



STUDY OF CORRELATION BETWEEN ANTHROPOMETRIC PARAMETERS (BMI, WC, WHR) AND ATHEROGENIC INDEX OF PLASMA (AIP) IN TYPE 2 DIABETICS IN JEDDAH, SAUDI ARABIA

Syed M Farid

Department of Nuclear Engineering, King Abdulaziz University, P.O. Box 80204, Jeddah, Saudi Arabia

ABSTRACT

This study aimed at investigating the relationships between lipid abnormalities, atherogenic index of plasma (AIP) and anthropometric indices (WC, BMI, WHR) among a group of Saudi type 2 diabetic patients living in Jeddah. A total sample of one hundred and thirty four male aged 27 to 75 years old participated in this study. Anthropometric measures and blood chemistries were obtained. The results revealed that there was a significant increase in serum TC, TG, LDL-c, VLDL-c and a significant decrease in HDL-c in patients. The most common lipid abnormality found in this study was triglycerides followed by HDL and LDL. The results revealed a weak, positive and significant correlation between BMI ($r=0.230$), WC ($r=0.349$), WHR ($r=0.187$) and HbA1c. In the case of lipid components, a weak, positive and significant correlation was obtained between BMI ($r=0.208$), WC ($r=0.325$), WHR ($r=0.274$) and TG while a weak, negative and statistically significant correlation was obtained between BMI ($r=-0.201$), WC ($r=-0.245$), WHR ($r=-0.231$) and HDL. Statistically significant and weak positive correlation was found between BMI ($r=0.115$), WC ($r=0.182$), WHR ($r=0.127$) and TC. Statistically significant and weak positive correlation was found between BMI ($r=0.315$), WC ($r=0.372$) and LDL while a weak, positive and non-significant correlation was found between WHR ($r=0.197$) and LDL. A weak, positive and non-significant correlation was obtained between BMI ($r=0.197$), WC ($r=0.018$), WHR ($r=0.227$) and VLDL. The results revealed that multiple anthropometric parameters are required to correlate lipid profile rather than single parameter in type 2 diabetes mellitus. This study showed that all of the studied anthropometric indices had a statistically significant positive correlation with AIP. The relationship was strongest between AIP and WC ($r=0.383$; $p=0.0024$) and the least was between AIP and waist-hip-ratio ($r=0.226$; $p=0.0042$). The results of the present study revealed that multiple anthropometric parameters are required to correlate lipid profile and AIP rather than single parameter in type 2 diabetes mellitus. Along with anthropometric measurements, lipid profile is also need be monitored in type 2 diabetics. Further broad study is advised.

KEYWORDS: Type 2 diabetes mellitus, anthropometric indices, glycated hemoglobin, lipid profile, AIP.

INTRODUCTION

Diabetes mellitus (DM) is an epidemic of vast proportions around the world that costs the nations billions in medical care, disability and early deaths. The prevalence of type 2 diabetes mellitus (T2 DM) is rising much more rapidly because of increasing obesity and reduced activity levels as countries become more industrialized. This is true in most countries, and 6 of the top 10 countries with highest rates are in Asia^[1]. T2 DM is commonly associated with obesity, hypertension, cardiovascular disease (CVD), and lipid abnormalities. The prevalence of DM among adults in Saudi Arabia is 30% and that figure is expected to be more than double by 2030. Half of the people over 30 years of age are prone to diabetes^[2,3]. Saudi Arabia ranks seventh worldwide and the first in the Gulf in terms of diabetes rates^[4]. We are in the midst of an obesity pandemic. Obesity is a metabolic disease that is casually related to serious medical illness, including T2 DM. The relationship of obesity with T2 DM has been recognized for several decades, and a close association between obesity and insulin resistance has been observed in all ethnic groups^[5,6,7]. DM is a worldwide health problem which leads to markedly increased cardiovascular mortality and indisposition^[8]. In T2 DM lipid

abnormalities are almost the rule. 70% to 97% of adults with T2 DM have one or more lipid abnormalities. Lipid irregularities significantly contribute to the increased risk of cardiovascular disease (CVD) and other morbidity in diabetics. There is a growing body of evidence showing that hyperglycemia and dyslipidemia are linked to increased cardiovascular risk^[9]. Atherogenic dyslipidemia of diabetes also known diabetic dyslipidemia is characterized by raised triglycerides (TG), reduced high density lipoprotein (HDL-C), and excess of small dense low density lipoprotein (LDL-C), which constitute the lipid triad and are considered as traditional risk factors for CVD^[10,11]. Patients with type 2 diabetes mellitus-associated dyslipidemia remain exposed to a high residual risk of CVD complications, even if they are treated with current standards of care, making this one of the major unmet needs in the treatment of patients with diabetes. An understanding of the complex interplay of how treating dyslipidemia reduces the risk for CVD events in patients with type 2 diabetes mellitus and an ability to assess at-risk patients is necessary to ensure the major appropriate treatment strategies are implemented. Lipid ratios have also been found to indicate an atherogenic risk and are said to better predictors of coronary artery diseases than

lipids alone [12]. An early intervention to normalize circulating lipids has been shown to reduce cardiovascular complications and mortality [13,14].

It has been demonstrated that the atherogenic index of plasma (AIP), a new indicator of atherogenicity, significantly increases with atherogenic risk [15]. Dobiasova and Frohlic [16,17] defined the atherogenic index as the logarithm of the ratio of plasma triglyceride to HDL-C levels. It is suggested that AIP values of 0.1 are related to low cardiovascular risk, between 0.1 and 0.24 are related to moderate cardiovascular risk, and > 0.24 are related to high cardiovascular risk [18,19,20]. Different investigators concluded that AIP has a better prediction of coronary artery disease than individual lipids, and/ or TC/HDL-c, LDL-c/HDL-c ratios. AIP which can easily be calculated from standard lipid profile can act as an adjunct that significantly adds predictive value for cardiovascular events beyond that of the individual lipid parameters [19,20,21]. According to some authors, calculating AIP can be more reliable in predicting the risk for development of atherosclerosis in diabetes mellitus patients. This parameter is easy to calculate every time a lipid profile is asked for, so that the cardiovascular risk of the patient can be assessed [16,18,19,20,21].

Over a period of time the anthropometric parameters have evolved into reliable indicators for predicting the incidence of various non-communicable disease risk factors in all populations though the threshold cut off values vary from population to population. Simple anthropometric measurements have been used as surrogate measurements of obesity and have more practical values in both clinical practice and for large-scale epidemiological studies [22]. Various studies have shown that anthropometric parameters such as body mass index (BMI), waist circumference (WC), and waist hip ratio (WHR) are useful indicators for predicting incidence of type 2 diabetes in populations [23,24,25]. Approximately 58% of diabetes and 21% of ischemic heart disease globally are attributable to a body mass index (BMI) above 21 kg/m². At the same time, around 60% of low income patients borrow, mortgage, or sell their property just to keep their blood sugar levels under control [26]. The anthropometric measures are being used for screening obesity, diabetes, and CVD. BMI is used as an indicator for generalized obesity and WC, WHR are measures of central obesity. Central obesity is considered a better indicator of cardiovascular risk and mortality than BMI. Some authors showed that BMI and WHR were predictors of type 2 diabetes outcome [27]. Whereas in other studies, WC was a better predictor of T2 DM and was more strongly correlated to intra-abdominal fat than WHR [25, 28]. A case control study from 57 countries has shown that WHR shows a graded and highly significant association with myocardial infarction risk worldwide [29]. A meta-analysis study has shown that abdominal obesity as measured by WC and WHR is significantly associated with the risk of incident CVD events [30]. However, the studies available to date still give no conclusive answer as to which anthropometric parameter best predicts cardiovascular events and mortality [24, 31, 32]. Studies have done on obesity indices predicting diabetes or coronary artery disease (CAD) in non-diabetics, but there are very limited studies

relating anthropometric variables for CAD among diabetics. There is also a dearth of studies on the use of AIP as an index of atherogenic risk in determining anthropometric predictors [33,34].

The objective of this study was (1) to examine anthropometric parameters and lipid profile patterns in type 2 diabetics, (2) to study the correlations between anthropometry and lipid profile in type 2 diabetics, and (3) to study the correlation of AIP with anthropometric parameters (WC, BMI, WHR).

MATERIALS & METHODS

This is a cross-sectional study. The study includes 134 T2 DM patients who satisfied the inclusion criteria, attending King Abdulaziz University health clinic, Jeddah (Saudi Arabia). Inclusion criteria for the patients were male subjects with age > 25 years residing in Jeddah city and having history of known DM for more than 5 years. Smokers, alcoholics, and subjects with hepatic, renal, endocrine disorders and those on lipid lowering agents were excluded from the study. Informed consent was sought and obtained from individuals before enrollment into the study. The study protocol was approved by institutional ethical committee. After taking a brief medical history, a detailed physical examination was conducted for all participants by a physician and the data was recorded in a predesigned questionnaire. Anthropometric measures included height, weight; waist and hip circumference were measured according to standard protocols and were recorded. BMI was calculated as weight in kilograms divided by height in squared meters. The waist to hip ratio (WHR) was calculated as the waist circumference divided by the hip circumference. The threshold cut-off values adopted for anthropometrical parameters were BMI => 25 kg/m², WC => 90 cm, WHR => 0.90 for males [35]. The cut-off values for dyslipidemia were according to National Cholesterol Education Program Adult Treatment Panel III criteria [36]. Venous blood samples were collected from each patient after at least 10 hours fasting into centrifuge tubes. Serum was separated by centrifugation at 3000 rpm for 15 minutes. The sera were analyzed for glycated hemoglobin (HbA1c), total cholesterol (TC), triglycerides (TG), and high density lipoprotein cholesterol (HDL-c) using an autoanalyzer (Roche Modular P-800, Germany). Serum low density lipoprotein cholesterol (LDL-c) was calculated by Friedewald's formulas shown below [37, 38].

$$\text{LDL-c} = \text{TC} - [(\text{HDL-c}) + (\text{TG}/5)]$$

The VLDL cholesterol concentration was calculated from the values of TG by Friedewald's formula [39].

The atherogenic indices were calculated as follows [18,19,37,38].

Atherogenic Index of Plasma (AIP) = log (TG / HDL-c)

The results were reported as mean ± SD. The statistical analysis was done by SPSS version 17.0 software. The results were evaluated by using the independent sample 't' test and the Pearson's correlation coefficient test. The results were considered significant when p < 0.05.

RESULTS

The study sample consisted of 134 males. The mean age of the patients was 53.94 ± 9.21 years while the mean duration of diabetes was 7.31±3.06 years. The baseline

characteristics of the type 2 diabetic patients are shown in Table 1. The mean values were above the threshold cut-off values for the three measured anthropometric parameters (BMI, WC, and WHR). According to WHO definition^[40], majority of patients in our cohort were either obese (48.2%) or overweight (39.2%); the mean level of BMI was $29.54 \pm 3.65 \text{ kg/m}^2$. Unfortunately, the subjects in our cohort had uncontrolled DM with HbA1c above the

optimum level (9.98 %)^[36]. There was a significant increase in serum TC, TG, LDL-c, VLDL-c and a significant decrease in HDL-c in patients. The most common lipid abnormality found in this study was triglycerides followed by HDL and LDL. The mean \pm SD of AIP was 0.58 ± 0.066 in men. According to the AIP category that mentioned before, the participants were in increased risk of CVD.

TABLE 1. Clinical and biochemical characteristics of the participants

Characteristics	Mean \pm SD
Number of subjects	134
Age (years)	53.94 ± 9.21
Duration of diabetes (years)	7.31 ± 3.06
Body mass index (kg/m^2)	29.54 ± 3.65
Waist circumference (cm)	99.57 ± 8.93
Waist hip ratio	0.98 ± 0.07
HbA1c (%)	9.98 ± 1.23
TC (mg/dl)	221.46 ± 45.61
TG (mg/dl)	186.40 ± 41.28
HDL-c (mg/dl)	38.01 ± 8.09
LDL-c (mg/dl)	144.55 ± 29.21
VLDL-c (mg/dl)	33.08 ± 2.65
Atherogenic index of plasma (AIP)	0.584 ± 0.066

Table 2 shows the results of correlation coefficient (r-value) showing strength of association between the anthropometric variables. The results revealed a good correlation ($r=0.6$ to 0.8) between BMI and HC. Mild

correlation ($r=0.4$ to 0.6) was seen between BMI, HC, WHR and WC. No correlation was observed between HC and WHR.

TABLE 2. Pearson's correlation coefficient (r value) among anthropometric parameters

Parameter	BMI	WC	WHR	HC
	$r = 0.51$		$r = 0.60$	$r = 0.53$
WC	$p = 0.05$		$p = 0.05$	$p = 0.05$
			$r = 0.50$	$r = 0.70$
BMI			$p = 0.05$	$p = 0.05$
				$r = 0.06$
WHR				$p = 0.05$

The strengths and directions of association between the various lipid profiles, HbA1c and anthropometric indices are shown in Table 3. The results revealed a weak, positive and significant correlation between BMI ($r=0.230$), WC ($r=0.349$), WHR ($r=0.187$) and HbA1c. In the case of lipid components, a weak, positive and significant correlation was obtained between BMI ($r=0.208$), WC ($r=0.325$), WHR ($r=0.274$) and TG while a weak, negative and statistically significant correlation was obtained between BMI ($r= -0.201$), WC ($r= -0.245$), WHR ($r= -0.231$) and HDL. Statistically significant and weak positive correlation was found between BMI ($r= 0.115$),

WC ($r= 0.182$), WHR ($r= 0.127$) and TC. Statistically significant and weak positive correlation was found between BMI ($r= 0.315$), WC ($r= 0.372$) and LDL while a weak, positive and non-significant correlation was found between WHR ($r=0.197$) and LDL. A weak, positive and non-significant correlation was obtained between BMI ($r=0.197$), WC ($r=0.018$), WHR ($r=0.227$) and VLDL. Table 4 shows that all anthropometric indices had significant positive correlation with AIP. The relationship was strongest between AIP and WC ($r = 0.383$; $p = 0.0024$) and the least was between AIP and waist-hip-ratio ($r = 0.226$; $p = 0.042$).

TABLE 3. Correlations between some anthropometric parameters, the lipid profile, and glycated hemoglobin values of Saudi males with T2 DM

Anthropo-metric parameters	TC	TG	HDL	LDL	VLDL	HbA1c
	$r=0.115$	$r=0.208$	$r= -0.201$	$r=0.315$	$r=0.197$	$r=0.230$
BMI	$p = 0.05$	$p = 0.05$	$p = 0.05$	$p = 0.05$	$p > 0.05$	$p = 0.05$
WC	$r=0.182$	$r=0.325$	$r= -0.245$	$r=0.372$	$r=0.018$	$r=0.349$
	$p = 0.05$	$p = 0.05$	$p = 0.05$	$p = 0.05$	$p > 0.05$	$p = 0.05$
WHR	$r=0.127$	$r=0.274$	$r= -0.231$	$r=0.197$	$r=0.227$	$r=0.187$
	$p = 0.05$	$p = 0.05$	$p = 0.05$	$p > 0.05$	$p > 0.05$	$p = 0.05$

TABLE 4. Correlation of atherogenic index of plasma (AIP) with BMI, WC and WHR

Anthropometric parameters	Pearson correlation coefficient	p-value
WC	r = 0.383	p = 0.0024
BMI	r= 0.378	p = 0.0037
WHR	r = 0.226	p = 0.0042

DISCUSSION

Diabetes is associated with a greater risk of morbidity and mortality from CVD, and heart disease is the leading cause of death among people with diabetes. DM is a chronic disease that requires long term medical attention both to limit the development of its devastating complications and manage them when they occur. A worldwide epidemic exists with respect to DM, primarily because of increased rates of obesity. Epidemiological studies have shown that, compared to lean individuals, very obese men and women (BMI > 35) have a several folds increase in probability of developing T2 DM [41]. Diabetes is becoming an epidemic in Saudi Arabia. Therefore there is an urgent need to generate an easy, understandable and effective ways for prevention of diabetes among Saudis. Also there is a need for an effective and easily understandable parameter as a predictor for diabetes risk. Anthropometric parameters above the threshold cut off values were found to be predictors of diabetes and other cardiovascular risk factors in various populations even though it is not clear which anthropometric parameter is ideal for a particular population. In literature, contradictory results were reported for correlation coefficients among anthropometric parameters in diabetic patients. The interactions among the anthropometric variables, in this study, are shown in Table 2 which ranged from weak to strong.

In the present study, the BMI was found to have a strong correlation with HC and a moderate correlation with WHR. Some studies have found that BMI is strongly correlated with HC [42,43,44], while other studies found weak correlation [24,45]. Our value of correlation coefficient (r= 0.50) between BMI and WHR is similar to the values obtained by previous authors [43,46]. In our study, we obtained a moderate correlation (r=0.51) between BMI and WC. Our value of r was higher than the values reported by previous authors [24,33] and lower than the values reported by different investigators [43,47]. Our value of correlation coefficient (r=0.60) between WC and WHR was similar to the values obtained by different authors [33,48]. The present value of correlation coefficient (r= 0.53) between WC and HC was higher than the published value [24] while it was lower than the value available in literature [42,44].

Our value of the correlation coefficient (r=0.06) between WHR and HC was the same as reported by Lokpo *et al.* [44].

HbA1c is the main indicator which is used for evaluation of glycemic control in diabetes mellitus. Epidemiological data and meta-analyses have shown a direct relationship between glycemic control and cardiovascular disease. The high values of HbA1c were associated with an increased risk of complications in patients with T2 DM [49]. A statistically significant association was found between the high levels of HbA1c and the mortality rates associated with diabetes. If the value of HbA1c was 8%, the risk of

death was 15.3% higher than in HbA1c 6% [50]. In our T2 DM patients, the HbA1c values exceeded the listed limits. Among three anthropometric parameters studied in the present study, it was found that HbA1c has the strongest relationship with WC [Table 3]. Pearson correlation coefficient of HbA1c with BMI was 0.230. This is concordant with some previous results [51,52,53]. The present correlation coefficient value (r=0.349) between HbA1c and WC was similar to the r- value of previous investigators [52,53]. We obtained a weak and statistically significant correlation coefficient (r=0.187) between HbA1c and WHR. Tayde *et al.* [54] observed that there was statistically significant linear positive correlation between HbA1c and WHR (r=0.349, p=0.013) while no significant correlation (p=0.165) was observed by Srinivasan *et al.* [55]. The HbA1c most accurately reflects the glycemic control, based on the preceding two to three months and it has been shown to predict the risk for the development of several chronic complications, as was observed in diabetes patients. Epidemiological evidence suggests that elevated HbA1c is associated with cardiovascular and ischemic heart disease. Both obesity and physical inactivity are considered to play important roles in the prevention and treatment of diabetes, with the ADA recommending that people with HbA1c of 5.6 - 6.4% undergo moderate weight loss (7% of initial body mass), as well as increasing physical activity to at least 150 min/week of moderate activity. Ageing is another factor that contributes to variance in HbA1c and diabetes risk. Even in non-diabetic adults with normal fasting glucose, HbA1c steadily increase with age, such that at 70+ years of age it is 5.5% [56].

Lipid abnormalities are common in diabetic patients and frequently seen in type 2 diabetic patients. Dyslipidemias make diabetic patients prone to develop cardiac heart disease and other complications of atherosclerosis. The investigated lipid profile of T2 DM Saudi male patients showed two unfavorable tendencies: elevated levels of TC, TG and LDL-cholesterol. Gloomy prediction provided the excess percentage of HbA1c too. Diabetes mellitus is a chronic disease which affects all organ systems. To be well controlled T2 DM requires an individualized to the patient multidisciplinary approach. This multidisciplinary approach induced us to look for correlations between some anthropometric parameters and the lipid profile, as well as HbA1c levels of Saudi males with T2 DM. The results of our investigations were depicted in Table 3.

Our study demonstrated a weak and statistically significant positive correlation between BMI with TC, TG, and LDL cholesterol while a weak, negative and statistically significant correlation was obtained between BMI and HDL. Similar results were reported by previous investigators [51,57,58,59]. There was a weak, positive and non-significant correlation between BMI and VLDL (p >0.05). A close association was also obtained between TG

and BMI ($r=0.286$, $p=0.001$) by Chan *et al.*^[60]. Himabindu *et al.*^[61] reported statistically significant positive correlation between BMI and VLDL ($r=0.210$, $p=0.034$) and statistically non-significant positive correlation between BMI and TC ($r=0.017$, $p=0.866$), TG ($r=0.117$, $p=0.243$) and HDL ($r=0.150$, $p=0.132$). Sharma and Prasad^[62] reported that BMI was non-significantly and inversely correlated with TC ($r=-0.03$, $p=0.857$), TG ($r=-0.08$, $p=0.584$), HDL ($r=-0.05$, $p=0.744$), LDL ($r=-0.05$, $p=0.733$), VLDL ($r=-0.11$, $p=0.450$). Kayode *et al.*^[63] reported that there was significant correlation between BMI and TC ($r=0.641$); BMI and LDL ($r=0.653$) and BMI and TG ($r=-0.393$).

In the present study, there was a weak significant positive correlation between WC and TC ($r=0.18$); WC and TG ($r=0.325$); WC and LDL ($r=0.372$), while a significant inverse correlation between WC and HDL ($r=-0.245$). The correlation between WC and VLDL was weak, positive and statistically non-significant. Kayode *et al.*^[63] reported that there was significant correlation between WC and TC ($r=0.560$); WC and LDL ($r=0.612$); BMI and TG ($r=-0.386$). Okafor *et al.*^[42] found a weak positive and statistically non-significant correlation between WC and TC ($r=0.035$); WC and LDL ($r=0.010$); WC and HDL ($r=0.074$) while a weak positive and statistically significant correlation between WC and TG ($r=0.172$) ($p=0.05$). Seidell *et al.*^[46] found a positive and statistically significant correlation between WC and TC ($r=0.18$); WC and LDL ($r=0.08$); WC and TG ($r=0.56$) while a significant inverse correlation between WC and HDL ($r=-0.34$). Himabindu *et al.*^[61] reported statistically non-significant negative correlation between WC and TC ($r=-0.078$); WC and TG ($r=-0.029$); WC and HDL ($r=-0.042$); WC and LDL ($r=-0.131$), and non-significant positive correlation between WC and VLDL ($r=0.027$). Chan *et al.*^[60] reported that HDL-cholesterol correlated negatively ($r=-0.335$, $p=0.001$) with WC, while TG correlated positively ($r=0.325$, $p=0.001$) with WC.

Our results revealed a weak, positive and statistically significant correlation between WHR and TC ($r=0.127$); WHR and TG ($r=0.274$) and a weak, positive and statistically non-significant correlation between WHR and LDL ($r=0.197$); WHR and VLDL ($r=0.227$), while a negative non-significant correlation for HDL ($r=-0.231$). Kanwar *et al.*^[64] found a weak, positive and statistically non-significant correlation of WHR with TC ($r=0.119$), LDL ($r=0.163$), VLDL ($r=0.245$) and positive significant correlation was obtained for TG ($r=0.251$) and negative significant correlation for HDL ($r=-0.383$). Koo *et al.*^[65] reported a weak, positive and significant correlation between WHR and TG ($r=0.18$), while a weak, negative and significant correlation between WHR and HDL ($r=-0.20$). They also found a weak, negative and statistically non-significant correlation between WHR and TC ($r=-0.05$); WHR and LDL ($r=-0.06$). Okafor *et al.*^[42] found a weak positive and statistically non-significant correlation between WHR and TC ($r=0.054$); WHR and LDL ($r=0.046$); WHR and HDL ($r=0.049$); WHR and TG ($r=0.130$). Seidell *et al.*^[46] found a positive and statistically significant correlation between WHR and TC ($r=0.32$); WHR and LDL ($r=0.21$); WHR and TG ($r=0.52$), while a significant inverse correlation between WHR and

HDL ($r=-0.32$). Himabindu *et al.*^[61] reported statistically non-significant negative correlation between WHR and TC ($r=-0.065$); WHR and TG ($r=-0.137$); WHR and LDL ($r=-0.098$); WHR and VLDL ($r=-0.139$), and no correlation between WHR and HDL ($r=0.000$). Jayarama *et al.*^[66] reported that the WHR and lipid profiles were not significantly correlated. In a study from North India Sandhu *et al.*^[67] reported positive correlations between WHR, TC, LDL, and TG in the 41 to 50 year age group in men. Discrepancies among the reported in the literature diverse and divergent correlations between the anthropometric parameters, the lipid profile values, and the biomarker HbA1c are probably due to the lifestyle, lifestyle and diet, and other specific factors in different nations (ethnic group, geographical region *etc.*). Methodological differences are also very important. The multidisciplinary approach to T2 DM requires along with anthropometric parameters, the lipid profile need also be monitored. This study revealed that as BMI or WC increases serum LDL, TC, and TG increases. These findings were consistent with previous studies^[42,57,58,59,63,64]. The lipid abnormalities in overweight and obesity is likely a consequence of insulin resistance^[68]. The rapid development of overweight or obesity in T2 DM patients will undoubtedly accelerate the prevalence of dyslipidemia^[68]. Obesity increases cardiovascular risk through risk factors such as increased fasting plasma triglycerides, high LDL-c, low HDL-c, elevated blood glucose and insulin levels and high blood pressure. Nobel lipid dependent, metabolic risk factors associated to obesity are the presence of the small dense LDL phenotype, postprandial hyperlipidemia with accumulation of atherogenic remnants and hepatic overproduction of apoB containing lipoproteins^[69]. Risk factors associated with dyslipidemia were aging, higher body size, hypertension, diabetes, and smoking. Dyslipidemia associated with obesity plays a major role in the development of atherosclerosis and cardiovascular disease in obese individuals. All of the components of the dyslipidemia, including higher triglycerides, decreased HDL levels and increased LDL particles have been shown to be atherogenic. WC and WHR were significantly higher in obese subjects compared to their non-obese counterparts. Increased WC and WHR have long been recognized to be associated with cardiovascular risk factors, and individuals with abdominal fat often carry a physiologic profile that places them at high risk of CVD^[5]. This is evident in this study as we observed a positive association among abdominal obesity markers (WC and WHR) and cardiovascular risk markers (TG and AIP).

Dyslipidemia is becoming an important public health problem. Obesity can be used to screen for dyslipidemia along with other coexisting risk factors such as hypertension and diabetes. There is an urgent need to institute more positive public health measures and screening programs and to treat patients diagnosed with dyslipidemia^[68]. A systematic review suggests that a weight reduction of 5% or 10% in obese patients has a simultaneous improvement in the serum lipid profile^[70]. A study revealed that a moderate-fat weight-loss and weight-maintenance diet improves the CVD risk profile on the basis of favorable changes in lipids and lipoproteins. The

moderate-fat diet elicited favorable changes in the lipoprotein profile^[71]. Both lipid profile and body fat have been shown to be the important predictors for metabolic disturbances including dyslipidemia, hypertension, diabetes, cardiovascular disease, hyper-insulinaemia. Association of lipid profiles is reported with lifestyle, age, intra-abdominal adiposity, obesity and BMI^[72]. There is enough evidence in literature to support the beneficial effect of lowering of serum lipids in retarding macro-vascular disease. It is important to realize that hyperlipidaemia and the resultant macro-vascular disease can develop even in the 'prediabetic phase' of type 2 DM. Hence, early detection and correction of dyslipidaemic state is essential in the management of diabetic patients. Patients with type 2 diabetes have increased risk of cardiovascular disease associated with atherogenic dyslipidemia and coronary artery disease, especially myocardial infarction is the leading cause of morbidity and mortality worldwide^[73]. This signifies individuals having diabetes associated obesity are more prone to develop cardiovascular disease than obese non-diabetic individuals. So in management of diabetes along with blood sugar control, control of obesity and dyslipidemia has to be included.

In the present study, the results revealed that multiple anthropometric parameters are required to correlate lipid profile rather than single parameter in type 2 diabetes mellitus. Along with anthropometric measurements, lipid profile is also need be monitored in type 2 diabetics. These findings were in agreement with the studies of different investigators^[33,64,66,74].

Health care providers, therefore have an important role to play in educating families and children about approaches that are useful in preventing diabetes mellitus. Losing weight and increasing physical activity is of great importance in lowering the risk of developing type 2 diabetes mellitus. If a person already has type 2 diabetes, losing weight and exercising, along with a healthy diet helps to control blood sugar levels, may delay or even prevent complications and also allow to reduce or even eliminate person's need for diabetes medication.

Atherogenic index of plasma (AIP), defined as $\log(\text{TG}/\text{HDL})$, has recently been proposed as a marker of plasma atherogenicity and reflects the balance between risk and protective lipoprotein forces - triglyceride refers to atherogenic lipids while HDL refers to the protective lipid^[19,20,38]. It has been successfully used as an additional index when assessing cardiovascular risk factors. This parameter is easy to calculate every time a lipid profile is asked for, so that the cardiovascular risk of the patient can be assessed. Moreover, in situations where all atherogenic parameter are normal, AIP may be the alternative screening tool^[75,76]. People with high AIP have a higher risk of coronary heart disease than those with low AIP, and vice versa. Identifying individuals at the highest risk of comorbidities of obesity is essential in order to identify those who might benefit most from management program^[77]. Our findings show that the participants were at high risk of future cardiovascular events (Table 1). A statistically significant positive correlation was obtained between the respective anthropometric measure of BMI, WC, WHR and AIP (Table 4). The relationship was

strongest between AIP and WC ($r = 0.383$; $p = 0.0024$) and the least was between AIP and waist-hip-ratio ($r = 0.226$; $p = 0.0042$). This finding is consistent with the observations reported by other researchers^[7,76,78]. The results of the present study revealed that multiple anthropometric parameters are required to correlate lipid profile and AIP rather than single parameter in type 2 diabetes mellitus. Along with anthropometric measurements, lipid profile is also need be monitored in type 2 diabetics.

A recent study has demonstrated significant differences in anthropometric parameters and lipid profile patterns in type 2 diabetics in three different ethnic groups living in Malaysia^[79]. Similar study were also conducted in different countries^[80,81,82,83]. These studies reveal that anthropometric parameters and lipid profile patterns may vary from one ethnic group to other, one geographical region to other and among different races. So the results of one study cannot be extrapolated to other studies and generalized conclusions cannot be drawn for all populations.

Obesity can be described as an imbalance between energy intake and expenditure such that excess energy is stored in fat cells, which enlarge or increase in number. As obesity is often characterized by metabolic complications that harm health, it has been suggested that it should be considered as a disease. Obesity, and particularly visceral obesity and the metabolic syndrome, actively promote biochemical and neurohormonal processes that are, both directly and indirectly, injurious to vascular health and increase the risk of atherosclerotic cardiovascular disease^[84]. Along with the cardiovascular benefits, there are significant metabolic changes that occur with weight loss leading to a decrease in overall morbidity and mortality. Lifestyle changes may lead to a 60% risk reduction in the development of diabetes mellitus and up to a 37% decrease in the prevalence of the metabolic syndrome^[85]. Recently, it was claimed that inactivity could be the primary criterion for early identification of those of at risk of CVD. This risk can be decreased by physical activity and balanced nutrition, which cannot be replaced by medication. As part of physical activity aimed to prevent or reduce atherogenic risk, it is recommended that individuals engage in at least 30 min of regular physical activity daily^[86].

It is generally accepted that obesity is a health hazard because of its association with numerous metabolic complications such as dyslipidaemia, type 2 diabetes, and cardiovascular diseases. Obesity, and particularly visceral obesity and the metabolic syndrome, actively promote biochemical and neurohormonal processes that are, both directly and indirectly, injurious to vascular health and increase the risk of atherosclerotic cardiovascular disease. Obviously, as our sedentary lifestyle combined with our diet rich in saturated fats and trans fatty acids and in refined sugars is "toxic" to our metabolism, any approach aimed at the management of risk of coronary heart disease in abdominally obese patients will require a multifaceted approach (balanced nutrition with more vegetables and fruits, fewer refined products rich in fat and sugar, more physical activity) directed at the critical factors involved in the aetiology of the patient's condition. In a broader

context of a comprehensive evaluation and treatment of risk (and not of body weight), it is hoped that this approach will help physicians to identify obese patients that may require pharmacotherapy aimed at waist rather than weight management.

Overwhelming evidence supports the importance of obesity in the pathogenesis and progression of CV disease. Obesity is an independent predictor of all-cause mortality in men and women. The physical, medical, economic, and social impact of the obesity epidemic is already staggering, and it will dramatically affect future generations. The multiple and ever increasing deleterious effects of obesity create a self-perpetuating cycle of clinical illness and disability that eventually confines its victims to a non-productive life of existence only. These are the end results of the natural history of this tragic epidemic. Further research is needed in the areas of obesity paradox, weight loss, lifestyle interventions, exercise training, obesity surgery, and stress reduction, and if the current obesity epidemic continues, we may soon witness an unfortunate end to the steady increase in life expectancy.

REFERENCES

- [1]. Asmita, P.B., Jayashree, G.V. (2014) Glycated hemoglobin and fasting blood glucose levels in type 2 diabetes mellitus. *Indian J. Basic Appl. Med. Res.*, 3(2): 555-559.
- [2]. Alqushi, K.A., Aljabri, K.S., Bokhari, S.A. (2011) Prevalence of diabetes mellitus in a Saudi community. *Ann. Saudi Med.*, 31: 19-23.
- [3]. Diabetes among Saudis, a major issue. *Arab News* (13 November, 2012).
- [4]. Diabetes: KSA is 7th. in the world, 1st. in Gulf. *Arab News* (24 June, 2015).
- [5]. Kanthe, P.S., Patil, B.S., Bagali, S., Deshpande, A., Shaikh, G.B., Aithala, M. (2012) Atherogenic index as a predictor of cardiovascular risk among women with different grades of obesity. *Int. J. Collab. Res. Intern. Med. Public Health*, 10: 1767-1774.
- [6]. Gallagher, D., Heymsfield, B., Heo, M. (2000) Health percentage body fat ranges, an approach for developing guidelines based on body mass index. *Am. J. Clin. Nutr.*, 72: 694-701.
- [7]. Hasan, B.F., Ibrahim, N.A.Kh., Hameedi, B.H. (2016) Atherogenic index of plasma and insulin resistance in obese diabetic patients. *Int. J. Sci. Res.*, 5(5): 2408-2412.
- [8]. Zimmet, P.Z., Mccarty, D.J., De Couten, M.P. (1997) The global epidemiology of non-insulin dependent diabetes mellitus and the metabolic syndrome. *J. Diabetes Complications*, 11: 60-68.
- [9]. O'Keffe, J.H., Bell, D. (2007) Postprandial hyperglycemia/ hyperlipidemia (postprandial dysmetabolism) is a cardiovascular risk factor. *Am. J. Cardiol.*, 62: 899-904.
- [10]. Kandula, R., Shegokar, V.E. (2013) A study of lipid profile in patients with T2 DM. *MRIMS J. Health Sci.*, 1(1): 23-26.
- [11]. Krauss, R.M. (2004) Lipids and lipoproteins in patients with type 2 diabetes. *Diabetes Care*, 27(6): 1496-1504.
- [12]. Habib, S.S. (2012) cardiovascular disease in diabetes: An enigma of dyslipidemia, thrombosis and inflammation. *Basic Res. J. Med. Clin. Sci.*, 1(3): 33-42.
- [13]. Vij, V., Chitnis, P., Gupta, V.K. (2012) Effect of gender on dyslipidemia in patients with type 2 diabetes mellitus. *World J. Pharma. Res.*, 1(5): 1486-1493.
- [14]. Windler, E. (2005) What is consequence of an abnormal lipid profile in patients with type 2 diabetes or the metabolic syndrome? *Atheroscler.* 6 (Suppl): 11-14.
- [15]. Tariq, M., Rajab, A. (2012) Comparative study for atherogenic index of plasma (AIP) in patients with type 1 diabetes mellitus, type 2 diabetes mellitus, beta thalassemia and hypothyroidism. *Int. J. Chem. Res.*, 2: 1-9.
- [16]. Dobiasova, M., Frohlich, J. (2001) The plasma parameter log(TG/HDL-c) as an atherogenic index: correlation with lipoprotein particle size and esterification rate in apoB-lipoprotein-depleted plasma (FER(HDL)). *Clin. Biochem*, 34(7): 583-588.
- [17]. Frohlich, J., Dobiasova, M. (2003) Fractional esterification rate of cholesterol and ratio of triglycerides to HDL-cholesterol are powerful predictors of positive on coronary angiography. *Clin. Chem.*, 49: 1873-1880.
- [18]. Dobiasova, M. (2006) Atherogenic index of plasma as a significant predictor of cardiovascular risk: from research to practice. *Vnitr. Lek.*, 52: 64-71.
- [19]. Bhardwaj, S., Bhattacharjee, J., Bhatnagar, M.K., Tyagi, S. (2013) Atherogenic index of plasma, Castelli risk index and atherogenic coefficient – New parameters in assessing cardiovascular risk. *Int. J. Pharm. Bio. Sci.*, 3(3): 359-364.
- [20]. Adu, E.M., Ukwamedu, H.A., Oghagbon, E.S. (2015) Assessment of cardiovascular risk indices in type 2 diabetes mellitus. *Trop. Med. Surg.*, 3(2): 184-187.
- [21]. Rajlaxmi, T., Ghangale, S.S., Iyre, C.M. (2015) Study of HbA1c as a biomarker in dyslipidemia and atherogenicity in type 2 diabetes mellitus. *Int. J. Clin. and Biomed. Res.*, 1(2): 5-11.
- [22]. Wu, H.Y., Chen, L.L., Zheng, J., Liao, Y.F., Zhou, M. (2007) Simple anthropometric indices in relation to cardiovascular risk factors in Chinese type 2 diabetic patients. *Chin. J. Physiol.*, 50: 135-142.
- [23]. Stevens, J., Couper, D., Pankow, J., Folsom, A.R., Duncan, B.B., Nieto, F.J. (2001) Sensitivity and specificity of anthropometrics for the prediction of diabetes in a biracial cohort. *Obes. Res.*, 9: 696-705.
- [24]. Marjani, A.J. (2011) Waist circumference, body mass index, hip circumference and waist-to-hip ratio in type 2 diabetes patients in Gorgan, Iran. *J. Clin. Diag. Res.*, 5(2): 201-205.
- [25]. Lotfi, M.H., Saadati, H., Afzali, M. (2014) Association between anthropometric parameters (WC, BMI, WHR) and type 2 diabetes in the adult Yazd population, Iran. *J. Diabetes Metab.*, 5(10): 444-447.
- [26]. WHO (2002) Reducing Risks, Promoting healthy Life: World Health Report (WHO publication).
- [27]. Sekikawa, A., Eguchi, H., Igarashi, K., Tominaga, M., Abe, T. (1999) Waist to hip ratio, body mass

- index, and glucose intolerance from Funagata population –based diabetes survey in Japan. *Tohoku J. Exp. Med.*, 189: 11-20.
- [28]. Wang, Z., Hoy, W.E. (2004) Body size measurements as predictors of type 2 diabetes in Aboriginal people. *Int. J. Obes. Relat. Metab. Disord.*, 28: 1580-1584.
- [29]. Yusuf, S., Hawken, S., Ounpuu, S., Bautista, L., Franzosi, M.G., Commerford, P. (2005) Obesity and the risk of myocardial infarction in 27,000 participants from 52 countries: a case-control study. *Lancet*, 366: 1640-1649.
- [30]. Koning, L., Merchant, A.T., Po gue, J., Anand, S.S. (2007) Waist circumference and waist-to-hip ratio as predictors of cardiovascular events: meta-regression analysis of prospective studies. *European Heart Journal*, 28: 850-856.
- [31]. Schneider, H.J., Friedrich, N., Klotsche, J., Pieper, L., Nauck, M., John, U. (2010) the predictive value of different measures of obesity for incident cardiovascular events and mortality. *J. Clin. Endocrinol. Metab.*, 95(4): 1777-1785.
- [32]. Tseng, C.H. (2008) Waist-to-height ratio and coronary artery disease in Taiwanese type 2 diabetic patients. *Obesity*, 16(12): 2754-2759.
- [33]. Shankarappa, C., Jayalakshmi, L., Sidd, M.A.M. (2013) Anthropometric variables predicting risk of coronary artery disease in type 2 diabetics. *IOSR J. Dental Med. Sci.*, 10(3): 9-13.
- [34]. Ezeukwu, A.O., Agwubike, E.O. (2014) Anthropometric measures of adiposity as correlates of atherogenic index of plasma in non-obese sedentary Nigerian males. *Libyan J. Med.*, 9: 1-5.
- [35]. Beber, A., Santos, R.G., Fanghanel, G., Reyes, L.S. (2001) Anthropometric indices in the prediction of type 2 diabetes mellitus, hypertension and dyslipidemia in a Mexican population. *Int. J. obes.*, 25: 1794-1799.
- [36]. Third Report of the National Cholesterol Education Program (NCEP) (2002) Expert Panel on detection, evaluation, and treatment of high blood cholesterol in adults (Adult Treatment Panel III) final report. *Circulation*, 106: 3143-3421.
- [37]. Al-Qaic, A.G.S. (2015) Lipid profile alteration and atherogenic indices in patients with DM II. *Int. J. Multidiscip. Curr. Res.*, 3: 1003-1006.
- [38]. Nimmanapalli, H.D. (2016) Lipid ratios, atherogenic coefficient and atherogenic index of plasma as parameters in assessing cardiovascular risk in type 2 diabetes mellitus. *Int. J. Res. Med. Sci.*, 4(7): 2863-2869.
- [39]. Grag, N., Agrawal, Y.B., Gupta, S. (2014) A study of lipid profile levels in diabetics and non-diabetics taking TC/HDL and LDL/HDL ratio into consideration. *J. Indian Acad. Clin. Med.*, 15(3-4): 192-195.
- [40]. WHO- World Health Organization; obesity: Preventing and managing the global epidemic. Report of a WHO Consultation. Geneva (2000).
- [41]. Ali, Z.U., Al-Zaidi, M.S. (2011) The association between body mass index, lipid profile and serum Estradiol levels in a sample of Iraqi diabetic premenopausal women. *Oman Medical J.*, 26(4): 263-266.
- [42]. Okafar, C.I., Fasanmade, O.A., Oke, D.A. (2008) Pattern of dyslipidemia among Nigerians with type 2 diabetes mellitus. *Nigerian J. Clin. Pract.*, 11(1): 25-31.
- [43]. AL-khazrajy, L.A., Raheem, Y.A., Hanoon, Y.K. (2010) Sex differences in the impact of body mass index (BMI) and waist /hip (W/H) ratio on patients with metabolic risk factors in Baghdad. *Global J. Health Sci.*, 2(2): 2010.
- [44]. Lokpo, S.Y., Owiredu, W.K.B.A., Yeboah, J.O., Obirikorang, C., Frempong, M.T.A. (2017) Association between anthropometry, dyslipidemia and the ten-year relative risk of cardiovascular disease in Ghanaians with type 2 diabetes and hypertension at the Battor Catholic hospital. *OALib J.*, 4(2): 1-13.
- [45]. Cui, R., Qi, Z., Zhou, L., Li, Z., Li, Q., Zhang, J. (2016) Evaluation of serum lipid profile, body mass index, and waistline in Chinese patients with type 2 diabetes mellitus. *Clin. Invest. In Aging*, 11: 445-452.
- [46]. Seidell, J.C., Perusse, L., Despres, J.P., Bouchard, C. (2001) Waist and hip circumferences have independent and opposite effects on cardiovascular disease risk factors: the Quebec Family Study. *Am. J. Clin. Nutr.*, 74: 315-321.
- [47]. Gieracg, M., Gierach, J., Ewertowska, M., Arndt, A., Junik, R. (2014) Correlation between body mass index and waist circumference in patients with metabolic syndrome. *ISRN Endocrinology*, 2014: 1-6.
- [48]. Mogre, V., Abedandi, R., Salifu, Z.S. (2014) Correlates and predictors of increasing waist circumference in patients with type 2 diabetes mellitus: A cross-sectional study. *Int. Scholarly Res. Notices*. 2014: 1-6.
- [49]. Gai, L., Matthews, F.F., Sargeant, L.A., Brayne, C. (2008) An investigation of the population impact of variation in HbA1c levels in older people in England and Wales: from a population based multi-center longitudinal study. *BMC Publ. Health*, 8: 54.
- [50]. Williams's text book of endocrinology, (12th.ed). Philadelphia: Elsevier/Saunders. pp. 1371-1435. ISBN 978-1-4377-0324-5.
- [51]. Babikar, W.G., Alshahrani, A.S.A., Hamid, H.G.M., Abdelraheem, A.H.M.K., Shalayel, M.H.F. (2016) The correlation of HbA1c with body mass index and HDL-cholesterol in type 2 diabetic patients. *Biomed. Res.-India*, 27(4): 1280-1283.
- [52]. Martins, R.A., Jones, J.G., Cumming, S.P., Silva, M.J.C., Teixeira, A.M., Verissimo, M.T. (2012) Glycated hemoglobin and associated risk factors in older adults. *Cardiovascular Diabetology*, 11(1): 13-20.
- [53]. Sheth, J., Shah, A., Sheth, F., Trivedi, S., Nabar, N., Shah, N., Thakor, P., Vaidya, R. (2015) The association of dyslipidemia and obesity with glycated hemoglobin. *Clinical Diabetes and Endocrinology*. DOI: 10.1186/s 40842-015-0004-6.
- [54]. Tayde, P., Borle, A., Zanwar, Y., Rode, M., Phatak, M. (2013) Glycated hemoglobin and its correlation with lipid profile in type 2 diabetic males in central India. *National J. Community Medicine (India)*, 4(4): 564-569.

- [55]. Srinivasan, A., Joshi, P., Raghavan, A. (2013) Association between waist circumference and serum triacylglycerol status in type 2 diabetes mellitus (T2DM): A study performed on a rural population in Puducherry. *J. Clin. Diagn. Res.*, 7(4): 631-634.
- [56]. American Diabetes Association: Diagnosis and Classification of Diabetes Mellitus (2010). *Diabetes Care*, 33: S62-S69.
- [57]. Begum, A., Ahmed, S., Prabhu, M.H. (2014) Study of correlation between BMI and lipid profile in Karnataka. *J. Biomed. Pharma. Res.*, 3(6): 65-68.
- [58]. Zeqollari, A., Spahiu, K., Vyskha, G., Cakerri, L. (2014) Lipid profile in diabetes mellitus type 2 patients in Albania and the correlation with BMI, hypertension, and hepatosteatosis. *J.Family Med. Community Health*, 1(4): 1018-1022.
- [59]. Omotoye, F.E., Fadupin, G.T. (2016) Effect of body mass index on lipid profile of type 2 diabetic patients at an urban tertiary hospital in Nigeria. *IOSR-JDMS*, 15(9):65-70.
- [60]. Chan, W.B., Tong, P.C.Y., Chow, C.C., So, W.Y., Ng, M.C.Y., Ma, R.C.W., Osaki, R., Cockram, C.S., Chan, J.C.N. (2005) triglyceride predicts cardiovascular mortality and its relationship with glycaemia and obesity in Chinese type 2 diabetic patients. *Diabetes Metab. Res. Rev.*, 21: 183-188.
- [61]. Himanindu, Y., Sriharibabu, M., Alekhya, K., Saisumanth, K., Lakshmanrao, N, Komali, K. (2013) Correlations between anthropometry and lipid profile in type 2 diabetics. *Indian J. Endocr. Metab.*, 17(4): 727-729.
- [62]. Sharma, P.P., Prasad, H.B. (2013) Study of height, weight and BMI in type 2 diabetes mellitus in Western Maharashtra. *Int. J. Scientific Res.*, 2(5): 462-465.
- [63]. Kayode, J.A., Sola, A.O., Matthew, A.S., Adesola, B.O., Ademola, I., Adedeji, A.T., Adelani, A.S. (2010) Lipid profile of type 2 diabetic patients at a rural tertiary hospital in Nigeria. *J. Diabetes Endocr.*, 1(4): 46-51.
- [64]. Kanwar, G., Shekhawat, K.S., Rathore, S., Jain, K.B. (2016) Study of correlation of waist-hip ratio and lipid profile in type 2 diabetes mellitus patients. *J. Pharm. Biomed. Sci.*, 6(3): 264-268.
- [65]. Koo, H.C., Robert, D.S., Jan, H.J.M. (2013) Which is a better anthropometric indicator of cardiovascular risk factors in type 2 diabetes mellitus patients? Waist-hip ratio or body mass index? *Mal. J. Nutr.*, 19(2): 163-172.
- [66]. Jayarama, N., Reddy, P.R., Reddy, M.M., Mahesh, V. (2014) Relation between waist-hip ratio and lipid profile in type 2 diabetes mellitus patients. *Asian J. Med. Sci.*, 5(3): 51-53.
- [67]. Sandhu, H.S., Koley, S., Sandhu, K.S. (2008) A study of correlation between lipid profile and waist to hip ratios in patients with diabetes mellitus. *Anthropologist*, 10: 215-218.
- [68]. Ni, W., Liu, X., Zhu, Z., Yuan, X., Song, J., Chi, H., Xu, J. (2015) Serum lipids and associated factors of dyslipidemia in the adult population in Shenzhen. *Lipids in Health and Diseases*, 14; 71-81.
- [69]. Klop, B., Elte, J.W.F., Cabezas, M.C. (2013) Dyslipidemia in obesity: Mechanisms and potential targets. *Nutrients*, 5(4): 1218-1240.
- [70]. Hutton, B., Fergusson, D. (2004) Changes in body weight and serum lipid profile in obese patients treated with orlistat in addition to a hypocaloric diet: a systematic review of randomized clinical trials. *American J. Clin. Nutr.*, 80: 1461-1468.
- [71]. Pelkman, C.L., Fishell, V.K., Maddox, D.H., Pearson, T.A., Mauger, D.T., Kris-Etherton, P.M. (2004) Effects of moderate- fat (from monounsaturated fat) and low-fat weight-loss diets on the serum lipid profile in overweight and obese men and women. *American J. Clin. Nutr.*, 79: 204-212.
- [72]. Sandhu, H.S., Koley, S., Sandhu, K.S. (2008) A study of correlation between lipid profile and body mass index (BMI) in patients with diabetes mellitus. *J. Hum. Ecol.*, 24(3): 227-229.
- [73]. Toth, P.P. (2012) Effective management of the type 2 diabetes patient with cardiovascular and renal disease: secondary prevention strategies after a myocardial infarction. *Curr. Diabetes Rev.*, 8(3): 219-228.
- [74]. de Oliveira, M.A.M., Fagundes, R.L.M., Moreira, E.A.M., Trindade, E.B.S.M., de Carvalho, T. (2010) Relation between anthropometric indicators and risk factors for cardiovascular disease. *Arq. Bras. Cardiol.*, 94(4): 451-457.
- [75]. Mudhaffar, S.K. (2013) Atherogenic index of plasma (AIP) as a parameter in predicting cardiovascular risk in males compared to the conventional dyslipidemic indices (Cholesterol ratios). *Karbala J. Med.*, 6(1): 1506-1513.
- [76]. Niroumand, S., Khajedaluae, M., Rezaiyan, M.K., Abrishami, M., Juya, M., Khodae, G., Dadgarmoghaddam, M. (2015) Atherogenic index of plasma (AIP): A marker of cardiovascular disease. *Med. J. Islam. Repub. Iran*, 29(240): 1-9.
- [77]. Cornier, M., Despres, J.P., Davis, N., Klein, S., Lamarche, B. (2011) Assessing adiposity: a scientific statement from the American Heart Association. *Circulation*, 124: 1996-2019.
- [78]. Okpa, H.O., Enang, O.E., Effa, E.E., Essien, O.E., Mbu, P.N. (2015) Comparative analysis of atherogenic index of plasma and its relationship with cardiovascular risk among patients with diabetes mellitus and concurrent diabetes mellitus with hypertension attending endocrinology clinic in a tertiary hospital south-south Nigeria. *IOSR J. Dental Med. Sci.*, 14(8): 102-107.
- [79]. Blebil, A.Q., Hassan, Y., Dujaili, J.A. (2011) Differences in demographics, lipid profile and other clinical characteristics among type 2 diabetic patients in the state of Penang, Malaysia according to gender and races. *Asian J. Pharm. Clin. Res.*, 4(suppl.2): 130-133.
- [80]. Yusuf, S., Reddy, S., Ounpuu, S., Anand, S. (2001) Global burden of cardiovascular diseases: Part II: variations in cardiovascular disease by specific ethnic groups and geographic regions and prevention strategies. *Circulation*, 104(23): 2855-2864.
- [81]. Akinboboye, O., Idris, O., Akinkugbe, O. (2003) Trends in coronary artery disease and associated risk

- factors in sub-Saharan Africans. *J. Hum. Hypertens.*,17(6): 381-387.
- [82]. Zhang, L., Qiao, Q., Dong, Y. (2012) Ethnic difference in lipid profile. *InTech*, DOI: 10.5772/27915, (www.intechopen.com).
- [83]. Silwa, K., Lecour, S., Carrington, M.J., Stewart, S., Lyons, J.G., Stewart, S., Marais, A.D., Raal, F.J. (2012) Different lipid profiles according to ethnicity in the Heart of Soweto study cohort of de novo presentations of heart disease. *Cardiovasc. J. Afr.*, 23(7): 389-395.
- [84]. Lavie, C.J., Milani, R.V., Ventura, H.O. (2009) Obesity and cardiovascular disease: Risk factor, paradox, and impact of weight loss. *J. Am. Coll. Cardiol.*, 53: 1925-1932.
- [85]. Clinical Guidelines on the identification, evaluation, and treatment of overweight and obesity in adults: The Evidence Report: National Institute of Health (1998). *Obes. Res.*, Suppl. 2: 51S-209S.
- [86]. Abraham, P.A., Kazman, J.B., Zeno, S.A., Deuster, P.A. (2013) Obesity and African Americans: physiologic and behavioural pathways. *ISRN Obes.*, ID314295.