2.1. Study area and Nature of Population

The present research work intends to study the association of body mass index with clinical profile of type-2 diabetic patients of Tirupati Municipal Corporation, Chittoor district, Andhra Pradesh State of South India. The patients are thus cross-cultural in nature and represents different socioeconomic strata.

2.1.1. State of Andhra Pradesh

Andhra Pradesh State is one of the 29 states of India, situated on the country's southeastern coast. The State is the eighth largest state in India covering an area of 160,205 km$^2$ (61,855 sq mi). The State borders are Telangana State in the northwest, Chhattisgarh State in the North, Tamil Nadu State in the south, Odisha State in the northeast, Karnataka State in the west and the water body of Bay of Bengal in the east. A small enclave of 30 km$^2$ (12 sq mi) of Yanam, a district of Pondicherry, lies in the Godavari delta to the northeast of the state.

The State has the second longest coastline of 972 km among all the states of India, only second to Gujarat State. There are two regions in the State namely Coastal Andhra and Rayalaseema and hence, the two regions are more often
referred as *Seemandhra* by the news media. There are 13 districts with nine in Coastal Andhra and four in Rayalaseema. Visakhapatnam, Vijayawada, Guntur, Nellore, Kurnool, Rajahmundry, Kadapa, Kakinada, Tirupati and Anantapur are the top 10 largest cities in the State. Hyderabad is the joint capital of both Andhra Pradesh and Telangana States for a period of 10 years.

The State is endowed with a variety of physiographic features ranging from Eastern Ghats, Nallamala Forest, Coastal plains to deltas of two major rivers of Krishna and Godavari. The State is largest producer of rice and hence, nick named as *Rice Bowl of India*. Telugu, which is one of the classical languages in India, is the official language of the State (91%). It is also rich in culture with various pilgrimage destinations of importance like Tirumala temple, alongside a host of historical monuments to the tourists.

Geographically, Andhra Pradesh State is bestowed with two mighty river systems of Krishna and Godavari. Its varied topography ranging from the hills of Eastern Ghats and Nallamallas to the shores of Bay of Bengal supports varied ecotypes, rich diversity of flora and fauna. The climate of Andhra Pradesh State varies considerably, depending on the geographical region. Monsoons play a major role in determining the climate of the State. Economy of the State is mainly based on Agriculture and Livestock. Rice is the major food crop and staple food of the State.

2.1.2. Chittoor District

The present study is carried out in the Chittoor district, also known as Chittur, is a district of India's Andhra Pradesh State in the Rayalaseema region. The word *Chittoor* comes from *Chittoor* (meaning "small town") in Tamil language and also from *chittadavula ooru* ("dense forest" in Telugu). The district headquarters is Chittoor City. The district has a population of 4,170,468 according to 2011 census of India. Chittoor district is famous for the Tirupati, Kanipakam and Sri Kalahasti temples. It is a major market center for mangos, grains, sugarcane and peanuts. There are 66 Mandals in Chittoor district. The district has a population density of 275 inhabitants per square
kilometer (710/sq mi). Its population growth rate over the decade 2001–2011 is 11.33%. Chittoor has a sex ratio of 1002 females for every 1000 males, and a literacy rate of 72.36%.

The district occupies an area of 15,359 square kilometers (5,930 sq mi). The district is bounded by Anantapur district to the northwest, Kadapa district to the north, Nellore district to the northeast, Krishnagiri district, Vellore district and Triuvallur district of Tamil Nadu State to the south, and Kolar district of Karnataka State to the west. Chittoor district lies extreme south of the Andhra Pradesh State approximately between 12°37′ - 14°8′ north latitudes and 78°3′ - 79°55′ east longitudes. Thirty percent of the total land area is covered by forests in the district. Mango and tamarind groves surround the city of Chittoor, and cattle are raised in the district. The soils in the district constitute red loamy 57%, red sandy 34% and the remaining 9% is covered by black clay black loamy, black sandy and red clay.

Out of the total Chittoor district population for 2011 census, 29.50% lives in urban regions of district. Sex Ratio in urban region of Chittoor district is 999 as per 2011 census data. Average literacy rate of Chittoor district in urban population as per census 2011 is 82.26%. As per 2011 census, 70.50% population of Chittoor districts lives in rural areas of villages. In rural areas of Chittoor district, sex ratio is 996 females per 1000 males. Literacy rate in rural areas of Chittoor district is 67.01% as per census data 2011.

2.1.3. Tirupati Municipal Corporation

Tirupati is a major pilgrim and cultural city in the Chittoor district of Andhra Pradesh State. It is located at the foothills of Tirumala, the abode of Lord Sri Venkateswara. It is one of the richest pilgrimage cities of any religious faith in the world. It is located at about 20 kilometers North West of Tirupati at an elevation of 853 meters (2,799 ft).
Tirupati Municipality constituted on 01-04-1886 and it is upgraded as Municipal Corporation on 02-03-2007. Municipal Corporation is spread over an area of 24 Sq.km. with 20 Revenue Wards and 50 Election wards and 42 slums. As per provisional reports of Census India, population of Tirupati in 2011 is 2, 87,035; of which male and female are 145,977 and 141,058 respectively. Although Tirupati city has population of 287,035; its metropolitan population is 459,985 of which 231,456 are males and 228,529 are females. Average literacy rate of Tirupati is 87.55 percent of which male and female literacy is 92.74 and 82.21 percent. The sex ratio of Tirupati is 966 per 1000 males. Child sex ratio of girls is 915 per 1000 boys.

2.2. Sampling

The material selected for the present study is type-2 diabetic patients attending the Outpatient Department at SVRR Medical College Hospital and four other prominent diabetic clinics in Tirupati town of Andhra Pradesh. Selection of one Government clinic and four private clinics allowed us to secure the sample representing all sections of the people. The data collection took place during the period of December 2011 to March 2013. During the period of data collection, a total of 1320 type-2 diabetic patients attended outpatient department in the defined Hospital/ Clinics. All the patients contacted for their possible inclusion in the study. 270 patients (20.45%) are dropped from the study as they do come under exclusion criteria. Further, 132 patients (10%) could not give consent and hence dropped from the study.

Finally, 918 type-2 diabetic patients who are screened for clinical profile are selected upon their written consent. The objectives of the study have been explained before taking the written consent. The exclusion criteria include subjects with suffering from any chronic disease or pregnant/ lactating women. The protocol, case report forms and consent forms are duly approved by the Sri Venkateswara University Ethics Committee on Human Subject Research.

Thus, a total of 918 type-2 diabetic patients (Males=500 and Females=418) in the age range of 30 to above 60 years are enrolled in the study. A structured and standardized questionnaire is used to collect the data on demography, socioeconomic
status, family history and duration of diabetes, physical activity, habit of smoking and alcohol consumption via face-to-face in-depth interviews. The physical assessment included height, weight and circumferences of waist and hip. Subject’s blood pressure is recorded as per the standard procedure. Fasting blood sample is collected in the morning time for biochemical investigation after an overnight fast of at least 10 hours. The serum is separated by centrifugation at 2500 rpm for 20 minutes into pre-labeled sterile tubes and separated serum is used for biochemical analysis to estimate the fasting blood glucose, triglycerides, total cholesterol, HDL cholesterol, LDL cholesterol, and VLDL cholesterol levels.

2.3. Methods

For the purpose of comparison, the subjects are divided into four age groups, like, 30-39 years, 40-49 years, 50-59 years, >60 years. SES is classified into five groups (i.e. SES-I to SES-V) based on scores of education, occupation, housing condition, ownership of durables and per capita income of the family (Singh et al., 1997). SES-I is the highest and SES-V is the lowest class. Physical activity is assessed from occupational and spare time activities and subjects are graded as sedentary, mild, moderate or heavy, based on scores of activities according to Indian criteria (Singh et al., 1997; IPA Questionnaire, 2005).

Physical Activity Assessment:

A. Occupation:

1. Sedentary workers such as office and desk work.
2. Mild activity workers such as peons, postman, tailor, barbers, housewife looking after grownup children, part time house work.
3. Moderate activity workers such as drivers, conductors, artisans, house wife looking after small children, part time housework.
4. Heavy activity workers such as manual labours, carpenters, house maids, all house work.
B. Spare time activity:

5. If walking 14.0Km/week and without any vigorous activity at least 5 days in a week.
6. If gardening in small plots, walking 14-35 Km/week.
7. If walking <35 Km/week, jogging, cycling, sports < 30 minute including swimming and dancing.
8. If walking >35 Km/week, jogging, sports > 30 minute at a time including swimming and dancing.

C. Activity Status:

<table>
<thead>
<tr>
<th>Sedentary</th>
<th>1-2</th>
<th>Mild activity</th>
<th>3-4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moderate activity</td>
<td>5-6</td>
<td>Heavy activity</td>
<td>7-8</td>
</tr>
</tbody>
</table>

2.3.1. Anthropometric Parameters

The physical assessment included height, weight and circumferences of waist and hip as per the procedure specified by Lohman et al (1988). The instruments are calibrated prior to take the measurements.

2.3.1.1. Height or Stature:

It measures the vertical distance from vertex to floor. The height is measured in centimeters using anthropometer rod. The subject is asked to stand on a horizontal platform with the heels together, stretching upward to the fullest extent, aided by the measures on the mastoid processes and by encouraging the subject to 'stand tall, take a deep breath and relax'. The subject’s back is as straight as possible with the head in Frankfort horizontal (F.H) plane while taking the measurement, which is achieved by rounding or relaxing the shoulders and manipulating the posture.
2.3.1.2. **Body Weight:**

The weight is recorded in kilograms to the nearest 0.5 kg with the subject standing bare-foot and with minimum clothing on a weighing machine without any support.

2.3.1.3. **Waist Circumference:**

The waist circumference is taken as the minimum circumference between the umbilicus and xiphoid process and measured to the nearest to 0.1 cm using measuring tape.

2.3.1.4. **Hip Circumference:**

The hip circumference is measured as the maximum circumference around the buttocks posteriorly and the symphysis pubis anteriorly and measured to the nearest to 0.1 cm using measuring tape.

2.3.2. Derived Measurements

2.3.2.1 Body mass index (BMI)

Body mass index is most frequently used to define individuals in to underweight, normal weight, overweight and obesity, which is a single number that evaluates an individual's weight in relation to height (weight in kilograms/height in metres square; kg/m\(^2\)). It is commonly employed index in epidemiological studies, to predict the obesity related morbidity and mortality in adults. Overweight/obesity is defined using the revised criteria as specified by WHO (2004).

<table>
<thead>
<tr>
<th>Classification</th>
<th>BMI (kg/m(^2))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Underweight</td>
<td>≤ 18.49</td>
</tr>
<tr>
<td>Normal range</td>
<td>18.50 - 24.99</td>
</tr>
<tr>
<td>Overweight</td>
<td>25.00 - 29.99</td>
</tr>
<tr>
<td>Obese</td>
<td>≥ 30.00</td>
</tr>
</tbody>
</table>
2.3.2.2. Waist Hip Ratio (WHR)

Waist hip ratio is calculated as waist circumference/hip circumference. WHR (Abdominal obesity) is diagnosed when WHR is >0.9 in males and >0.8 in females as per the National Cholesterol Education Programme (NCEP, 2002).

2.3.3. Physiological Parameters

2.3.3.1. Blood Pressure

Blood pressure is measured at the study site by measuring the appearance and disappearance of Korotkoff’s sounds to the nearest 2 mmHg on a seated subject, with a random zero mudler sphygmanometer as specified by Rose et al. (1982).

Hypertension is diagnosed when the systolic blood pressure is > 140 mmHg and/or the diastolic blood pressure is > 90 mmHg, as per the guidelines prescribed by the seventh joint national committee on detection, evaluation and treatment of high blood pressure (Chobanian, 2003).

2.3.4. Biochemical Parameters

A fasting blood sample is collected in the morning for biochemical investigation after an overnight fast of at least 10 hours. Two ml of blood sample is drawn from each subject by anticubital vein puncture with the help of a disposable syringe and needle. It is transferred into sterile, clean pre-labeled tube containing disodium ethylenediamine tetra-acetate (EDTA) as anticoagulant (0.5 mg/ ml) and immediately placed on ice in a thermos flask. These tubes are then brought to the laboratory in ice box to the Department of Anthropology, Sri Venkateswara University, Tirupati. The serum is separated after centrifugation at 2500 rpm for 20 minutes into pre-labeled sterile tubes and separated serum is used for biochemical analysis. Biochemical analyses include estimation of fasting blood glucose only.
2.3.4.1. Estimation of Blood Glucose

Blood glucose is determined by the glucose-oxidase method with an intra- and inter-assay coefficient of variation of <1% as per the procedure of Trinder (1964). Glucose is oxidized by the enzyme Glucose oxides (GOD) to give D- gluconic acid and hydrogen peroxide. Hydrogen peroxide in the presence of the enzyme Peroxidase (POD) oxidizes phenol which combines with 4-Aminoantipyrine to produce a red colored quinoneimine dye. The intensity of the color developed is proportional to glucose concentration in the sample.

\[
\text{GOD} \\
\text{D-Glucose + H}_{2}\text{O +O}_2 \rightarrow \text{D-Gluconic acid +H}_2\text{O}_2
\]

\[
\text{POD} \\
\text{H}_2\text{O}_2 + 4\text{Aminoantipyrine + Phenol} \rightarrow \text{Quinoneimine dye + H}_2\text{O}
\]

**Reagents:** Enzyme reagent, Buffer solution and Glucose standard (100 mg %)

**Reagent storage and stability:** All reagents are stable for three months at 2-8°C.

**Reagent preparation:** Dissolve the enzyme reagent with 125 ml of buffer solution in the empty bottle. Mix gently to dissolve. The prepared reagent is stable for at least 90 days when stored at 2-8°C.

**Procedure:** Pipette into a clean dry test tube labeled blank (B) standard (S) and test (T)

<table>
<thead>
<tr>
<th>Details</th>
<th>Blank (ml)</th>
<th>Standard (ml)</th>
<th>Test sample (ml)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enzyme reagent</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>Distilled water</td>
<td>0.01</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Standard glucose</td>
<td>-</td>
<td>0.01</td>
<td>-</td>
</tr>
<tr>
<td>Sample</td>
<td>-</td>
<td>-</td>
<td>0.01</td>
</tr>
</tbody>
</table>
To 10 microlitres of the test sample, 1000 microlitres of the enzyme reagent is added, mixed well and incubated at 37°C for 10 minutes. Measures of the absorbance of test and standard against blank on a spectrophotometer at 505 nm (Hg 546 nm).

**Calculation:**

\[
\text{Glucose in mg\%} = \frac{\text{Absorbance of Test Sample}}{\text{Absorbance of Standard}} \times 100
\]

**Precision:** The coefficient of variation determined is 1.8% (n=20).

Hyperglycaemia is defined as blood glucose >120 mg% (Diabetes Care, 2005; WHO, 2007).

### 2.3.4.2. Estimation of Total Cholesterol

Total cholesterol in serum is determinant using visible spectrophotometer. Cholesterol is a steroid, which exists in free as well as in esterifies form. Many methods developed for cholesterol estimation rely on color procedure either in strongly acidic conditions or by the action of specific enzymes. The use of strong corrosive acids and the instability of reagents stand as limitations of many conventional chemical methods. Allain et al., (1974) developed a method in which both the separate step of hydrolysis of cholesterol ester and oxidation of cholesterol are carried out a single system containing esterase and oxidase enzymes.

Cholesterol esterase (CHE) is hydrolysis cholesterol ester. Free cholesterol is oxidized by the cholesterol oxidase (CHO) to cholest-4-en-3-one and hydrogen peroxide. Hydrogen peroxide formed reacts with 4-aminophenazone and phenol in the presence of peroxidase (POD) to produce pink colored quinine-imine dye. The intensity of color produced is proportional to the cholesterol concentration.
**Reagents:** Enzyme reagent, Buffer solution and Cholesterol standard (200 mg %).

**Reagent storage and stability:** All reagents are stable for at 2-8°C.

**Reagent preparation:** Reconstitute the enzyme reagent with 35 ml of buffer solution in the empty bottle. The prepared reagent is stable for at least four weeks when stored at 2-8°C. The prepared reagent is protected from light.

**Procedure:** Pipette into a clean dry test tube labeled blank (B) standard (S) and test (T)

<table>
<thead>
<tr>
<th>Details</th>
<th>Blank (ml)</th>
<th>Standard (ml)</th>
<th>Test sample (ml)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enzyme reagent</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>Distilled water</td>
<td>0.02</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Standard cholesterol</td>
<td>-</td>
<td>0.02</td>
<td>-</td>
</tr>
<tr>
<td>Sample</td>
<td>-</td>
<td>-</td>
<td>0.02</td>
</tr>
</tbody>
</table>

To 10 microlitres of the test sample, 1000 microlitres of the enzyme reagent is added, mixed well and incubated at 37°C for 10 minutes. Measures of the absorbance of test and standard against blank on a spectrophotometer at 505 nm (Hg 546 nm).

**Calculation:**

\[
\text{Cholesterol in mg\%} = \frac{\text{Absorbance of Test sample}}{\text{Absorbance of Standard}} \times 200
\]
**Precision:** The coefficient of variation determined is 2.1% (n=40). The cholesterol values are classified following National Cholesterol Education Programme (NCEP, 1994) guidelines.

Hypercholesterolemia:
- < 200 mg/dL – Desirable
- 200-239 mg/dL – Moderate risk
- > 240 mg/dL – High risk

2.3.4.3. Estimation of HDL cholesterol

Serum high density lipoprotein cholesterol (HDLC) is estimated using the method of Wiebe and Jaysmith (1985).

**Reagents:** Precipitating reagent, HDLC standard (25 mg%).

**HDL cholesterol assay:**

**Step 1-** Precipitation of VLDL and LDL

Pipette into a clean dry centrifuge tube

<table>
<thead>
<tr>
<th>Details</th>
<th>Blank (ml)</th>
<th>Standard (ml)</th>
<th>Test sample (ml)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enzyme reagent</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>Distilled water</td>
<td>0.05</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>HDLC Standard</td>
<td>-</td>
<td>0.05</td>
<td>-</td>
</tr>
<tr>
<td>Supernatant from step 1</td>
<td>-</td>
<td>-</td>
<td>0.05</td>
</tr>
</tbody>
</table>

Mix well and allow standing at RT for 5 minutes. Centrifuge at 2000-3000 rpm for 10 minutes to obtain a clear supernatant.

**Step 2-** Assay of HDL Cholesterol

Pipette into a clean dry test tube labeled Blank (B), Standard (S) and Test (T).
Mix well and incubate at 37°C for 5 minutes. Measure the absorbance of Test sample (T) and Standard (S) against Blank (B) on a spectrophotometer at 505 nm (Hg 546 nm).

**Calculation:**

\[
\text{HDL cholesterol in mg\%} = \frac{\text{Absorbance of Test sample}}{\text{Absorbance of Standard}} \times 50
\]

HDLc values are classified according to the National Cholesterol Education Programme (NCEP, 1994) guidelines.

- HDLC > 40 mg/dL – Desirable
- 40-35 mg/dL – Moderate risk
- < 35 mg/dL – High risk

### 2.3.4.4. Estimation of Triglycerides

Serum triglycerides are estimated using the method of Fossati and Prencipe (1982). Triglycerides are hydrolyzed by lipase to glycerol and free fatty acids. Glycerol is phosphorylated by ATP in the presence of Glycerol kinase (GK) to Glycerol-3-phosphate (G-3-P) which is oxidase by the enzyme Glycerol-3-phosphate oxidase (G-P-O) producing hydrogen peroxide. Hydrogen peroxide so formed react with 4-aminophenazone and 3,5-dichloro-2-hydroxy benzene sulfonic acid (DHBS) in the presence of the enzyme peroxide (POD) to produce a red quinine-imine dye. The intensity of the color developed is proportional to the triglycerides concentration.

\[
\text{Triglycerides + H}_2\text{O} \xrightarrow{\text{Lipase}} \text{Glycerol + Fatty acids} \xrightarrow{\text{Triton x-100}} \text{Glycerol + fatty acids} \\
\text{Glycerol + ATP} \xrightarrow{\text{GK}} \text{L- } \alpha\text{-glycerol-phosphate} \xrightarrow{\text{MgCl}_2}
\]
L-α-glycerol-phosphate + O₂ → \( \text{H}_2\text{O}_2 \) + Dihydroacetonephosphate

\( \text{H}_2\text{O}_2 \) + 3, 5-dichloro-2-hydroxy benzene sulfonic acid + 4-aminophenazonel → \( \text{POD} \)

\( \text{K}_4\text{Fe(CN)}_6 + \text{K}_3\text{Fe(CN)}_6 \)

Red quinine-imine dye + 2H₂O

**Reagents:** Enzyme reagent, Buffer solution and Triglyceride standard (200 mg %).

**Reagent storage and stability:** All reagents are stable for at 2-8°C.

**Reagent preparation:** Reconstitute the enzyme reagent with 15 ml of buffer solution in the empty bottle. The prepared reagent is stable for at least three weeks at 2-8°C.

**Procedure:** Pipette into a clean dry test tube labeled blank (B) standard (S) and test (T)

<table>
<thead>
<tr>
<th>Details</th>
<th>Blank (ml)</th>
<th>Standard (ml)</th>
<th>Test sample (ml)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enzyme reagent</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>Distilled water</td>
<td>0.02</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Triglyceride standard</td>
<td>-</td>
<td>0.02</td>
<td>-</td>
</tr>
<tr>
<td>Sample</td>
<td>-</td>
<td>-</td>
<td>0.02</td>
</tr>
</tbody>
</table>

Mix well and incubate at 37°C for 5 minutes. Measure the absorbance of Test sample (T) and Standard (S) against Blank (B) on a spectrophotometer at 505 nm (Hg 546 nm). The final color is stable for 30 minutes.

**Calculation:**

\[
\text{Serum Triglycerides in mg\%} = \frac{\text{Absorbance of Test sample}}{\text{Absorbance of Standard}} \times 200
\]

**Precision:** The coefficient of variation determined is 0.73% (n=20). The triglyceride values are classified following National Cholesterol Education Programme (NCEP, 1994) guidelines.
Triglycerides:  
- < 150 mg/dL – Desirable
- 150-199 mg/dL – Moderate risk
- > 200 mg/dL – High risk

2.3.4.5. Estimation of LDL cholesterol:

The LDL-cholesterol is calculated by using Friedewald’s (1972) formula.

\[
LDL \text{ cholesterol} (\text{mg} \%) = TC - TG/5 - HDL \text{ cholesterol}
\]

The obtained LDLC values are classified following National Cholesterol Education Programme (NCEP, 1994) guidelines.

- LDL cholesterol:  
  - < 130 mg/dL – Desirable
  - 130-160 mg/dL – Moderate risk
  - > 160 mg/dL – High risk

2.3.4.6. Estimation of VLDL Cholesterol:

The VLDL cholesterol is calculated by using the formula of Wilson and Spiger (1973).

\[
VLDL \text{ cholesterol} (\text{mg} \%) = \frac{\text{Triglycerides}}{5} \text{ OR } TC - (\text{HDLC} + \text{LDLC})
\]

2.3.4.7 Metabolic Syndrome (MetS) Definition:

MetS is defined according to the census definition (IDF/ NHLBI/ AHA/ WHF/ IAS/ IASO) (Alberti et al., 2009). Participants are defined as having MetS if they met, or exceeded, the criteria for three or more of the following five variables:

a) WC ≥90 cm in men and ≥85 cm in women
b) BP ≥140/90 mmHg
c) FBG level ≥120 mg%
d) TG ≥200 mg% and
e) HDL cholesterol ≥40 mg%
2.4. Statistical Analysis

Statistical analysis is carried out via Statistical Package of Social Sciences (SPSS) version 16.0 (SPSS Inc, 2007) and alpha levels are set at p<0.05. The sample size is varies from variable to variable due to non availability of data. Continuous variables are provided with descriptive statistics and discontinuous variables with percentages. Mean values between groups are compared with students “t” test and within the age groups, socioeconomic status and physical activity with one way analysis of variance (ANOVA). Chi square test is applied to see the association of overweight/obesity with age, socioeconomic status and physical activity. Bivariate relationships among the variables are tested by Pearson correlation coefficients. Age and sex adjusted binominal logistic regression model is used to see the effect of socioeconomic and lifestyle factors towards the prevalence of overweight and obesity. Further a simple linear regression model is fitted to see the variation exerted by the body mass index on blood pressure and blood glucose levels after adjusting for age and sex.

2.4.1. Statistical Treatment:

The following statistical measures are employed for the analyses of the data.

2.4.1.1. Descriptive statistics

i) Arithmetic Mean

This is one of the measures of location which is a most widely used measure representing the entire data by one value.

\[
A.M. = \bar{X} = \frac{(\sum f d)}{N} \times C.I
\]

Where,

A = Assumed or arbitrary mean

fd = Summation of class frequency (f) deviation from the assumed mean measured in classes (d)

C.I = Class Interval
ii) Standard deviation (S.D.)

It is a measure of dispersion and is the square of variance.

\[ S.D.(\sigma) = \sqrt{\left(\frac{\sum fd^2}{N}\right) - \left(\frac{\sum fd}{N}\right)^2} \times C.I \]

Where,
- \( f \) = Class frequency
- \( d \) = deviation from the assumed mean measured in classes
- \( N \) = Total number
- \( C.I \) = Class interval

2.4.1.2. Tests of significance

Different tests are employed to evaluate the magnitude of difference between the observed and expected values of variables under comparison.

i) Chi – square \( (\chi^2) \) test

To test the significance of difference between the observed \((O_i)\) and expected \((e_i)\) numbers for a given set of variables \((k)\) distributed in \(r\times c\) contingency tables, the following formula is applied.

\[ \chi^2 = \sum_{i=1}^{k} \frac{(o_i - e_i)^2}{e_i} \]

An appropriate correlation \((0.5)\) has been made whenever necessary for continuity when the exact distribution of \(\chi^2\) in a \(r\times c\) \((\text{eg.} 2\times 2)\) table is discrete. The following is the formula.

\[ \chi^2 = \frac{\left[(o_i - e_i) - 0.5\right]^2}{e_i} \]

The degree of freedom \((df)\) is noted as number of categories in rows – 1 x number of categories in columns-1.
ii) t-test

The t test is applied to know the significance difference, if any, between the mean values of quantitative variables of various components.

\[ t = \frac{\bar{x}_1 - \bar{x}_2}{\sqrt{S.E^2_1 + S.E^2_2}} \text{ with df } (n_1 + n_2 - 2) \]

Where,

\( \bar{x}_1 \) = Mean of the variables of first sample

\( \bar{x}_2 \) = Mean of the variable of second sample

\( S.E_1 \) = Standard error of first sample

\( S.E_2 \) = Standard error of second sample

\( n_1 \) = Size of the first sample.

\( n_2 \) = Size of the second sample

In case of dermatoglyphics the variables \( x_1 \) on the right (R) and left (L) hands of an individual are not independent; hence paired t-test is applied to see the significance of difference between the palms.

\[ t = \frac{\bar{d}}{sd} \text{ with } (n - 1) \cdot df \]

Where,

\( \bar{d} = \sum d_i / n \)

\( d_i = X_{ir} - X_{il}, \text{ and} \)

\[ sd = \sqrt{\frac{\sum d_i^2 - (\sum d_i)^2 / n}{(n - 1)n}} \]
iii) F – test (ANOVA)

Analysis of variance (ANOVA) is performed to know the extent of variability so as to understand whether the variance between the groups is more than that within the group. The procedural steps are tabulated below.

**ANOVA TABLE**

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>Sum of squares (SS)</th>
<th>df</th>
<th>Mean squares (MS)</th>
<th>F-test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between the groups</td>
<td>$\sum_{i=1}^{h} k \left( \bar{x}_i - \bar{x} \right)^2$</td>
<td>$h-1$</td>
<td>$\sum_{i=1}^{h} k \left( \bar{x}_i - \bar{x} \right)^2 / h - 1$</td>
<td>Between MS</td>
</tr>
<tr>
<td>Within the group</td>
<td>$\sum_{i=1}^{h} \sum_{j=1}^{k} k \left( x_{ij} - x_i \right)^2$</td>
<td>$N-h$</td>
<td>$\sum_{i=1}^{h} \sum_{j=1}^{k} k \left( x_{ij} - x_i \right)^2 / N - h$</td>
<td>Within MS</td>
</tr>
<tr>
<td>Total</td>
<td>$\sum_{i=1}^{h} \sum_{j=1}^{k} k \left( x_{ij} - x_i \right)^2$</td>
<td>$N-1$</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

iv) Bivariate Pearson Correlation

The bivariate Pearson Correlation produces a sample correlation coefficient, $r$, which measures the strength and direction of linear relationships between pairs of continuous variables. By extension, the Pearson Correlation evaluates whether there is statistical evidence for a linear relationship among the same pairs of variables in the population, represented by a population correlation coefficient, $\rho$ (“rho”). The Pearson Correlation is a parametric measure. This measure is also known as Pearson’s correlation and Pearson product-moment correlation (PPMC).

The bivariate Pearson Correlation is commonly used to measure the Correlations among pairs of variables, Correlations within and between sets of variables. The bivariate Pearson correlation indicates the whether a statistically significant linear relationship exists between two continuous variables, the strength of a linear relationship (i.e., how close the relationship is to being a perfectly straight line), the direction of a linear relationship (increasing or decreasing).
Comparing bivariate correlations within a single population

Our first question was whether there is a difference between the correlations that the two predictors family social support (FASS) and loneliness (RULS) have with the criterion variable stress. This is called a question about “correlated correlations.” The two correlations being compared are not independent, because they share a variable, in this case, the criterion variable.

The long-time standard test of correlated correlations (originally designed for use with experimental data) is Hotelling’s t-test, shown below:

\[
t = \frac{[r_{12} - r_{13}] \times \sqrt{\frac{N-3}{2 \times [1-r_{23}^2 - r_{12}^2 - r_{13}^2 + [2*r_{23}*r_{13}]]}}}{\sqrt{N-3}}
\]

\[df = N - 3\] if \(|t| > t\text{-critical}\), then Reject \(H_0\): at that \(p\)-value

Steiger’s Z-test for "correlated correlations" within a population

Under some circumstances Hotelling's \(t\) will overestimate the \(t\)-value, resulting in a Type I error. One of the difficulties is that the formula uses the actual correlation values, even though \(r\)-values are not normally distributed. Fortunately, this can be overcome using Fisher's transformation, changing \(r\) to a \(Z\)-score, and using these \(Z\)s in the significance testing formula. In addition, the \(Z\)-critical values do not depend on \(df\), and so are consistent for all analyses.

\[
Z = \frac{[Z_{12} - Z_{13}] \times \sqrt{\frac{N-3}{2 \times [1-r_{23}^2]}}}{h}
\]

\(Z_{12} \& Z_{13}\) are the Fisher's \(Z\) transformations of \(r_{12} \& r_{13}\), respectively.

If \(Z > 1.96\), \(p < 0.05\); \(Z > 2.58\), \(p < 0.01\)
v) General Linear Model

The general linear model is a statistical linear model. It may be written as:

\[ Y = XB + U \]

Where \( Y \) is a matrix with series of multivariate measurements, \( X \) is a matrix that might be a design matrix, \( B \) is a matrix containing parameters that are usually to be estimated and \( U \) is a matrix containing errors or noise. The errors are usually assumed to be uncorrelated across measurements, and follow a multivariate normal distribution. If the errors do not follow a multivariate normal distribution, generalized linear models may be used to relax assumptions about \( Y \) and \( U \).

The general linear model incorporates a number of different statistical models: ANOVA, ANCOVA, MANOVA, MANCOVA, ordinary linear regression, t-test and F-test. The general linear model is a generalization of multiple linear regression models to the case of more than one dependent variable. If \( Y \), \( B \), and \( U \) were column vectors, the matrix equation above would represent multiple linear regression. Hypothesis tests with the general linear model can be made in two ways: multivariate or as several independent univariate tests. In multivariate tests the columns of \( Y \) are tested together, whereas in univariate tests the columns of \( Y \) are tested independently, i.e., as multiple univariate tests with the same design matrix.

Multiple linear regression is a generalization of linear regression by considering more than one independent variable, and a specific case of general linear models formed by restricting the number of dependent variables to one. The basic model for linear regression is

\[ Y_i = \beta_0 + \beta_{x_{i1}} + \beta_{x_{i2}} + \ldots + \beta_{x_{ip}} + \epsilon_i \]

In the formula above, we consider \( n \) observations of one dependent variable and \( p \) independent variables. Thus, \( Y_i \) is the \( i^{th} \) observation of the dependent variable, \( X_{ij} \) is \( i^{th} \) observation of the \( j^{th} \) independent variable, \( j=1, 2, \ldots p \). The values \( \beta_j \) represent parameters to be estimated, and \( \epsilon_i \) is the \( i^{th} \) independent identically distributed normal error.