010; Maria Lola Evia-Viscarra et al., 2013). In this study, in urban sample, the means of BMI and its prevalence rates are above with increased prevalence of hypertension and hyperglycemia, which indicates that a substantial fraction of these subjects may be at risk. Similar results are observed elsewhere (Abu Sayeed et al., 1995; Roberts et al., 2006; Andre Pascal Kengne et al., 2007; Halpin et al., 2010; Michael Miller et al., 2011; Sengwayo et al., 2013).

In conclusion, the above discussion clearly indicates the urban rural differences in the prevalence rates of NCD risk factors. Body mass index is found to be the significant risk factor in developing hypertension and diabetes vis-à-vis in developing noncommunicable diseases. The magnitude of the burden is accounted greater in urban population than rural population. The composite effect of major risk factors such as age, physical activity and socioeconomic status explained only a small fraction of variation in risk factors in both urban and rural populations. These differences contrast sharply with rising NCD risk factor prevalence in urban subjects suggest either that other risk factors account for this trend or that the relationship between obesity and blood pressure and blood glucose in NCD risk may differ between the two populations. If the hypothesis that obesity is more strongly protective of NCD is correct, then some of the benefits of lifestyle modifications aimed at preventing NCD may well be operating through altered lifestyle mechanisms.