PREVALENCE OF OBESITY AND ITS ASSOCIATION WITH BLOOD PRESSURE AND BLOOD GLUCOSE LEVELS

Report of the Major Research Project (MRP)
submitted to University Grants Commission (UGC)
(UGC Ref. No. F.No.42- 498/2013)

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Introduction

Biological anthropologists in the beginning concentrated on body dimension, human evolution, race and cranial dimensions. Afterwards Biological anthropologists are interested not only in understanding human evolution through the study of biological variation in modern man, but also conducting studies relating to the understanding of the variation within and between populations based on several genetic markers viz., blood groups, serum and red cell proteins and enzymes, dermatoglyphics etc., throughout the world (Bhasin and Singh, 1998). In recent times, biological anthropologists are conducting studies on Epidemiological and genetic epidemiological research pertaining to certain diseases and their associated risk factors (Majumdar and Rao, 1991; Venkatramana and Reddy, 2002; Reddy, 2010). Physical anthropologists for the past more than three decades are conducting epidemiological studies on Coronary Heart Disease (CHD) risk factors. The epidemiological studies have reported increasing prevalence of the major coronary risk factors such as smoking, hypertension, diabetes, hypercholesterolemia, overall obesity and truncal obesity (Reddy and Yusuf, 1998; Reddy, 1993; Gupta and Gupta, 1996; Gopalan, 1994, Gupta, 1996; Gupta and Singhal, 1997 and Ramachandran et al, 2001, Huxley etal., 2010). The increase in these risk factors correlates positively with the increasing CHD in India (Gupta and Singhal, 1997).

World Health Organization (WHO, 2002) and the Global Forum for Health observed that the non-communicable diseases (NCD) constitute a serious and increasing health hazard both in developed and developing countries. Nearly 60 % of deaths globally are now due to NCDs. Of all the other risk factors, hypertension, hyperglycemia, hypercholesterolemia, smoking, low physical activity, overweight and

obesity are playing a major role in causing non-communicable diseases such as diabetes (Gordon et al., 1977; Bose, 1992), coronary heart disease (CHD) (Foster and Burton, 1985; Ghosh et al, 2003, 2004), respiratory complications, dyslipidaemia, osteoarthritis of large and small joints, sleep apnoea (Seidell and Bouchard, 1997), hypertension (Bose and Taylor, 1998; Vague et al., 1998) and cancer (Murray and Lopez, 1996). Because of its causative nature in several chronic non-communicable diseases, it is of great interest to understand the prevalence of obesity, type 2 diabetes and hypertension among the general populations. It is in this background the present study has been undertaken to examine the prevalence of the Obesity, Hypertension and type 2 Diabetes and the association of obesity with blood pressure and blood glucose levels among the three populations viz., *Reddy, Balija* and *Mala* of Andhra Pradesh state.

A brief description on Obesity, Hypertension and type 2 diabetes is presented below:

OBESITY is defined as a condition of abnormal or excessive fat accumulation in the fat tissue of the body. The practical and clinical definition of obesity is based on the Body Mass Index (BMI; weight (kg)/height (m^2), (or) Obesity is defined as a condition of excessive fat and is associated with a large number of life threatening disorders (WHO, 1998). Stunkard and Wadden (1993) defined obesity as an excessively high amount of fat or adipose tissue in relation to lean body mass. Overweight/obesity refers to increased body weight in relation to weight, when compared to the same standard of acceptable or desirable weight.

Obesity is increasing alarmingly throughout the world. WHO (1998) estimated that there are more than 250 million obese people world-wide, equivalent to 7% of the

adult population. The research results from different corners of the globe indicate that the problem of overweight/obesity has been showing an increasing trend not only in the developed countries but also among the developing countries including Asian countries (Florentino, 2002). World Health Organization (2002) has collected data on obesity among adults from 84 countries around the world in 1999-2000. The results indicated that the global prevalence of obesity (BMI≥30 kg/m^2) was 8.7%. The prevalence was lowest in the least developed countries and highest in the developed countries.

The WHO stated that the growth in the number of severely overweight adults is expected to be double that of under-weight during 1995-2025 (WHO 1998). Although obesity is the starting scene in India compared to western countries, nevertheless it needs to be tackled aggressively before it assumes serious epidemic properties. Obesity is increasing at an alarming rate throughout the world and has become a global problem. The World Health Organization (WHO) has declared as one of the top 10 health risks in the world and one of the top five in developed nations (WHO, 2002).

Once considered a problem related to affluence, obesity is now fast growing in many developing countries and in poor neighborhoods of the developed countries (WHO, 2003; WHO, IASO&IOTF, 2000). Even in countries like India, which are typically known for high prevalence of under nutrition, a significant proportion of overweight and obese people now coexist with those who are under nourished (Popkin, 2002).

In many developing countries, with increasing urbanization, mechanization of jobs and transportation, availability of processed and fast foods, and dependence on television for

leisure, people are fast adopting less physically active lifestyles and consuming more "energy-dense, nutrient-poor" diets (WHO, 2003; Bell, Ge and Popkin, 2002; Popkin, 2002, 2001, 1998; Popkin et. al., 2001; Drewnowski and Popkin, 1997). Because of urbanization and modernization, our lives are becoming more sedentary and less physically active than before. Urbanization involves changes in occupation patterns, lifestyles, family structures and value systems. These changes have an impact on dietary practices and the levels of physical activity.

The prevalence of obesity is increasing in most populations of the world, irrespective of gender and age. A number of factors have been linked to obesity, including age, gender and socio-economic status with the advancement of science and technology, in industrialized societies, the prevalence of this menace is low in higher socio-economic groups, but in developing countries this relationship is reversed (Sobol and Stunkard, 1989; Randrianjohany et al., 1993). This difference is attributed to the rapid transition in life styles in the process of urbanization, wherein, urban lifestyle has been linked with dramatic changes leading to the increased consumption of high energy dense foods and increased leisure time physical activity.

In India also the prevalence of overweight and obesity has been showing an increasing trend for the last few years (Gopalan,1988). The prevalence is higher in urban populations than rural, however a rise is seen in both the groups (Venkatramana and Chengal Reddy, 2002; Pradeepa etal., 2015). Research results to date emphasize to treat the overweight and obesity as a major public health issue which demands urgent attention.

Epidemiological and population health promotion surveys usually take body mass index (BMI: body weight in (kg)/height in (m^2) as a useful indicator for measuring

overall obesity and also it is an indicator to measure chronic energy deficiency (CED). The waist circumference (WC) and waist-hip-ratio (WHR) are being used to measure abdominal fat accumulation that is, the indicator of central obesity.

Body Mass Index and its cut-off points to assess overall obesity

The Food and Agriculture Organization (FAO) since its inception focuses on under nutrition and hunger. But over the past decade FAO has recognized the growing obesity epidemic occurring not only in the developed world but also among all income and socio-economic groups of the developing world. Hence, FAO in consultation with International Dietary Energy Consultative Group (IDECG) has proposed the following classification for under/overweight and obesity (table –1).

Table 1 : IDECG BMI categories for under/overweight and obesity

BMI (kg/m^2)	Classification	
< 16.0	Category III	Category of Under nutrition/CE
16.0-16.9	Category II	Category of Under nutrition/CED
17.0-18.4	Category I	Category of Under nutrition/CED
18.5-24.9	Normal	
25.0-29.9	Category I obesity	A Garrow's risk-based category of obesity
30.0-39.9	Category II Obesity	A Garrow's risk-based

The FAO and the World Health Organization (WHO) have collaborated and formed the cut-off points of BMI for underweight, overweight and obesity for the entire globe. The BMI cut-off points (table-2) for adults recommended by the WHO (1998) consultation on obesity for Preventing and Managing the global epidemic were the first such cut-off values at the international level.

Table 2: Classification of adults according to BMI

Classification	BMI (kg/m^2)
Underweight (CED)	< 18.5
Normal range	18.5-24.9
Overweight	
Pre-obese	25.0-29.9
Obese class I	30.0-34.9
Obese class II	35.0-39.9
Obese class III	≥40.0

CED=chronic energy deficiency

After this classification, a good number of works shown cut-offs for obesity. The Asian populations are 'lean' and 'small' and being multiethnic and multilingual, population variation is predominant in this region. While applying the possible BMI risk based cut-off points, the prevalence of overweight and obesity appeared to be lower than elsewhere in the world populations. But statistical inference regarding the obesity and related diseases are growing in the region. This phenomenon suggests the need for a separate cut-offs for Asia. Based on large sample surveys, Inoue (2002) for Japanese populations have redefined obesity as a BMI of 25 or more and Zhou (2002) for Chinese as a BMI of 24 and 28 as markers for overweight and obesity, respectively. Later the WHO Western Pacific Regional Office in collaboration with International Obesity Task Force (IOTF) has proposed the following classification (table 3) for the Asian people (Steering Committee, 2000).

Table 3. IOTF-proposed classification of BMI categories for Asia

Classification	BMI (kg/m^2)
Underweight	< 18.5
Normal	18.5-22.9
At - risk of obesity	23.0-29.9
Obese I	25.0-29.9
Obese II	≥ 30.0

WAIST-HIP-RATIO (WHR) OR WAIST CIRCUMFERENCE (WC) TO ASSESS ABDOMINAL OBESITY: The cut-off points of waist-hip-ratio for men was greater than 0.9 and for women it was greater than 0.8 . Men and women with WC values ≤102 and ≤ 88 cm, respectively, were considered to have a normal WC, whereas men and women with WC values > 102 and >88cm, respectively, were considered to have a high WC (NCEP, 2001).

Blood Pressure: The normal pressure of blood against the walls of the arteries is called blood pressure. The normal blood pressure when the heart contracts, is called systolic pressure and in between 100-140 mm of Hg. When the heart relaxes, the pressure is known as diastolic pressure and lies between 70-90 mm of Hg. The United States Fifth Joint National Committee recommendations (National High Blood Pressure Education Programme,1993) were followed for identifying the hypertensives. According to which, hypertension is defined as blood pressure ≥ 140 mmHg of systolic or ≥90mmHg of diastolic blood pressure. As the leading global risk factor for mortality, hypertension is a common healthcare problem in the world. The total number of patients with hypertension is likely to grow in the next few decades as the population age and the prevalence of obesity and diabetes increase. Hypertension, as a major modifiable risk factor for cardiovascular disease, results in more deaths than any other risk factors,

including diabetes and cigarette smoking. High prevalence, inadequate awareness, suboptimal treatment and low rate of achieving guideline-recommended target blood pressure control are key factors leading to severe cardiovascular complications that impose a heavy socioeconomic burden, especially in developing countries (Jin et al., 2013). Asia is the world's largest and most populous continent with approximately 4.3 billion people, hosting 60% of the world's current human population, and has a high growth rate. Asia differs vary widely from the West with regard to ethnic groups, cultures, environment, economics, historical ties and government systems.

The symptoms of high blood pressure: Most hypertensive people have no symptoms at all. There is a common misconception that people with hypertension always experience symptoms, but the reality is that most hypertensive people have no symptoms at all. Sometimes hypertension causes symptoms such as headache, shortness of breath, dizziness, chest pain, palpitations of the heart and nose bleeds. Hypertension is a serious warning sign that significant lifestyle changes are required. The condition can be a silent killer and it is important for everybody to know their blood pressure reading.

Hypertension and life-threatening diseases: The higher the blood pressure, the higher the likelihood of harmful consequences to the heart and blood vessels in major organs such as the brain and kidneys. This is known as cardiovascular risk, and can also be high in people with mild hypertension in combination with other risk factors e.g., tobacco use, physical inactivity, unhealthy diet, obesity, diabetes, high cholesterol, low socioeconomic status and family history of hypertension. Low socioeconomic status and poor access to health services and medications also increase the vulnerability of developing major cardiovascular events due to uncontrolled hypertension.

Blood Glucose levels: A blood glucose test measures the amount of a type of sugar, called glucose, in our blood. Diabetes was diagnosed if the blood glucose levels are >126 mg/dl (7.0 mmol/l) (WHO, 2002).

Diabetes Mellitus (DM): Diabetes mellitus is mainly of two types, type 1 diabetes and type 2 diabetes.

Type 1 Diabetes: Type 1 diabetes was previously called insulin dependent diabetes mellitus (IDDM) or juvenile-onset diabetes. Type 1 diabetes may account for 5% to 10% of all diagnosed cases of diabetes. In this type of diabetes, the beta cell of the pancreas undergoes autoimmune destruction by body itself, and is rendered incapable of making insulin. The rate of destruction may be rapid in some individuals and slows in others (Zimmet *et al.*, 1994).

Type 2 Diabetes: Previously type 2 diabetes was called as non-insulindependent diabetes mellitus (NIDDM) or adult-onset diabetes. Type 2 diabetes may account for about 90% to 95% of all diagnosed cases of diabetes and most often occurs in adults (Zimmet *et al.*, 2001; Ramachandran *et al.*, 2002).

Rising Trend of type 2 Diabetes

Type 2 diabetes has reached epidemic proportions in many developed and developing countries. So diabetes will be one of the major threats to human health in the 21st century. The number of people with diabetes has been increasing due to population growth, aging, and urbanization and increasing prevalence of obesity and physical inactivity and also due to changes in lifestyle. Global estimated and projections of the prevalence of diabetes in the age-group 20–79 are available for 212 countries and territories of seven IDF

regions (IDF Atlas, 2003). It is estimated that currently about 194 million people worldwide, or 5.1% in the adult population have diabetes in 2003, which is expected to increase to 333 million, or 6.3% of adult population by 2025.

The current studies in India indicate that there is alarming rise in the prevalence of diabetes which has gone beyond epidemic form to a pandemic one. To elaborate this situation one should understand the difference between epidemic and pandemic occurrence of a disease. Epidemic of a disease usually indicates an 'unusual' occurrence in a community or region of a disease which is clearly in excess of expected occurrence, while pandemic of a disease denotes an epidemic usually affecting large population, occurring over a wide geographic area, section, or entire nation (Park, 1998). With this definition, DM in India has now acquired a pandemic form. The prevalence of type 2 diabetes is rising rapidly in all non-industrialized populations. By 2025, three-quarters of the world's 300 million adults with diabetes will be in non-industrialized countries and almost a third in India and China alone. This epidemic has been triggered by social and economic development and urbanization, which is linked with general improvements in nutrition and longevity, but also with obesity, reduced physical exercise and other diabetogenic factors (King *et al*., 1998).

The percent prevalence of type 2 DM in some of the countries in 2012 are of the following: India (9.01), China (8.82), USA (9.35), Finland (5.29), Bangladesh (7.11), Germany (5.52) and Afghanistan (7.60). The prevalence of type 2 diabetes in some of the urban and rural Indian populations are as follows : Rural (Puducherry (5.9%,) and Tirupati (4.2) (south India), and urban population in India i.e. Tirupati (14.4%,

Venkatramana et al., 2001), Hyderabad (16.6%, Ramachandran et al., 2001), Chennai (13.5, Ramachandran et al., 2001), Kerala (12.4%, Kutty et al., 2000).

Aim and Objectives

Selection of three pulations Reddy, Balija and Mala from Andhra Pradesh.

To collect the data on demography, behaviourable variables, anthropometry, blood pressure and glucose levels;

To assess the prevalence of obesity among the three endogamous populations; and

To evaluate the association of obesity with blood pressure & glucose levels.

MATERIAL AND METHODS

In the present study prevalence of obesity, hypertension and type 2 diabetes among the three populations namely *Reddy*, *Balija* and *Mala* from Chittoor and Kadapa Districts of Andhra Pradesh, covering both urban and rural areas was studied. A total of 1086 subjects (*Reddy* Male- 218; Female-182); (*Balija* Male-180; Female-162) and (*Mala* (Male-184; Female-160) were covered with an age range of 20-60 years. The data for the present study were collected in Tirupati and Kadapa towns and surrounding villages of Tirupati and Kadapa towns. A simple random sampling technique was employed for collecting the data.

Study populations

Reddy: The Reddy community is one of the forward castes in Andhra Pradesh. The 'Reddis' are also known as 'Kapu' in Rayalaseema. It is a land owning community and now many of them engaged in Government/private jobs and some are engaged in business.

Balija: The Balija community is a forward and predominant caste in Rayalaseema region of Andhra Pradesh. In coastal Andhra Pradesh, Balijas are called as *Kapus*. In rural areas agriculture is their chief economy. In urban sector, Balijas are involved in Govt/private jobs and in business as well.

Mala: Mala is one of the largest scheduled caste population in India. In the caste hierarchy, they occupy the lowest stratum and are economically poor. Most of the

population live in villages and work as agriculture labour and few cultivate their own land. During the recent times, Malas are also moving to towns in view of employment and occupied important positions in administration and in academics.

Data on age, sex, alcohol intake, smoking and life style measures were collected. Based on alcoholic consumption the study respondents were categorized into alcoholics and non-alcoholics. Subjects were categorized into smokers and non-smokers based on presence and absence of smoking. Current smokers, past smokers and users of all forms of tobacco were termed as smokers. Data on Physical activity were collected for each subject and the physical activity levels were divided into four categories namely, sedentary, light, moderate and strenuous (heavy) as described by Ramachandran et al (2004). Subjects involved in the executive jobs and business, landowners and elderly were considered as sedentary. House wives and those involved in the office work and sales were categorized as involved in the light physical activity. Those involved in agriculture, semi skilled, skilled workers and doing regular exercise are termed as having moderate physical activity and farm labours, rickshaw pullers, washer man, artisan groups or those who engaged in strenuous exercise were included under heavy physical activity group.

The anthropometric measurements like height, weight, waist circumference (WC) and hip circumference (HC) were recorded. The skinfold measurements at five sites (triceps, biceps, subscapular, suprailiac and abdominal) were recorded according to Lohmann et al (1988). Height was measured while the subjects standing in erect posture with anthropometer rod . Weight was measured with minimum dress and bare foot, with

calibrated weighing machine. Waist girth was measured between the xiphisternum and the umbilicus while a person in normal breathing. Hip girth was measured at inter-trochanteric level. Non-elastic tape was used to measure waist and hip girth measurements. Subject's blood pressure (systolic and diastolic) levels were measured with Omron automatic blood pressure monitor. Blood glucose levels were estimated with Accu-Chek glucose monitor.

Derived Measurements

Body Mass Index (BMI) : $BMI = \frac{Weight(Kg)}{Height(m^2)}$

Waist Hip Ratio (WHR) : $= \frac{Waist\ Circumference}{Hip\ Circumference}$

General obesity and abdominal obesity was defined using the revised criteria for Asian Indians (The Asia Pacific perspective, 2000); underweight: BMI <18 .5 Kg/m^2, normal range: BMI 18.5–22.9 Kg/m^2, overweight: at risk: BMI 23–24.9 Kg/m^2, obese I: BMI 25–29.9 Kg/m^2, obese II: BMI ≥30 Kg/m^2 for both males and females. Waist circumference based Abdominal obesity was diagnosed when waist circumference was ≥102 cm for males and ≥88 cm for females. WHR based abdominal obesity was diagnosed when WHR was >0.9 in males and 0.8 in females as per the National Cholesterol Education Program (NCEP, 2002)

Blood Pressure: Blood Pressure (Systolic and Diastolic) were measured using calibrated automated blood pressure monitor. Hypertension was defined when systolic blood pressure ≥140 mm Hgmm and/or diastolic blood pressure ≥90 mmHgmm or history of medication for hypertension.

Type 2 diabetes (T2DM): T2DM was diagnosed when blood glucose levels ≥ 126mg/dl.

Statistical analysis: Statistical analysis of the data were done using Statistical Package for Social Sciences version 20, IBM.

Results and Discussion

The present study was conducted among three populations namely *Reddy, Balija* and *Mala* of Chittoor and Kadapa districts of Andhra Pradesh. Results of the study are presented as table form below.

Reddy population

Descriptive statistics for variables and the prevalence of non-communical disease risk factors is presented in tables 1 and 2 respectively. The association of age and obesity measures (BMI,WC and WHR) with SBP, DBP and blood glucose levels is evaluated by the correlation analysis and the results are presented in table 3.

Table 1: Descriptive statistics for different variables in *Reddy* population

Variables	Male (n=218)		Female (n=182)	
	Urban (n=98)	Rural (n=120)	Urban (n=82)	Rural (n=100)
	Mean ± S.D	Mean ± S.D	Mean ± S.D	Mean ± S.D
Age (yrs)	42.45±13.56	43.35±12.64	41.56±11.89	44.87±10.98
Height (cm)	168.45±8.1	166.78±9.3	156.73±6.25	157.67±7.5
Weight (kg)	65.38±7.42	59.87±8.87	56.72±10.43	50.45±7.8
Body Mass Index	25.45±4.3	23.87±3.2	22.41±4.65	21.43±4.75
Waist circumference (cm)	91.11±9.5	85±10.78	87.70±9.33	80.76±9.33
Hip circumference (cm)	96.88±10.1	90.75±8.67	97.13±10.69	91.89±10.69
Waist-Hip Ratio	0.92±0.06	0.88±0.05	0.87±0.07	0.84±0.07
Triceps sft(mm)	12±3.9	8.87±4.1	13±4.2	9±4.3
Biceps sft(mm)	6±3.2	5±3.4	8±2.3	6±3.8
Subscapular sft(mm)	15±5.2	12±4.9	16±4.3	13±5.4
Suprailiac sft(mm)	17±6.3	15±3.1	18±3.8	15±4.8
Abdominal sft (mm)	18±6.5	16±4.2	20±4.9	16±5.5
Systolic blood pressure (mmHg)	126.33±12.98	118±13.67	121.46±11.12	112.13±11.87
Diastolic blood pressure (mmHg)	86.52±8.3	84.65±7.43	83.88±7.70	78.98±8.98
Glucose(mg/dl)	111.25±20.12	102.34±18.46	105.75±22.98	98.75±20.97

Sft:skinfold thickness

Table 2: Percent prevalence of obesity, hypertension, type 2 diabetes and behaviourable variable among *Reddy* population

Variable	Urban	Rural
Obesity (BMI ≥30)	19.92	10.78
Abdominal Obesity	25.67	15.98
Hypertension ≥140/90 mmHg	20.67	9.87
Hypergylycemia	8.97	4.98
Smoking	26.65	35.76
Alcoholic consumption	12.97	14.98
Low/sedentary physical activity	42.89	22.97

Table 3: Association of age, BMI, WC and WHR with SBP, DBP and glucose levels among *Reddy* population

Variable	Age	BMI	WC	WHR
SBP	0.196*	0.326**	0.234**	0.098
DBP	0.122	0.195*	0.142	0.084
Glucose levels	0.132	0.298**	0.232**	0.087

**Correlation is significant at 0.01 level (2 tailed)
*Correlation is significant at 0.05 level (2 tailed)

Balija population

The descriptive statistics and the prevalence of risk factors are presented in tables 4 and 5 respectively. The results of correlation analysis between age and obesity measures (BMI,WC and WHR) with SBP, DBP and blood glucose levels is presented in table 6.

Table 4: Descriptive statistics for different variables in *Balija* population

Variables	Male (n=180)		Female (n=162)	
	Urban (n=78)	Rural (n=102)	Urban (n=66)	Rural (n=96)
	Mean±S.D	Mean±S.D	Mean±S.D	Mean±S.D
Age (yrs)	44.25±12.31	42.18±10.32	40.56±12.19	43.88±11.56
Height (cm)	167.31±7.2	168.82±8.4	157.11±6.40	156.73±6.8
Weight (kg)	66.12±7.71	60.19±8.10	55.21±8.43	52.12±8.12
Body Mass Index (kg/m^2)	25.96±4.9	23.82±3.1	23.14±4.10	21.92±4.86
Waist circumference (cm)	92.14±8.6	86.14±9.42	85.67±9.30	82.78±8.92
Hip circumference (cm)	97.52±10.1	92.04±8.57	98.43±8.34	93.86±8.76
Waist-Hip Ratio	0.93±0.07	0.89±0.06	0.88±0.05	0.85±0.06
Triceps sft(mm)	12±4.3	9±3.76	11±4.2	9±8.6
Biceps sft(mm)	7±2.4	5±2.92	7±3.1	6±2.4
Subscapular sft(mm)	14±4.7	11±3.4	15±2.9	12±3.1
Suprailiac sft(mm)	17±5.1	14±2.9	19±4.2	16±3.4
Abdominal sft(mm)	19±5.7	15±3.4	21±4.9	17±4.6
Systolic blood pressure (mmHg)	128.43±13.73	121.76±11.74	122.92±12.86	114.93±10.82
Diastolic blood pressure (mmHg)	87.62±8.9	85.60±6.46	82.88±7.80	79.14±8.24
Glucose (mg/dl)	114.86±15.87	104.24±19.49	106.89±21.74	99.46±22.63

Table 5: Percent prevalence of obesity, hypertension, type 2 diabetes and behaviourable variable in *Balija* population

Variable	Urban	Rural
Obesity (BMI ≥30)	20.21	12.14
Abdominal obesity	23.45	16.42
Hypertension ≥140/90 mmHg	19.14	10.12
Hypergylycemia	10.14	5.82
Smoking	25.14	38.56
Alcoholic consumption	13.82	16.86
Low/sedentary physical activity	44.95	24.84

Table 6: Association of age, BMI, WC and WHR with SBP, DBP and Blood glucose levels in *Balija* population

Variable	Age	BMI	WC	WHR
SBP	0.236**	0.442**	0.286**	0.076
DBP	0.176*	0.126**	0.248**	0.099
Glucose levels	0.192*	0.412**	0.246**	0.089

**Correlation is significant at 0.01 level (2 tailed)
*Correlation is significant at 0.05 level (2 tailed)

Mala population

The descriptive statistics, prevalence of risk factors and correlation test conducted between age and obesity measures (BMI,WC and WHR) with SBP, DBP, and Glucose levels is presented in tables 7, 8 and 9 respectively.

Table 7: Descriptive statistics for variables in *Mala* population

Variables	Male (n=184)		Female (n=160)	
	Urban (84)	Rural (100)	Urban (70)	Rural (90)
	Mean±S.D	Mean±S.D	Mean±S.D	Mean±S.D
Age (yrs)	40.08±11.12	41.81±10.31	38.14±9.86	39.42±10.24
Height (cm)	165.74±7.14	164.21±8.48	151.49±5.31	150.97±5.42
Weight (kg)	57.24±9.40	52.20±9.50	48.74±7.34	47.49±9.63
Body Mass Index (kg/m^2)	22.54±3.41	20.91±3.40	20.98±4.22	20.12±3.49
Waist circumference (cm)	77.41±8.40	74.81±7.67	73.22±7.25	72.46±6.72
Hip circumference (cm)	89.34±7.44	84.50±6.54	90.48±9.46	87.67±7.48
Waist-Hip Ratio	0.88±0.06	0.87±0.05	0.81±0.05	0.80±0.04
Triceps sft(mm)	10±3.5	7±3.4	12±4.1	8±4.3
Biceps sft(mm)	5±3.5	4±2.9	7±3.2	6±2.4
Subscapular sft(mm)	13±4.9	11±4.0	14±4.6	12±5.2
Suprailiac sft(mm)	14±5.6	13±2.6	15±4.2	13±4.8
Abdominal sft(mm)	15±6.1	14±4.2	18±4.0	15±5.0
Systolic blood pressure (mmHg)	119.47±11.98	117.65±12.98	120.86±11.42	114.80±11.86
Diastolic blood pressure (mmHg)	84.62±8.2	82.96±7.21	82.88±5.60	78.98±8.98
Glucose (mg/dl)	108.46±16.73	104.46±15.48	106.82±18.46	100.96±20.24

Table 8. Percent prevalence of obesity, hypertension, type 2 diabetes and behaviourable variable in *Mala* population

Variable	Urban	Rural
Obesity (BMI ≥30)	17.79	10.24
Abdominal obesity	17.34	9.78
Hypertension ≥140/90 mmHg	16.71	10.79
Hypergylycemia	9.72	6.79
Smoking	32.94	50.39
Alcoholic consumption	24.96	29.54
Low/sedentary physical activity	32.84	12.91

Table 9: Association of age, BMI, WC and WHR with SBP, DBP and Blood glucose levels in *Mala* population

Variable	Age	BMI	WC	WHR
SBP	0.299**	0.280**	0.398**	0.098
DBP	0.076	0.232*	0.187*	0.187*
Glucose levels	0.121	0.256**	0.341**	0.087

**Correlation is significant at 0.01 level (2 tailed)
*Correlation is significant at 0.05 level (2 tailed)

It is observed from the tables that greater mean values are observed in urban than rural population in all the three populations ($p<0.05$). Greater mean values are found among upper caste populations (Reddy and Balija) compared to Mala(lower caste population) ($p<0.05$). However, in urban this trend is minimum. It was found that the prevalence of obesity, hypertension, type 2 diabetes and sedentary life style was higher among urban than rural dwellers and in upper than lower caste populations ($p<0.05$). The habit of smoking is observed to be higher among the rural ones ($p<0.05$). None of the female subjects is smoker and alcoholic. The correlation coefficients between obesity(BMI,C

and WHR) with blood pressure and glucose levels shows that general obesity (BMI) and abdominal obesity (measured through WC) had significant associations with blood pressure and glucose levels in three endogamous populations. Our results are in agreement with the earlier research studies on south Indian population groups that BMI and WC had significant associations with CHD risk factors (Venkatramana and Chengal Reddy, 2002). The results showed that the prevalence of obesity, hypertension and hyperglycemia has been showing an increasing trend compared to the earlier studies (Nirmala Reddy, 1998; Venkatramana and Chengal Reddy, 2002). The results on the epidemiology of obesity, hypertension and type 2 diabetes are discussed as under:

Obesity:

The research results shows that the age standardized prevalence of obesity increased from 3.2% in 1975 to 10.8% in 2014 in men and from 6.4% to 14.9% in women (NCD-RISC, 2016). It is estimated that by 2025, global prevalence of obesity will reach 18% in men and 21% in women (NCD-RISC, 2016). Men showed higher rate of overweight and obesity in developed countries, whereas in developing countries, women showed higher rate of overweight and obesity. In developed countries, men than women above 15 years showed higher rate of overweight and obesity peaking at 55 years in men and 60 years in women. In developing countries, women than men showed higher rates of overweight and obesity and peaking at 55 years in women and 45 years in men. It is estimated that 50% (693 million) of obese people live ten countries namely USA, China, India, Russia, Brazil, Mexico, Egypt, Pakistan, Indonesia, and Germany. Half of the population were found to be obese in men of Tonga and women of Kuwait, Mincronesia, Libya, Qatar, Tonga and Somoa.

In India, 3.7% of men and 4.2% of women were found to be obese (Ng et al., 2014). Higher prevalence of obesity was observed in both sexes in urban than rural areas (men: 15.9% vs 5.6%; women: 23.5% vs 7.2%) in India (Report of National commission on population, India, 2006). The postulated risk factors for increasing obesity were increase in calorie intake, changes in the composition of diet, declining levels of physical activity and changes in the gut microbiome (Ng et al., 2014).

National Family Health Survey 2015-16 (NFHS-4) shows that there is a sharp rise in the prevalence of obesity in most of the Indian states. The prevalence of obesity is more than 30% in Andhra Pradesh, Andaman and Nicobar, Puducherry, Sikkim and Chandigarh whereas the prevalence of obesity is more than 10 per cent in Bihar, Madhya Pradesh, Meghalaya, Tripura and West Bengal. The prevalence has doubled since the last National Family Health Survey of 2005-06. The survey also shows that the prevalence of obesity is more in urban population compared to their rural counterparts, however a rising trend is observed in rural areas as well.

In India, cited reasons for increase in obesity were increasing urbanization, use of mechanized transport, increasing availability of processed and fast foods, increased television viewing, adoption of less physically active lifestyle and consumption of more energy dense, nutrient-poor diets (Pradeepa et al., 2015). No country showed decline in obesity in last 35 years. Increased risk of cardiovascular disease, cancer, diabetes, osteoarthritis, chronic kidney disease was observed with the rise of BMI above 23. Majority of deaths due to cardiovascular deaths (coronary heart disease and stroke) were

attributed to overweight and obesity through mediation of elevated blood pressure and cholesterol (Ng et al., 2014).

Type 2 Diabetes

he prevalence of type 2 diabetes among the Indian populations (King *et al*., 1988; Gupta and Phatak, 2003; Mohan *et al*., 2004; Ramachandran *et al*., 2005) including in the present study is increasing alarmingly. The earlier studies shows that the prevalence is 2.4% in the rural population as compared to 11.6% in the urban population in south India (Ramaiya *et al*., 1990; Ramachandran *et al*., 1997) while in north India (Moradabad) the prevalence of diabetes was 2.8% vs. 6.0 % respectively in rural and urban areas (Singh *et al*., 1998). In developing countries, the prevalence of diabetes is lower among those with a low income than among more affluent groups (Sayeed *et al*., 1997; Mbanya *et al*., 1997; Mohan *et al*., 2001). The socio-economic status (SES) shows that a significant role in diagnosis of diabetes. In Bangalore Urban district Diabetes (BUD) Study a four-year delay in diagnosis of diabetes was observed between the highest and lowest SES groups (Rayappa *et al*., 1999).The higher SES group had two-fold higher prevalence of diabetes compared to the lower socio-economic group (Mohan *et al*., 2001). The reason for high prevalence has been attributed to the consumption of unhealthy diets like foods rich in calorie and fat and lack of physical activity in the higher SES group. The same study also demonstrated that the prevalence of components of the insulin resistance syndrome, which includes diabetes, hypertension, dyslipidemia and obesity are more common among the higher SES, compared to lower SES (Mohan *et al*., 2001; Deepa *et al*., 2002; Pradeepa *et al*., 2003). The higher prevalence of diabetes mellitus in the urban strata of Indian society adds on to the serious implications on the economy of our country.

In the developed countries, most studies suggest that higher prevalence of type 2 diabetes, associated risk factors and diabetic complication rates vary inversely with socio-economic status i.e., in the lower SES population (Brancati *et al*., 1996; Connolly *et al*., 2000). The reason for the higher prevalence of type 2 diabetes among subjects with lower socio-economic status could be due to practice of unhealthy life style (Helmert *et al*., 1990), nutritional inadequacies and psychological stress (Feinstein, 1993).

The reasons for high prevalence of obesity and other risk factors in these population may be due to a considerable shift in their dietary and lifestyle profile. The dietary profile is changed to a mixture of rural and urban diets, with higher consumption of saturated fat and low intake of fibre. Further, most of these people used to be hard working farmers in the fields in their villages, and have changed to sitting around on the roadside as vendors, thus radically changing their activity profile. Barker's hypothesis may also be invoked to explain these observations (Hales *et al*., 1991; Barker *et al*., 1993). Although originally reported from the developed countries, these observations have now been recorded from the Indian subcontinent as well (Yajnik *et al*., 1995; Fall *et al*., 1998).

The metabolic effects of adverse in-utero environment and low birth weight appear in childhood and adolescence, and may be further exacerbated in the face of deteriorating lifestyle factors. Such a situation is likely to occur in economically deprived people who move from the villages to large cities. Further, activation of hypothalamus and pituitary adrenocortical axis is known to occur due to adverse socio-economic circumstances, which is often combined with psychological stress and 'physiological defeat reaction

(Bjorntorp *et al*., 1991; Bjorntorp, 1996). Increased WHR and generalized obesity may thus result (Brunner *et al*., 1997).

Cross-sectional epidemiological studies have shown that physical inactivity was associated with type 2 diabetes and glucose intolerance within populations. Groups of subjects with type II diabetes were found to be less active currently (Taylor, 1983; Taylor, 1984; King, 1984; Dowse, 1990; Ramaiya, 1991; Kriska, 1993) than nondiabetic persons. In addition, cross-sectional studies that have shown the relationship between physical activity and glucose intolerance (Kriska, 1993; Periera, 1995). It is thus clear that a combination of environmental and genetic factors contribute to diabetes. The increased prevalence of obesity in the urban adolescents, a factor responsible for development of diabetes could also be due to sedentary activity (Ziv, 1995).

National Family Health Survey 2015-16 (NFHS-4) shows that the prevalence of type 2 diabetes is between 10% to 15 % in many Indian states (Andhra Pradesh, Goa, Puducherry, Tamilnadu, Tripura, West Bengal, New Delhi, Kerala, Andaman and Nicobar, Daman & Diu) but in rest of the states the prevalence is less than 10 per cent. The prevalence is more in urban areas compared to rural and more in males.

The reasons for the rising prevalence of diabetes in Indian populations could be better understood by considering three possible reasons such as environmental factors particularly associated with urbanization, stronger genetic factors and increased insulin resistance. Urbanization produces lifestyle changes involving changes in diet habits, low levels of physical activity, and increased mental stress. Dietary changes include consumption of excess calories, reduction in complex carbohydrates, and increased consumption of simple sugars and fats. Such diets have been partly responsible for

several conditions including diabetes, cardio-vascular diseases, cancer and gastrointestinal problems (Ramachandran, 2003). Socio-economic development over the last 40-50 years in India has resulted in a dramatic change in lifestyle from traditional to modern, leading to physical inactivity due to technological advancement; affluence leads to consumption of diets rich in fat, sugar and calories and a high level of mental stress (Mohan *et al*., 2004). All these could adversely influence insulin sensitivity and lead to obesity. This could be reflecting the prevalence variation in India, comparing urban and rural populations.

Hypertension

Research studies undertaken on hypertension epidemiology in India have shown higher prevalence in both urban and rural areas (Gupta et al., 1996 and Gupta 2004). Indian urban population studies from the mid-1950s to late 1990s used the older WHO guidelines for diagnosis (known hypertension or BP ≥160 mm Hg systolic and/or ≥ 95 mm Hg diastolic). A significantly increasing adult prevalence of hypertension has been reported changing from 4.4% in Agra (Mathur, 1961), 6.4% in Rohtak (Gupta, 1975), 15.5% in Bombay (Dalal, 1980), 14.1% in Ludhiana (Sharma et al., 1985), 11.0% in Jaipur (Gupta et al., 1995), 11.6% in Delhi (Chadha et al., 1997), and 13.1% in Chandigarh (Thakur et al., 1999) (χ 2 for trend = 5.99, P = 0.014). Although there is a lower prevalence of hypertension in rural Indian populations, there has been a steady increase over time here as well. Prevalence increased from 0.5% in Bombay (Shah and Kunjannam, 1959), 2.0% in Delhi (Padmavati et al.,1959), 3.6% in Haryana (Gupta et al., 1978), 5.4% in Delhi (Wasir et al.,1983), 5.6% in Rajasthan (Baldwa et al., 1984), 4.0% in Maharashtra (Joshi et al., 1993), 3.4% in Maharasthtra (Jajoo et al., 1993), 7.1% in

Rajasthan (Gupta and Sharma, 1994) and 3.6% in Haryana (Gilberts et al., 1998) (χ 2 for trend = 2.75, P = 0.097).

In Kerala Joseph et al. (2000) reported that rural subjects are almost urbanized, the prevalence has been reported to be as high as 17.8 (1993) and 12.5% (1994). Prevalence of hypertension using the current criteria (known hypertension or systolic BP ≥140 mm Hg and/or diastolic BP ≥90 mm Hg) has been reported among some urban Indian populations and in population-based studies. Gupta et al. (1995) reported hypertension in Jaipur in 30% men and 33% women aged ≥20 years, Joseph et al. (2000) reported it in 31% men and 41% women in Thiruvananthapuram, while Mohan et al. (2007) reported a crude prevalence rate of 21% in Chennai. Anand (2000) reported hypertension in 34% middle-class executives in Mumbai, but after multiple BP measurements it was confirmed in 27% male and 28% female officers. Gupta et al. (2003) reported its prevalence in 36% men and 37% women in Jaipur. Gupta et al. (2004) reported hypertension in 44% men and 45% women in Mumbai. Reddy et al. (2006) also reported high prevalence of hypertension in a study among industrial populations at multiple sites in India. These findings are in consonance with many developed countries where it has been reported that at any given time almost half of all individuals have high BP (Kearney et al., 2005).

Panesar et al (2013) were studied to assess the prevalence and identify the correlates of hypertension among adult residents of a slum-resettlement colony in east Delhi. The overall prevalence of hypertension was 17.4%. The prevalence was slightly higher in men (17.8%) than in women (17.1%). Among the studied participants 35% were

prehypertensive. The prevalence was 5.7%, 19.3%, 31.9% and 36.6% in age groups 20–29, 30–39, 40–49 and 50–59 years, respectively. Kashyap et al. (2015) aimed to determine prevalence of hypertension in a rural area of Jharkhand, and to find the association between hypertension and selected socio-demographic variables. Prevalence of hypertension and pre-hypertension in the population was found to be 19.8% and 27.6% respectively. Hypertension was significantly associated with age (p-value < 0.001), ethnicity (p-value = 0.017) and educational status (p-value = 0.005) of study subjects. Significant association was not found with sex (p-value = 0.075) and occupation (p-value = 0.167) of the subjects. Hypertension occurs in 25-30% of middle aged individuals in urban and 15-20% in rural areas of the country (Gupta and Gupta, 2013). The Prospective Urban Rural Epidemiology (PURE) study has reported that hypertension prevalence in South Asian adults aged 35- 70 years varies from 30.7% in India, 33.5% in Pakistan and 39.3% in Bangladesh (Chow et al., 2013). Among those with hypertension, awareness (40.4%), treatment (31.9%) and control (13.0%) are very low (Chow et al., 2013).

National Family Health Survey 2015-16 (NFHS-4) shows that the prevalence of hypertension is in between 15 to 20% in few states of north east (Sikkim, Arunachal Pradesh and Assam) and also in Punjab & Andaman. But in rest of the states (Andhra Pradesh, Bihar, Goa, Haryana, Karnataka, Madhya Pradesh, Meghalaya, Puducherry, Tamilnadu, Telangana, Tripura, Uttarakhand and West Bengal) the prevalence is below 10%. As expected the prevalence is more in urban than living and among men than women.

To prevent the increasing prevalence of obesity physical activity should be encouraged, traditional and balanced diet intake, using of public transportation and sports and physical activity levels of school children should be promoted, high taxes should be levied on junk

food and advertisements on junk food should be banned. There is an urgent need for increasing awareness and screening of populations for hypertension, strict adherence to drug regimen and reduced salt intake should be encouraged. Relevant for India and other lower middle and low income countries, are policy initiatives such as creating adequate avenues for pedastrians, increasing taxes on tobacco related products such as beedi and banning of gutkas, free screening facilities of type 2 diabetes and bringing the related medication within the access of people of lower strata, counselling of obese and motivating highly obese to initiate life style changes may go a long in reducing triple burden of non-communicable disease risk factors and non-communicable diseases.

Summary

Retrospective analysis of previous Indian CHD and risk factor epidemiological studies have reported increasing prevalence of the major coronary risk factors such as obesity, hypertension, diabetes, hypercholesterolemia etc., Coronary heart disease (CHD) is forecast to be the most common cause of death globally, including India, by 2020. In the light of this, the present study has been undertaken to assess the prevalence of obesity, hypertension, type 2 diabetes, physical activity and smoking habits in a total sample of 1086 with an age ranging from 20-60 years. The sample have been drawn from three populations such as Reddy (Male=218; Female=182), Balija (Male=180; Female=162) and Mala (Male=184; Female=160) from Chittoor and Kadapa districts of Andhra Pradesh. Informed consent was obtained before participation in the study.

The information on age, behavioural variables and anthropometric measurements were obtained. The behavioural variables like smoking habit and physical activity were obtained using the interview schedule. The smoking was categorized into smokers and non-smokers. The subjects who are currently smokers, past smokers and those who use all forms of tobacco are pooled together as smokers. Physical activity was categorized into three levels such as sedentary, medium and high. Low/sedentary activity refers to people involved in office work, research, teaching, business and owners, medium activity was attributed to dual jobs and land owners who involve in agriculture work, and heavy activity includes farmers actively engaged in the field and agriculture labour.

The anthropometric measurements such as height (cm), weight (kg) waist circumference (cm) and hip circumference (cm) were recorded. The skinfold measurements at five sites (triceps, biceps, subscapular, suprailiac and abdominal) were also collected. Overall

obesity was defined as BMI≥30kg/m^2. Abdominal obesity was diagnosed when waist circumference was ≥102 cm for males and ≥88 cm for females. Subject's blood pressure (systolic and diastolic) levels were measured with Omron automatic blood pressure monitor. Blood glucose levels were collected with Accu-Chek glucose monitor. Subjects were identified as hypertensive, based on the United States Fifth Joint National Committee recommendation (1993), if their blood pressure ≥ 140 mmHg systolic or 90 mmHg diastolic. The subjects were classified as hyperglycaemia (type 2 diabetes) when the blood glucose levels are ≥126mg/dl.

The results show that greater mean values for most of the variables is found among the Reddy and Balija. Further, the prevalence of CHD risk factors is also observed to be greater in Reddy and Balija community than the Mala. When the out come of the present work compared with the erstwhile population groups of India (North India: Wander et al., 1994; Singh et al, 1998; Western India; Gupta and Gupta, 1998; and South Indian Population: Begom and Singh, 1995; Venkatramana and Chengal Reddy, 1998 & 2002; Reddy et al, 2002), it is observed that the South Indian communities including the present population groups are elevated in the prevalence of CHD risk factors. It is also observed that the prevalence of CHD risk factors have been showing increasing trend not only in urban but in rural populations as well. The increasing prevalence of CHD risk factors is attributed to adoption of urban life, increasing consumption of processed fast foods and more energy dense and nutrient-poor diets., and physically inactive lifestyle.

The prevalence of obesity, hypertension and hyperglycemia (urban vs rural) among the three populations are as follows. Among the Reddy : obesity (20% vs 11%); abdominal

obesity (26vs16); hypertension (21% vs 10%); hyperglycemia (10%vs5%); sedentary physical activity (43% vs 23%); In Balija, obesity (20% vs 12%); abdominal obesity (23% vs 16%); hypertension (19% vs 10%); hyperglycemia (10% vs 6%); low physical activity (45% vs 25%). In the case of Mala population the prevalence of obesity (18% vs 10%); abdominal obesity (17% vs 10%); hypertension (17% vs 11%); hyperglycemia (10% vs 8%); low physical activity (33% vs 13%). The prevalence of the CHD factors is comparatively greater among the Reddy followed by other populations. The correlation coefficients in between the obesity with blood pressure and blood glucose levels shows that obesity in general and abdominal obesity in particular had significant association with blood pressure glucose levels.

References

Agrawal, PK. 2002. Emerging obesity in northern Indian states: A serious threat for health. Paper presented at the IUSSP conference in Bangkok, June 10-12.

Berber, A., Santos, R., Fanghane, G. and Sanchez-Reyes, L. 2001. Anthropometric indexes in the prediction of type 2 diabetes mellitus, hypertension and dyslipidaemia in a Mexican population. Int. J. Obesity. 25: 1794–1799

Brown, D.B. About Obesity. International Obesity Task Force. Accessed at http://www.obesity.chair.Ulaval.ca/iotf.htm

Chandrasekhar Rao, P., P. Venkatramana, P. Annaiah and P. Chengal Reddy. Association of Body Composition with Glucose Levels: An Epidemiological Approach. S*outh Asian Anthropologist:* 12: 13-18.

Chandrasekhar Rao, P., P. Venkatramana, P. Annaiah and P. Chengal Reddy. Prevalence and predictors of hypertension in an ethnic population of South India. *The Anthropologist:* 15:193-197.

Dudeja, V., Misra, A., Pandey, R.M., Devina, G., Kumar, G. and Vikram, N.K. 2001. BMI does not accurately predict overweight in Asian Indians in northern India. Br J Nutr. 86: 105-112.

Florentino, R.F. 2002. The burden of obesity in Asia: challenges in assessment, prevention and management. Asia Pacific J Clin Nutr. 11 (Suppl): S676-S680.

Flegal, K.M., Carroll, M.D., Kuezmarski, R.J. and Johnson, C.I. 1998. Overweight and obesity in the United States: Prevalence and trends. 1960-94. Int J Obesity. 22:39-47.

Gill, T.P., Antipatis, V.J. and James, W.P.T. 1999. The global epidemic of obesity. Asia Pacific J Clin Nutr. 8:75-81.

Gopalam, C. Obesity in the Indian urban 'Middle class'. Bulletin of the Nutrition Foundation of India., 19:1-15 (1998).

Gupta, R and Majumdar, S. 1994. Correlation of waist-hip-ratio with coronary heart disease and risk factor prevalence in a rural male population. Ind Heart J. 46: 145-146.

Hunter, G.R., Giger, J.N., Weaver, M., Strickland, O.L., Zuckerman, P. and Taylor, H. Fat distribution and cardiovascular disease risk in African-American women. J Natl Black Nurses Assoc. 11:7-11.

Huxley R, Mendis S, Zheleznyakov E, Reddy S, Chan J. Body mass index, waist circumference and waist hip ratio as predictors of cardiovascular risk—a review of the literature. European Journal of Clinical Nutrition (2010) 64, 16–22.

Inoue, S. 2002. Criteria for obesity in Japan and Asia-Oceania and causes for obesity in Japan. Presentation at the ILSI-SAR symposium and workshop 'Forging effective strategies for prevention and management of overweight and obesity in Asia'. Singapore.

Khor, G.L., Yusof, A.M., Tee, E.S., Kandiah, M. and Huang, M.S.L. 1999. Prevalence of overweight and obesity among Malaysian adults from rural communities. Asia Pacific J Clin Nutr. 8:272-279.

Lean, M.E.J., Han, T.S and Seidell, J.C. 1998. Impairment of health and quality of life in people with large waist circumference. Lancet. 351:853-856.

Lohman, T.G., Roche, A.F. and Mortorell, A.R. 1988. *Anthropometric standardization reference manual*. Human kinetics books, Champaign.

Monteiro, C.A., Mondini, L., Desouza, A.L.M. and Popkin, B.M. 1995. The nutritional transition in Brazil. Eur J Clin Nutr. 49:105-113.

National High Blood Pressure Education Programme. 1993. Working group report on primary prevention of hypertension. US Department of health and human services. NIH Publication. No. 93.2669.

Nirmala Reddy, B. 1998. Body mass index and its association with socio-economic and behavioral variables among socio-economically heterogeneous populations of Andhra Pradesh, India. Hum. Biol., 70:901-917.

Pandya, H Lakhani, D and Patel, N. 2011. Obesity is becoming synonym for diabetes in rural areas of India also – an alarming situation. Int J Biol Med Res. 2 (2): 556-560.

Pascot, A., Lemieux, I., Prud'homme, D., Tremblay, A., Nadeau, A., Couillard, C., Bergeron, J., Lamarche, B. and Despres, J.P. 2001. Reduced HDL particle size as an additional feature of the atherogenic dyslipidemia of abdominal obesity. J lipid Res. 42:2007-2014.

Pradeepa R, Anjana RM, Joshi SR, Bhansali A, Deepa M, Joshi PP et al. Prevalence of generalized and abdominal obesity in urban & rural India the ICMR - INDIAB Study (Phase-I) [ICMR - INDIAB-3].Indian J Med Res. 2015 Aug; 142: 139–150.

Prescott-Clarke, P. and Primatesta, P. 1997. Health survey for England 1995:

Anthropometric measures and children's iron status. London: HMSO (Her Majesty's Stationary Office). 305-345. Series HS no. 7.

Paffenberger, R.S., Hyde, R.T., Wing, A.L., Lee, I.M., Jung, D.L. and Kampert, J.B. 1993. The association of changes in the physical activity level and other life style characteristics with mortality among men. N Eng J Med. 328:538-543.

Randrianjohany, A., Balkau, B. and Cubeau, J. (Year) The relationship between behavioural pattern, overall, and central adiposity in a population of healthy French men. Int J Obes. 17:651-655.

Reddy, KSN., Reddy, KK and Sudha, G. 2010. Overall and abdominal adiposity on blood pressure: Consistency and evaluation of their association in an adult Indian population. Journal of Life Science. 2:117-125.

Siong, T. E. 2002. Obesity in Asia: Prevalence and issues in assessment methodologies. Asia Pacific J Clin Nutr. 11:S694-S701.

Steering Committee, 2000. The Asia-Pacific perspective: Redefining obesity and its treatment. Melbourne: International Diabetes Institute.

Sobol, J. and Stunkard, A.J.: Socioeconomic status and obesity: A review of the literature. Psychol Bull., 105:260-275.

Stunkard, A.J. and Wadden, T.A. 1993. *Obesity: theory and therapy*. Second edition, New York: Raven press.

Venkatramana, P. and Chengal Reddy, P. 1999. An epidemiological study of cardiovascular risk factors. The Anthropologist. 1:195-198.

Venkatramana, P. and Chengal Reddy, P. 2002. Association of overall and abdominal obesity with coronary heart disease risk factors: Comparison between urban and rural Indian men. Asia Pacific J Clin Nutr 11:66-71.

Venkatramana, P., Chandrasekhar Rao, P., Annaiah, P., Madhavi, P. and Chengal Reddy, P. 2005. Prevalence of overweight and obesity among the rural populations of Andhra Pradesh. Hum. Ecol. 13:99-102.

WHO. 1997. Global strategy for non-communicable disease prevention and control (Draft). Geneva. WHO/NCD/GS/97.1.

WHO, 1998. Obesity: Preventing and Managing the Global Epidemic. Report of a WHO consultation on Obesity, Geneva.

WHO, 2002. Nutrition Data Bank. Global Data Base on obesity and body mass index (BMI) in adults. (Accessed at http://www.who.int/nut/db_bmi.htm.

Zhou, B.F. 2002. Predictive values of body mass index and waist circumference of risk factors of certain related diseases in Chinese adults-Study of optimal cut-off points of body mass index and waist circumference in Chinese adults. Biomed Environ Sci. 15:83-95.