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Prevalence of Type 2 Diabetes and Obesity in Gangadikara Vokkaligas of Mysore, Karnataka

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ABSTRACT

The present paper discusses prevalence of Type 2 diabetes and obesity among Gangadikara Vokkaligas of Mysore. Data was collected from 1318 subjects comprising 569 males and 749 females, by well trained investigators using standardized protocols, such as medical history, demographics, phenotypic and genotypic information including anthropometric measurements. Prevalence of diabetes, among the Gangadikara Vokkaliga of Mysore, is very high (27.5 %) compared to coastal Karnataka (16%) and Chennai populations (15.5%). It is observed that both male and female diabetics have more body weight compared to non-diabetics, though they are under medication and diet restrictions. However, female diabetics are more obese compared to male diabetics. The frequency of obesity among Gangadikara Vokkaliga of Mysore (24%) is lower than in coastal Karnataka population (28%).

INTRODUCTION

Diabetes mellitus is a complex multi factorial metabolic disorder caused by both environmental and genetic factors. The incidence of Type 2 Diabetes is increasing globally from 2.8 per cent in 2000 to 4.4 per cent in 2030 as per World Health Organization (Wild et al, 2004). The prevalence of Type 2 Diabetes in Asian Indians ranges from 2.7 per cent in rural India to 14 per cent in urban India. India has the highest number of diabetes

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in the world (Basnayar and Rajapasha 2004; Yach et al. 2004). Even though most Indians are vegetarians, they have high prevalence of Type 2 Diabetes Mellitus with a relatively young age of onset (Sanghera et al, 2006). The National Urban Diabetic Survey reported 12.1 per cent of diabetes and 14 per cent of impaired glucose tolerance (Ramachandran et al, 2001). The prevalence of diabetes was 16 per cent in coastal population of Karnataka (Rao et al, 2010). The incidence of obesity among Type 2 Diabetes of Mysore population was reported (Shekar et al, 2005). A few genetic studies of Type 2 Diabetes among Asian Indians have focused on public health significance of this disorder (Chadha et al, 1990; Mckeigue et al, 1991; Misra et al, 2001). The studies on the genetics of Type 2 diabetes in endogamous castes in India are scanty, except the study on Khatri Sikhs of Punjab and Haryana states in northern India (Sanghera et al, 2006). In India 13 per cent of women and 9 per cent men are either Overweight or Obese, according to the National Family Health Survey (2005- 06) and the incidence is rising at an alarming rate. The incidence of obesity is around 25 per cent in European population.

Anthropological Survey of India launched 11th plan research project, Bio-cultural risk factors assessment for Type 2 Diabetes in Gangadikara Vokkaligas of Mysore, Karnataka. Gangadikara Vokkaliga is a major dominant agricultural community. They speak Kannada, a Dravidian language. Gangadikara derives the name from Gangavadi, the original habitation of a country ruled by Ganga kings who ruled over southern Karnataka for many centuries (Nanjundayya and Iyer, 1930; Banerjee 1966). Vokkaliga means a man whose profession is agriculture. They are predominantly distributed in Mysore, Kodagu, Hassan, Mandya, Tumkur, Ramanagaram and Chamarajanagar districts. Gangadikara Vokkaligas are non-vegetarians and their staple food constitutes Rice and Ragi (millets). Vokkaliga man affixes Gowda as title, meaning headman. Traditionally they were two endogamous divisions namely, Pettigeyavaru and Bujjanigeyavaru based on their customary practice of carrying marriage ritual articles (Nanjundayya and Iyer, 1930). Inter group marriages between these divisions are allowed at present. They had numerous exogamous kulas (clans) named after material objects that are sacred. Banerjee (1966) wrote that the clan system in Gangadikara Vokkaligas of Mysore is based on the worship of gods called Devara Vokkalu, i.e. families who worship a common divine couple form a unit. These exogamous clans regulate their marital alliances. They marry consanguineous relatives and prefer marriage between first cousins. Gangadikara Vokkaliga worship both Shiva and Vishnu and have family gods to whom they show special reverence. They worship Bhairaveswara and Venkataramana as their family gods. They bury the dead and observe ancestor worship on Mahalaya Amavasya day by setting up a Kalasha and offer water libations. Traditionally Gangadikara Vokkaliga had caste Panchayats called kattemanes, which were presided by the hereditary Gowda. In recent years Vokkaliga caste associations have taken over the functions of caste panchayats in implementing welfare and development programs.

This is the first systematically conducted family based study undertaken in south India. Gangadikara Vokkaliga caste was selected for the study after discussions with local Clinicians, Endocrinologists and Diabetologists. Institutional ethical committee clearance

was obtained prior to the initiation of the study. The selection of diabetes probands was identified from the clinical records of Apoorva diabetes foundation, Mysore. Written informed consent was obtained from all the participants. Data from diabetes and their families was collected using predesigned questionnaire, comprising 1330 individuals of either sex aged 18 years and above. Study variables included demographic traits, food intake of the subjects, socio-economic parameters, physical activity, psychological information, anthropometric measurements: Height, Weight, Waist and hip circumferences, Skin fold measures, and Body Composition Estimation by Bioimpedence, clinical profile of the participants, blood pressure and blood samples were analyzed for glucose levels, Insulin, C-peptide, Resistin, and Lipid profile: Total cholesterol, HDL cholesterol, LDL cholesterol, and Triglycerides, Ghrelin, thyroxine (T4), triiodothyronine (T3) and thyroid stimulating hormone (TSH). Alkaline phosphatase, Alanine aminotransferase, Aspartate aminotransferase and Total bilirubin, Adiponectin, Leptin, Glucagon-like Peptide-1 (GLP-1), Tumor necrosis factor-alpha (TNF-a), Interleukin-6 (IL-6), and C-reactive protein, Creatinine, Blood urea nitrogen (BUN), and Albumin. Urine samples were tested for Total protein, Creatinine, and Albumin.

After a 12 hour overnight fast, venous blood samples were drawn by a Phlebotomist under the supervision of a Physician. The samples were drawn after obtaining their informed consent of each participant from the densely populated southern districts of Karnataka. Samples were immediately sent to the biochemistry laboratory and plasma/serum was separated by centrifugation. The fasting plasma/serum concentrations of glucose and lipids were measured on fully automated analyzer (Transasia EM360, Bio- chemical analyzer, India). A person was considered having diabetes, if he / she was already diagnosed case of diabetes or on treatment or current fasting blood glucose >110 mg /dl (WHO, 1999). Blood pressure and blood glucose estimation were done for the individuals of the household irrespective of whether they had diabetes or hypertension. Individuals with either a parent or a sibling (brother or sister) having diabetes were considered to have a positive family history.

The present study reports on the prevalence of Type 2 Diabetes and Obesity in Gangadikara Vokkaligas of Mysore, Karnataka.

Methods

The diabetes patients were identified from clinical records available at Apoorva Diabetes Foundations, Mysore, as stated earlier. Initially, 250 diabetes patients' clinical records were screened and identified the probands of Gangadikara Vokkaliga community living in the neighbouring districts of Mysore. Enquiries were made with all willing participants to enroll themselves in Mysore Family Diabetic Study after obtaining their informed consent. Extended pedigrees were drawn to ascertain the family size of each proband with Type 2 Diabetes and such probands were enrolled for detailed genetic study of Type 2 Diabetes. A standardized protocol was implemented and obtained data from each participant, such as medical histories, demographics, phenotypic (i.e., Type 2 diabetes, obesity, hypertension, and metabolic syndrome) and genotypic information. Anthropometric

measurements were taken on 1318 subjects comprising 569 males and 749 females by well trained investigators using standardized anthropometric protocols. Height was measured to the nearest 0.1cm using Stadiometer (Holtain, UK) and the highest value is recorded. Weight was measured to the nearest 0.1kg using a calibrated balance beam scale (Tanita Weighing Machine HD 318, Japan). Waist circumference measurement was taken at the end of normal expiration to the nearest 0.1cm, measuring from the narrowest point between the lower borders of the rib cage and the iliac crest using flexible measuring tape. Hip circumference was measured at the level of the greater trochanters (i.e. widest portion of the hip) to the nearest 0.1cm with a measuring tape, following Anthropometric manuals (WHO, 1995). The Body mass index (BMI) is calculated by dividing weight (Kg) by height (m2). Waist- hip ratio is calculated as the ratio of waist circumference over hip circumference (WHO, 1995). A person is considered Obese, if the body mass index (BMI) > 30 kg/ m2 and overweight when BMI > 25 kg / m2, and normal when BMI < 24.9 kg/ m2. Central/

abdominal obesity is considered to be present when waist circumference is > 90 cm in males and > 80 cm in females, and Waist hip ratio > 0 .95 for males and > 0.80 for females is defined as truncal obesity for Asians as proposed by WHO, (2000).

Results and Discussion

Out of 1318 subjects, 27.52 per cent subjects are diabetes (16.06 % males and 12.44 % females), while 71.48 per cent are non diabetes (27.09 % males and 44.39 % females) (Fig 1). The prevalence of diabetes in Gangadikara Vokkaligas is higher than the coastal Karnataka population (16%) (Rao et al, 2010) and Chennai urban-rural population (15.5%) (Mohan et al, 2006).

Height

The height of male diabetes ranges from 151.2 cm to 189.7 cm, while it ranges from 149.4 cm to 185.2 cm in male non diabetes. The height of female diabetes ranges from 141.1 cm to 167.2 cm, while it ranges from 141.2 cm to 171.6 cm in female non diabetes. The mean height of males varies from 167.90 cm in diabetes to 169.06 cm in non diabetes, where the difference (1.16 cm) is insignificant (t value 2.123, $P < 0.02$). The mean height of females varies from 153.50 cm in diabetes to 155.11 cm in non diabetes, where the difference (1.61 cm) is significant (t value 3.214, $P > 0.001$) (Table 1). Significant differences (14.40 cm) are observed in between the mean height of male and female diabetes (t value 22.627, $P > 0.001$). Significant differences (13.95 cm) are also observed in between the mean height of male and female non diabetes (t value 36.698, $P > 0.001$) (Table 2).

Weight

The body weight of male diabetes ranges from 37.4 kg to 99.1 kg, while it ranges from 39.1 kg to 111.8 kg in male non diabetes. The body weight of female diabetes ranges from 41.7 kg to 99.2 kg, while it ranges from 34.8 kg to 129.7 kg in female non diabetes. It is evident from the above that both male and female non diabetes have put on body

weight compared to male and female diabetes The mean weight of males varies from 68.48 kg in non diabetes to 71.16 kg in diabetes, where the difference (2.68 kg) is significant (t value 2.573, P < 0.001). The mean weight of females ranges from 61.32 kg in non diabetes to 65.40 kg in diabetes, where the difference (4.08 kg) is significant (t value 4.443, P > 0.001) (Table 1). Significant differences are observed in between the mean body weight of male and female diabetes (5.76 kg) (t value 5.159, P > 0.001). Significant differences (7.16 kg) are also observed in between the mean weight of male and female non diabetes (t value 8.155, P > 0.001) (Table 2).

Body mass index (BMI)

The BMI value of male diabetes ranges from 14.55 kg/m2 to 35.10 kg/m2, while it ranges from 15.00 kg/m2 to 37.70 kg/m2 in male non diabetes. The BMI value of female diabetes ranges from 19.59 kg/m2 to 38.20 kg/m2, while it ranges from 14.42 kg/m2 to 51.24 kg/m2 in female non diabetes. It appears that female diabetes is obese compared to male diabetes. The mean BMI values for males range from 24.01 kg/m2 in non diabetes to 25.22 kg/m2 in diabetes, where the difference (1.21 kg/m2) is significant (t value 3.794, P > 0.001). The mean BMI values for females range from 25.48 kg/m2 in non diabetes to 27.77 kg/m2 in diabetes, where the difference (2.29 kg/m2) is significant (t value 6.116, P > 0.001). The mean BMI values for females indicate that women are obese; whereas the mean BMI values of males indicate that only diabetes are obese (Tablel). The mean BMI values in female diabetes (27.92 kg/m2) show 2.55 kg/m2 higher value than in male diabetes (25.19 kg/m2), where the difference is significant (t value 6.504, P > 0.001). The mean BMI values in female non diabetes (25.38 kg/m2) show 1.47 kg/m2 greater value than in male non diabetes (23.81 kg/m2), where the difference is significant (t value 4.833, P > 0.001).

There are 2 diabetes males (0.35%) and 7 non diabetes males (1.23%) in severe underweight category, while there are 4 non diabetes females (0.53%) in severe underweight category (<16 kg/m2). There are 3 diabetes males (0.53%) and 6 non diabetes males (1.05%) in moderate underweight category, while there are 11 non diabetes females (1.47%) in moderate underweight category (16 -16.9 kg/m2). There are 2 diabetes males (0.35%) and 14 non diabetes males (2.46%) in mild underweight category, while there are 23 non diabetes females (3.07%) in mild underweight category (17 -18.49 kg/m2).

The frequency of male non diabetes (4.74%) is greater by 3.51% than male diabetes ((1.23%)) in BMI Underweight category (<18.5 kg/m2), while female non diabetes record 0.33% higher frequency (5.07%) than male non diabetes (4.74%). The frequency of male diabetes (16.70%) shows 11.49% greater frequency than that of female diabetes (5.21%) in the BMI Normal category (18.5- 24.9 kg/m2). The above trend continues in non diabetes also, where the frequency of male non diabetes (33.22 %) is greater by 1.18 % than female non diabetes (32.04 %) in BMI Normal category. The frequency of overweight male diabetes (13.64 %) is greater by 3.10% than in female diabetes (10.54%), while the frequency of female non diabetes (28.03 %) is higher by 7.75% than in male non diabetes (20.38 %) in BMI overweight category (25.0 - 29.9 kg/m2). The frequency of obesity in

female diabetes (6.15%) is greater by 3.61% than in male diabetes (2.99%) and the same trend continues in non diabetes also, where the frequency of obesity in female non diabetes (12.95%) show 8.55% higher frequency than in male non diabetes (4.40 %). The frequency of male diabetes (2.81%) is 1.73% lower than that of female diabetes ((4.54%) in BMI Obesity Grade I category (30.0-34.9 kg/m2). While the frequency of female non diabetes (9.48%) record 5.61% higher than in male non diabetes (3.87%). The frequency of male diabetes (0.18%) is lower by 1.16% than in female diabetes ((1.34%)) in Obesity Grade II category (35.0 - 39.9 kg/m2). While the frequency of female non diabetes (2.00%) record 1.65% higher than in male non diabetes (0.35%). There are 6 non diabetic females (0.80 %) in Obesity Grade III category (> 40.0 kg/m2) in Gangadikara Vokkaligas as per WHO (2000) BMI classification of Obesity (Table 3 & Fig 2).

Waist circumference

The waist circumference of male diabetes ranges from 61.0 cm to 114.0 cm, while it ranges from 60.0 cm to 117.8 cm in male non diabetes. The waist circumference of female diabetes ranges from 66.4 cm to 128.3 cm, while it ranges from 54.4 cm to 138.0 cm in female non diabetes. The mean waist circumference of male diabetes (93.12 cm) is greater by 7.32 cm than that of male non diabetes (85.80 cm) and the difference is significant (t value 8.281, P > 0.001). The mean waist circumference of female diabetes (89.51 cm) is 8.21 cm higher than in female non diabetes (81.30 cm) and the difference is significant (t value 9.456, P > 0.001) (Table 1). The difference in the mean waist circumference between male diabetes and female diabetes (3.61 cm) is significant (t value 3.744, P > 0.001). Significant differences (4.50 cm) are also observed in mean waist circumference between male and female non diabetes (t value 5.725, P > 0.001) (Table 2).

The frequency of central /abdominal obesity in male diabetes (27.70%) is higher than female diabetes (19.25%), while the frequency of central /abdominal obesity among female non diabetes (43.45%) is significantly greater than in non male diabetes (25.88%). The frequency of normal category of diabetes in males (11.62%) is greater than in females (2.54%), while the frequency of normal category of non diabetes in males (36.79%) is lower than in female non diabetes (34.76%) (Table 5 & Fig 3). The waist circumference of male non diabetes with central / abdominal obesity recorded greater range (90 cm - 117.8 cm) than that of male diabetes (90 cm -114 cm) and the same trend continues in females also, where the waist circumference of female non diabetes with central /abdominal obesity recorded greater range (80 cm - 138 cm) than that of female diabetes (80 cm - 128.3 cm). The mean value of male diabetes with central / abdominal obesity (97.70 cm) is slightly greater than in male non diabetes (97.10 cm). The mean value of female diabetes with central /abdominal obesity (91.50 cm) is slightly greater than in male non diabetes (89.40 cm) (Table 7 & Fig 5).

Hip circumference

The hip circumference of male diabetes ranges from 73.8 cm to 110.8 cm, while it ranges from 71.0 cm to 120.6 cm in male non diabetes. The waist circumference of female

diabetes ranges from 75.8 cm to 123.0 cm, while it ranges from 74.2cm to 143.3 cm in female non diabetes. The mean hip circumference of male diabetes (94.20 cm) show greater value than that of male non diabetes (92.70 cm) and the difference (1.50 cm) is insignificant (t value 2.356, P > 0.01). The mean hip circumference of diabetes females (100.38 cm) is 3.68 cm greater than the mean value of diabetes females (97.00 cm) and the difference is significant (t value 4.461, P > 0.001) (Tablel). The mean hip circumference of female diabetes (100.38 cm) is greater than mean value of male diabetes (94.20 cm) and the difference 6.18 cm is significant (t value 7.659, P > 0.001) (Table 1). The mean hip circumference of non diabetes females (97.00 cm) is 4.30 cm greater than the mean value of male non diabetes (92.70cm) and the difference is significant (t value 6.986, P > 0.001) (Table 2).

Waist: hip ratio

The waist: hip ratio of male diabetes ranges from 0.78 to 1.24, while it ranges from 0.70 to 1.14 in male non diabetes. The waist: hip ratio of female diabetes ranges from 0.74 to 1.12, while it ranges from 0.64 to 1.11 in female non diabetes. The mean waist: hip ratio of male diabetes (0.99) is 0.07 units greater than the value of male non diabetes (0.92) and the difference is significant (t value 12.374, P > 0.001). Whereas the mean waist: hip ratio of female diabetes (0.89) is greater by 0.05 units than in female non diabetes (0.84) and the difference is significant (t value 4.903, P > 0.001) (Table 1). The waist: hip ratio of male diabetes (0.99) is greater by 0.10 units than the mean value of female diabetes (0.89) and difference is significant (t value 15.618, P > 0.001). The waist: hip ratio of male non diabetes (0.92) is greater by 0.06 units than the mean value of female non diabetes (0.84) and difference in is significant (t value 17.889, P > 0.001).

The frequency of truncal obesity in male diabetes (29.57%) is greater than in female diabetes (19.65%), while the frequency of truncal obesity in female non diabetes (56.01%) is far greater than in male non diabetes (26.41%). The overall frequency of truncal obesity in females (75.66%) is greater than in males (55.98%). The frequency of normal category of diabetes in males (7.58 %) is greater than in females (2.15%), while the frequency of normal category of non diabetes in males (36.44 %) is greater than in female non diabetes (22.19%) (Table 6 & Fig 4). The waist: hip ratio of male diabetes with truncal obesity recorded greater range (0.95 -1.24) than that of male non diabetes (0.90 -1.14) and the same trend continues in females also, where the waist hip ratio of female diabetes with truncal obesity recorded greater range (0.80 - 1.12) than that of female non diabetes (0.80 - 1.11). The mean value of male diabetes with truncal obesity (1.01) is slightly greater than in male non diabetes (0.99). The mean value of female diabetes with truncal obesity (0.90) is slightly greater than in male non diabetes (0.87). The waist: hip ratio of male diabetes in the normal category recorded greater range (0.78 - 0.94) than that of male non diabetes (0.70 - 0.94) and the same trend continues in females also, where the waist hip ratio of female diabetes in the normal category recorded greater range (0.74 - 0.79) than that of female non diabetes (0.64 - 0.79). The mean waist hip ratio of male diabetes in normal category (0.90) is greater than the mean value of male non diabetes normal

category (0.87) and the same trend continues in females also in the normal category (Table 8 & Fig 6).

Body mass index (BMI): Waist circumference

The waist circumference in male diabetes varies from 60.0 cm to 69.0 cm, while it ranges from 62.0 cm to 74.0 cm in male non diabetes. The waist circumference in female non diabetes varies from 54.4 cm to 83.8 cm. The mean waist circumference in male diabetes (67.96 cm) is 1.55 cm greater than that of male non diabetes (66.41cm) and the difference is insignificant (t value 0.607, $P < 0.05$). The mean waist circumference in female non diabetes is 66.37cm in BMI underweight category.

The waist circumference in male diabetes varies from 75.2 cm to 99.0 cm, while it ranges from 65.0 cm to 105.1 cm in male non diabetes. The waist circumference in female diabetes varies from 66.4 cm to 93.0 cm, while it ranges from 56.0 cm to 95.0 cm in male non diabetes. In BMI normal category, the mean waist circumference in male diabetes (88.39 cm) is greater than that of male non diabetes (81.00cm) and the difference is significant (t value 9.347, $P > 0.001$). The female diabetes falling in BMI normal category have greater mean waist circumference (81.01 cm) than that of female non diabetes (75.00 cm) and the difference is significant (t value 5.621, $P > 0.001$).

The waist circumference in male diabetes varies from 80.8 cm to 114.0 cm, while it ranges from 64.0 cm to

107.8 cm in male non diabetes. The waist circumference in female diabetes varies from 73.0 cm to 105.2 cm, while it ranges from 69.0 cm to 102.0 cm in female non diabetes. The male diabetes falling in BMI overweight category show greater mean waist circumference (97.65 cm) than in male non diabetes (94.20 cm) and the difference is significant (t value 3.930, $P > 0.001$). The BMI overweight category female diabetes (89. 00 cm) record greater mean value than female non diabetes (85.20 cm) and the difference is significant (t value 4.531, $P > 0.001$).

The waist circumference in male diabetes varies from 95.0 cm to 111.0 cm, while it ranges from 60.0 cm to

117.8 cm in male non diabetes. The waist circumference in female diabetes varies from 84.0 cm to 128.3cm, while it ranges from 68.0 cm to 138.0 cm in female non diabetes. The male diabetes falling in BMI obesity category shows slightly greater mean value (104.90 cm) than in male non diabetes (103.30 cm) and the difference is insignificant (t value 0.625, $P < 0.05$). The mean waist circumference of female diabetes (97.90 cm) falling in BMI obesity category show marginally higher value than in female non diabetes (96.20 cm) and the difference is insignificant (t value 1.051, $P< 0.05$) (Table 4).

Body mass index (BMI): Hip circumference

The hip circumferences in male diabetes vary from 76.0 cm to 86.0 cm, while it ranges from 71.0 cm to 86.0 cm in male non diabetes in BMI underweight category. The hip circumferences in female non diabetes vary from 74.2 cm to 89.8 cm. The mean hip

circumference in male diabetes (80.01 cm) is greater than in male non diabetes (78.80 cm) and the difference is insignificant (t value 0.834, $P < 0.05$), while the mean hip circumference in female non diabetes is 81.66 cm in BMI underweight category.

The hip circumference in male diabetes varies from 73.8 cm to 98.2 cm, while it ranges from 74.0 cm to 106.4 cm in male non diabetes in BMI normal category. The hip circumference in female diabetes varies from 75.8 cm to 103.0 cm, while it ranges from 75.8 cm to 110.0 cm in female non diabetes in BMI normal category. The mean hip circumferences in male diabetes (91.42 cm) show greater mean value than in male non diabetes (91.19 cm) in BMI normal category and difference is insignificant (t value 1.359, $P < 0.05$). The mean hip circumferences of female diabetes (90.23 cm) falling in BMI normal category show slightly higher value than in female non diabetes (89.40 cm) and the difference is insignificant (t value 0. 217, $P < 0.05$) (Table 4).

The hip circumference in male diabetes varies from 85.0 cm to 109.0 cm, while it ranges from 78.0 cm to

110.0 cm in male non diabetes. The hip circumference in female diabetes vary from 88.0 cm to 120.0 cm, while it ranges from 86.2 cm to 119.4 cm in female non diabetes in BMI overweight category. The mean hip circumference in male diabetes (97.70 cm) shows lower value than in male non diabetes (98.70 cm) in BMI overweight category and the difference is insignificant (t value 1. 521, $P < 0.05$). The mean hip circumference in female diabetes (100.60 cm) falling in BMI normal category show slightly higher mean values than in female non diabetes (99.88 cm) and difference is insignificant (t value 0. 856, $P < 0.05$).

The hip circumference in male diabetes varies from 95.0 cm to 110.8 cm, while it ranges from 78.0 cm to 120.6 cm in male non diabetes in BMI obesity category. The hip circumference in female diabetes varies from 95.0 cm to 123.0 cm, while it ranges from 85.0 cm to 143.3 cm in female non diabetes. The mean hip circumference in male diabetes (103.0 cm) is lower than in male non diabetes (104.90 cm) in BMI obesity category and the difference is insignificant (t value 0. 965, $P < 0.05$). The mean hip circumference in female diabetes (108. 80cm) is slightly lower than in female non diabetes (111.20 cm) and the difference is insignificant (t value 1 .705, $P < 0.05$) (Table 4).

Body mass index (BMI): Waist- hip ratio

The waist hip ratio in male diabetes varies from 0.78 to 0.95, while the ratio ranges from 0.76 to 0.93 in male non diabetes. The waist hip ratio in female non diabetes ranges from 0.68 to 0.99 in BMI underweight category. The mean waist - hip ratio in male diabetes (0.85) is slightly greater than the mean ratio in male non diabetes (0.84) and difference is insignificant (t value 0 .456, $P < 0.05$). The mean waist hip ratio in female non diabetes is 0.76.

The waist hip ratio in male diabetes varies from 0.83 to 1.18, while the ratio ranges from 0.70 to 1.13 in male non diabetes. The waist hip ratio in female diabetes ranges from 0.76

to 1.03, while in female non diabetes, the ratio ranges from 0.67 to 1.02 in BMI normal category. The mean waist hip ratio in male diabetes (0.98) shows greater value than the mean ratio in male non diabetes (0.91) and the difference is significant (t value 9.900, $P > 0.001$) in BMI normal category. The mean waist hip ratio in female diabetes (0.89) shows greater waist - hip ratio than in female non diabetes (0.82) and the difference is significant (t value 2.196, $P < 0.001$).

The waist hip ratio in male diabetes varies from 0.84 to 1.24, while the ratio ranges from 0.78 to 1.14 in non diabetes in BMI overweight category. The waist hip ratio in female diabetes ranges from 0.74 to 1.12, while the ratio ranges from 0.64 to 1.06 in female non diabetes. The mean waist hip ratio in male diabetes (1.00) show higher mean waist - hip ratio than in male non diabetes (0.96) and the difference is significant (t value 4.714, $P > 0.001$) in BMI overweight category. The mean waist hip ratio in female diabetes (0.89) shows slightly higher mean waist - hip ratio than in female non diabetes (0.85) and the difference is significant (t value 4.240, $P > 0.001$) in BMI overweight category.

The waist hip ratio in male diabetes varies from 0.93 to 1.10, while the ratio ranges 0.77 to 1.10 in male non diabetes. The waist hip ratio in female diabetes ranges from 0.79 to 1.09, while the ratio ranges from 0.71 to 1.11 in female non diabetes in BMI obesity category. The mean waist hip ratio in male diabetes (1.02) shows higher mean waist - hip ratio than in male non diabetes (0.98) in BMI obesity category and the difference is insignificant (t value 1.638, $P < 0.05$). The mean waist hip ratio in female diabetes (0.90) shows higher mean waist - hip ratio than in female non diabetes (0.87) and difference is insignificant (t value 2.343, $P < 0.01$) (Table 4).

Conclusions

The incidence of Type2 Diabetes, metabolic syndrome, and diabetes complications have been alarmingly rising worldwide and such trends also have been observed in several Indian populations, especially those living in the urban environment (Chennai City: 18.6%, Kanchipuram Town: 16.4%, Panruti, a semi urban village: 9.2%, Rural Andhra Pradesh: 3.7%). Approximately, 79 million people in India are expected to be afflicted with diabetes by the year 2030

The prevalence of diabetes (27.5 %) in Gangadikara Vokkaligas of Mysore is very high compared to coastal Karnataka population (16%) and Chennai population (15.5%). It is observed that both male and females diabetes have more body weight compared non diabetes, though they are under medication and diet restrictions. However, female diabetes is obese compared to male diabetes. The frequency of obesity in the present study (24%) is lower than in coastal Karnataka population (28%). Incidence of central and truncal obesity is more common in male diabetes. The difference in mean values of waist and

hip circumference in both males and females in underweight and obese categories are insignificant while they show significant differences in normal and overweight BMI categories.

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Table 1 : Statistical constants for anthropometric traits

Anthropometric traits	Male (N 568) Diabetes N 211 Mean ± SD	Non Diabetes N 357 Mean ± SD	t value	Female (N 748) Diabetes N 163 Mean ± SD	Non Diabetes N 585 Mean ± SD	t value	Male + Female Diabetes N 374 Mean ± SD	Non Diabetes N 942 Mean ± SD	t value
Height (cm)	167.90 ± 6.48	169.06 ± 5.91	2.123	153.50 ± 5.73	155.11 ± 5.36	3.214	161.63 ± 9.44	160.40 ± 8.77	2.160
Weight (kg)	71.16 ± 11.33	68.48 ± 13.17	2.573	65.40 ± 9.59	61.32 ± 12.77	4.443	68.67 ± 10.97	64.03 ± 13.38	6.444
BMI (kg / m2)	25.22 ± 3.56	24.01 ± 4.07	3.794	27.77 ± 3.90	25.48 ± 4.99	6.116	26.33 ± 3.92	24.93 ± 4.71	5.600
Waist circumference(cm)	93.12 ± 9.20	85.80 ± 11.83	8.281	89.51 ± 9.36	81.30 ± 11.44	9.456	91.50 ± 9.43	83.02 ± 11.78	2.615
Hip circumference(cm)	94.20 ± 6.72	92.70 ± 8.44	2.356	100.68 ± 9.08	97.00 ± 10.20	4.461	97.02 ± 8.46	95.40 ± 9.79	2.977
Waist:hip ratio	0.99 ± 0.06	0.92 ± 0.08	12.374	0.89 ± 0.07	0.84 ± 0.07	4.903	0.95 ± 0.08	0.87 ± 0.08	16.000

Table 2 Inter group comparison of Diabetes and Non Diabetes

Anthropometric traits	Diabetes Male (211) Mean ± SD	Diabetes Female (163) Mean ± SD	t value	Non Diabetes Male (357) Mean ± SD	Non Diabetes Female (585) Mean ± SD	t value
Height (cm)	167.90 ±6.48	153.50 ± 5.73	22.627	169.06 ±5.91	155.11 ±5.36	36.698
Weight (kg)	71.16 ± 11.33	65.40 ± 9.59	5.159	68.48 ± 13.17	61.32 ± 12.77	8.155
BMI (kg / m^2)	25.22 ± 3.56	27.77± 3.90	6.504	24.01 ±4.07	25.48 ±4.99	4.833
Waist circumference (cm)	93.12 ±9.20	89.51 ± 9.36	3.744	85.80 ± 11.83	81.30 ± 11.44	5.725
Hip circumference (cm)	94.20 ± 6.72	100.68 ±9.08	7.659	92.70 ± 8.44	97.00 ± 10.20	6.986
Waist:hip ratio	0.99 ± 0.06	0.89 ± 0.07	15.618	0.92 ±0.08	0.84 ± 0.07	17.889

Table 3 BMI categories among Diabetes and Non Diabetes

Category	BM! Clasification BMI values	Male (N 569) Diabetes N 212	Male (N 569) Non Diabetes N 357	Female (N 749) Diabetes N 164	Female (N 749) Non Diabetes N 585
Underweight	<18.5 kg/ m^2	7 (1.23)	27 (4.74)	0	38 (5.07)
Normal	18.5 - 24.9 kg/m^2	95 (16.70)	189 (33.22)	39 (5.21)	240 (32.04)
Overweight	25-29.9 kg/m^2	93 (13.64)	116 (20.39)	79 (10.54)	210 (28.03)
Obesity	> 30 kg/m^2	17(2.99)	25 (4.40)	46 (6.15)	97 (12.95)

Table 4 Comparison of waist and hip circumference of males and females in BMI categories

Anthropometric traits	Male BMI category : Under weight Diabetes (N 7) Mean ± SD	 Non Diabetes (27) Mean ± SD	t value	Female BMI category : Under weight Diabetes (N 0) Mean ± SD	 Non Diabetes (38) Mean ± SD	t value
Waist circumference (cm)	67.96 ±6.51	66.41 ± 3.56	0.607	0.00	62.37 ±6.32	–
Hip circumference (cm)	80.01 ± 3.38	78.80 ±3.53	0.834	0.00	81.66 ±3.49	–
Waist: hip ratio	0.85 ±0.07	0.84 ± 0.05	0.456	0.00	0.76 ± 0.06	–
	BMI category: Normal Diabetes (N 94)	 Non Diabetes (189)		BMI category: Normal Diabetes (N39)	 Non Diabetes (240)	
Waist circumference (cm)	88.39 ± 5.48	81.00 ±7.74	9.347	81.01 ±6.05	75.00 ±7.00	5.621
Hip circumference (cm)	90.23 ±4.58	89.40 ± 5.33	1.359	91.42 ±6.27	91.19 ±5.47	0.217
Waist: hip ratio	0.98 ± 0.05	0.91 ±0.07	9.900	0.89 ±0.07	0.82 ± 0.06	2.196
	BMI category : Overweight Diabetes (N 93)	 Non Diabetes (116)		BMI category : Overweight Diabetes (N 79)	 Non Diabetes (210)	
Waist circumference (cm)	97.65 ±6.24	94.20 ±6.31	3.930	89.00 ±6.40	85.20 ±6.20	4.531
Hip circumference (cm)	97.70 ± 4.44	98.70 ± 5.06	1.521	100.60 ± 6.65	99.88 ±5.49	0.856
Waist: hip rati	1.00 ±0.005	0.96 ±0.06	4.714	0.89 ± 0.07	0.85 ±0.07	4.240
	BMI category: Obesity Diabetes (N 17	 Non Diabetes (25)		BMI category: Obesity Diabetes (N 45)	 Non Diabetes (97)	
Waist circumference (cm)	104.90± 4.44	103.30 ± 11.54	0.627	97.90± 9.09	96.20 ± 8.78	1.051
Hip circumference (cm)	103.00 ±4.47	104.90 ±8.19	0.965	108.80 ±6.88	111.20 ±9.43	1.705
Waist: hip ratio	1.02± 0.06	0.98 ±0.08	1.638	0.90 ± 0.07	0.87 ±0.08	2.343

Table 5 : Central Obesity among male and female Diabetes and non Diabetes by waist circumference

Disease status	Male (N 568) Abodominal	 Normal	Female (N 748) Abodominal	 Normal
	obesity (≥ 90cm)	(< 90 cm)	obesity (≥ 80 cm)	(< 80 cm)
Diabetes	146 (25.70%)	66 (11.62%)	144 (19.25%)	19 (2.54%)
Non Diabetes	147 (25.88%)	209 (36.79%)	325 (43.45%)	260 (34.76%)
Total	293 (51.59%)	275 (48.41%)	469 (62.70%)	279 (37.30%)

Table 6 : Truncal Obesity among male and female Diabetes and non Diabetes by waist -hip ratio

	Male (N 568)		Female (N 748)	
	Truncal obesity (≥ 0.95)	Normal (< 0.95)	Truncal obesity (≥ 0.80)	Normal (< 0.80)
Diabetes	168 (29.57%)	43 (7.58%)	207 (36.44%)	250(44.02%)
Non Diabetes	150 (26.41%)	207 (36.44%)	419 (56.01%)	166 (22.19%)
Total	318 (55.98%)	250 (44.02%)	566 (75.66%)	182 (24.34%)

Table 7 : Statistical constants for Central Obesity among male and female Diabetes and non Diabetes

	Male				Female			
	Diabetes		Non Diabetes		Diabetes		Non Diabetes	
Statistical	N 146 ≥ 90	N 65 < 90	N 147 ≥ 90	N 210 < 90	N 144 ≥ 80	N 19 < 80	N 324 ≥ 80	N 261 < 80
Minimum	90	61	90	60	80	66.4	80	54.4
Maximum	114	89.8	117.8	89.4	128.3	79.8	138	79.8
Mean ± SE	97.70 ± 0.49	82.80 ± 0.82	97.10 ± 0.49	77.80 ± 0.53	91.50 ± 0.67	74.77 ± 0.85	89.40 ± 0.42	71.35 ± 0.40
S. D	5.89	6.64	5.95	7.71	8.06	3.7	7.57	6.47

Table 8 : Statistical constants for Truncal Obesity among male and female Diabetes and non Diabetes

	Male				Female			
	Diabetes		Non Diabetes		Diabetes		Non Diabetes	
Statistical	N 169 ≥ 0.95	N 42 < 0.95	N 150 ≥ 0.95	N 207 < 0.95	N 147 ≥ 0.80	N 16 < 0.80	N 419 ≥ 0.80	N 166 < 0.80
Minimum	0.95	0.78	0.95	0.7	0.8	0.74	0.8	0.64
Maximum	1.24	0.94	1.14	0.94	1.12	0.79	1.11	0.79
Mean ± SE	1.01 ± 0.005	0.90 ± 0.007	0.99 ± 0.003	0.87 ± 0.004	0.90 ± 0.005	0.78 ± 0.004	0.87 ± 0.002	0.75 ± 0.002
S. D	0.05	0.04	0.04	0.05	0.06	0.02	0.06	0.03

Fig. 1 : Disease Status among males and females

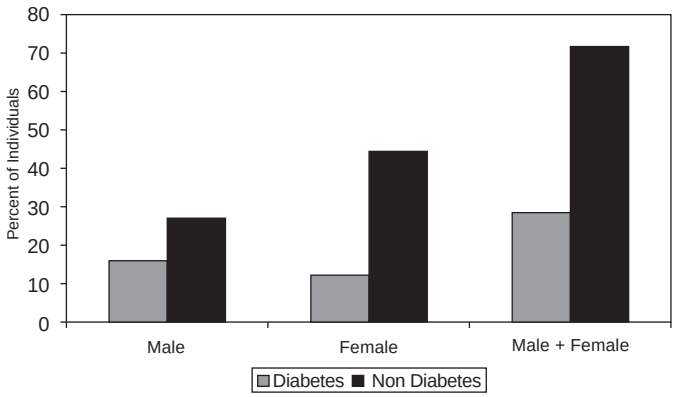

Fig. 2 : BMI categories among male and female by disease status

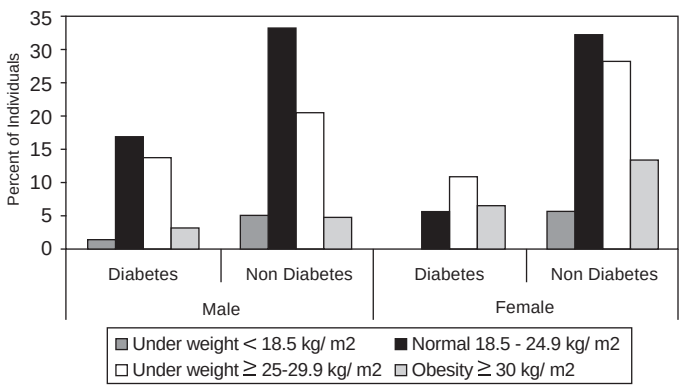

Fig. 3 : Abdominal obesity among male and female by disease status

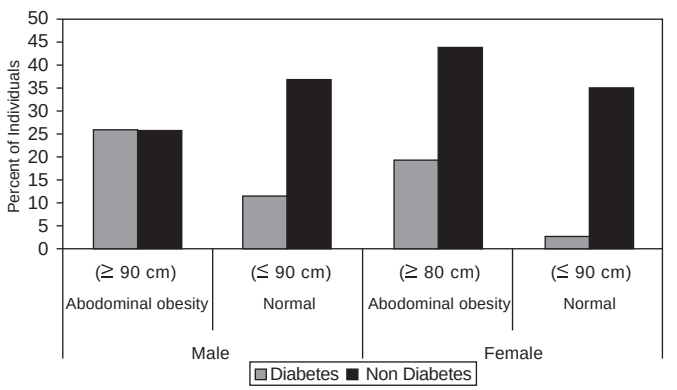

Fig. 4 : Truncal obesity among male and female by disease status

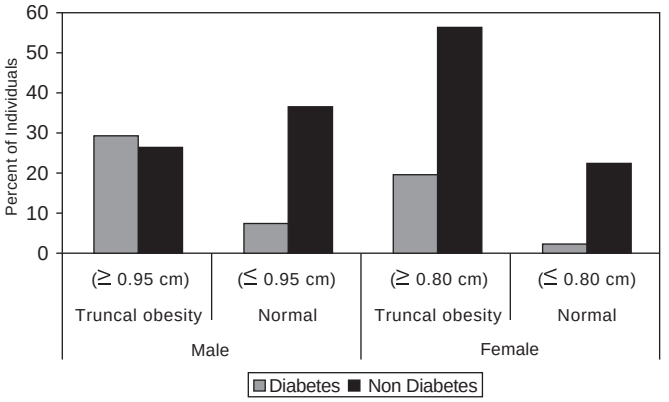

Fig. 5 : Mean central obesity among male and female by disease status

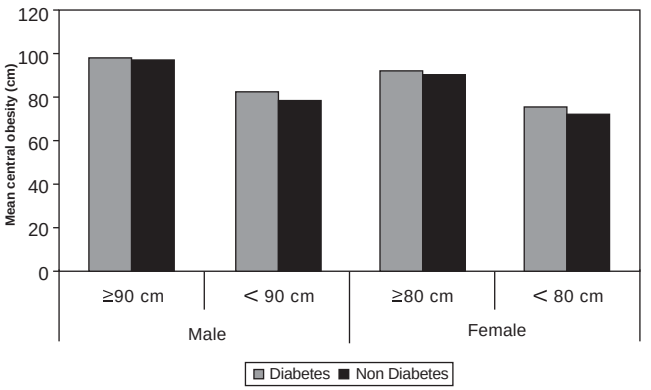

Fig. 6 : Mean waist hip ratio among male and female by disease status