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NDSP 12: Atherogenic index of plasma as a useful marker of cardiovascular disease risk among Pakistani individuals; a study from the second National Diabetes Survey of Pakistan (NDSP) 2016–2017

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ABSTRACT

Aim: To investigate the reliability of atherogenic index of plasma (AIP) as a marker of cardiovascular disease risk and its correlation with CVD risk factors.

Methodology: It is a sub-study of the second National Diabetes Survey of Pakistan (NDSP) 2016–2017, an epidemiological survey including both genders with >20 years of age in all four provinces of Pakistan. Out of 213 clusters, twenty-seven clusters were selected and households were identified from each cluster. Selected members of every 10th household were counseled for a visit to the campsite after observing an overnight fast. Standardized techniques were used for measuring height, weight, BMI, waist circumference, and blood pressure. Biochemical parameters including oral glucose tolerance test, lipid profile, and various lipid-derived parameter/ratios were also analyzed via standardized methods.

Results: A total of 7351 individuals were selected for this sub-analysis after fulfilling the inclusion criteria. Mean AIP score was calculated as 0.38 ± 0.31 with statistically significant difference among all groups ($p < 0.0001$), and according to the AIP risk categorization, a majority of 6996 individuals (95.2%) fell in the high-risk category of developing CVD, whereas 258 (3.5%) were in moderate and only 97 (1.3%) individuals were found in the low-risk category. Multiple logistic regression analyses showed male gender and diabetes as risk factors for developing CVD based on the AIP score. Furthermore, various lipid-derived parameters LDL-C and HDL-C, TG and HDL-C, lipoprotein combined index (LCI) were shown a strong correlation with AIP.

Conclusion: The significant association between AIP and CVD risk factors exists and high levels of AIP in Pakistani population may be an alarming sign in developing cardiovascular disease.

1. Introduction

Cardiovascular diseases (CVD) remain one of the leading cause of morbidity and mortality across the globe, atherosclerosis being the most common underlying cause of it.[1] The global burden of CVD estimated approximately 17.8 million deaths in 2017, of which more than three quarters were in low-income and middle-income countries.[2] Dyslipidemia is an established risk factor for atherosclerotic cardiovascular disease (ASCVD) and related conditions worldwide. To evaluate dyslipidemia-induced ASCVD risk, many measures were taken. The low-density lipoprotein (LDL-C) and high-density lipoprotein (HDL-C) ratios, triglycerides (TGs), and HDL-C lipoprotein combined index (LCI) are in clinical use among others.[3] Furthermore, the Atherogenic Index of Plasma (AIP) was also introduced as a compatible marker recently.[4]

AIP is a logarithmic transformation of TGs/HDL cholesterol ratio and is considered as a better predictor of CVD.[5] It is found as an independent risk factor for CVD by Cai et al. (2017).[6] Additionally, epidemiological studies evaluated strong association between AIP and CVD risk factors including hypertension, obesity and diabetes mellitus.[7,8]

In 2016–2017, a nation-wide second National Diabetes Survey of Pakistan (NDSP) was conducted to assess the prevalence of diabetes among Pakistani population.[9] Subsequently, sub-studies were extracted from the NDSP data on the prevalence and risk factors for dyslipidemia, obesity, and hypertension that showed an increasing burden of them in

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this population.[10–12] We hypothesized that the AIP level is related to the risk of CVD in Pakistani population. Therefore, this study was aimed to assess the correlation between atherogenic index of plasma and cardiovascular disease risk factors.

2. Materials and methods

This study is a sub analysis of the second NDSP 2016–2017 survey conducted across Pakistan. The National Bioethics Committee (NBC) of Pakistan approved this survey [Ref: No.4-87/17/NBC-226/NBC/2664] and written informed consent was taken from all survey participants in their respective languages. The study recruited adult Pakistani nationals aged ≥20 years and above, both genders, willing to provide informed consent. All pediatric, gestational population and participants aged less than 20 years were excluded. Individuals who had incomplete data of any parameter of lipid profile were also excluded from the study. The comprehensive methodology of the NDSP 2016–2017 was already published.[9] A total of 7351 people were selected for this sub-analysis after fulfilling the inclusion criteria.

Stratification of the population was done including urban and rural areas of all four provinces (Punjab, Sindh, Khyber Pakhtunkhwa and Baluchistan) of Pakistan as defined in the last census.[9] Each province was taken as a stratum and the districts (a subdivision of provinces) as clusters, which were identified from each stratum. Towns/tehsils, as further bifurcation of districts, were considered sub-clusters from each identified cluster, for the cited survey. Clusters and sub-clusters were selected randomly; by using the probability proportional to size technique and the number of clusters was taken from each province by using the 'rule of thumb'. Out of 213 clusters, twenty-seven clusters were selected across Pakistan. A total of 46 sub-clusters; 21 from urban and 25 from rural were identified, respectively. Households were identified and selected members of every 10th household were counseled to come to the campsite after observing an overnight fast. Seventeen teaching hospitals and/or diabetes centers were involved in this survey.[9]

Standardized techniques were used for measuring height, weight, BMI, waist circumference, and blood pressure. Biochemical parameters were analyzed using standard methods. Sterilized disposable vacutainer tubes were used to collect blood samples. Total cholesterol (TC) was measured by CHOD-PAP method, for triglycerides GPO-PAP method was used, and for high-density lipoprotein cholesterol (HDL-C) homogeneous enzymatic colorimetric method, while for low-density lipoprotein cholesterol (LDL-C), CHOD-PAP method (Selectra Pro S instrument) was used. HbA1c test was performed by high-performance liquid chromatography (HPLC) method by D10 analyzer. The oral glucose tolerance test was used as gold standard diagnostic method for diagnosis of diabetes and pre-diabetes performed as per standard guidelines for diabetes diagnosis with fasting blood sugar ≥126 mg/dl and 2 h ≥200 mg/dl, and for pre diabetes diagnosis, fasting blood sugar 110–125 mg/dl and random blood sugar 140–199 mg/dl.[9]

As per WHO's criteria, results of plasma glucose testing were categorized as follows: Isolated impaired fasting glucose (IFG) - fasting plasma glucose level between 110 mg/dL and 125 mg/dL with 2-h post glucose level (PGL) ≤140 mg/dL. Isolated impaired glucose tolerance (IGT) - fasting glucose level <110 mg/dL and 2-h PGL between 141 mg/dL and 199 mg/dL. Newly diagnosed diabetes was defined as fasting plasma glucose level ≥126 mg/dL or 2-h PGL ≥200 mg/dL or both. Known diabetes was considered if the participant had been already diagnosed or taking anti-diabetic medication.[13] Obesity was defined as BMI (kg/m^2) which were categorized as follows: normal weight (18–22.9 kg/m^2), overweight (23.0–24.9 kg/m^2) and obese (≥25.0 kg/m^2).[11] Dyslipidemia was classified in fasting state as per Adult Treatment Panel III guidelines [20]. People were also considered as dyslipidemic if they were taking any lipid-lowering medication. With overnight fasting, the sample for participant's biochemical parameters were collected for OGTT, fasting and 2 h' glucose levels.

The atherogenic index of plasma (AIP) was calculated by using formula log10 (TG/HDL), as explained by Dobiasova and Frohlich[14] for all survey participants. Based on AIP values < 0.1, 0.1 to 0.24, >0.24, people were divided into three categories low, medium and high-risk groups respectively.[15]

3. Statistical analyses

Statistical analyses were conducted by using SPSS version 20.0 (SPSS Institute, Chaicago, IL) and data were expressed in n (%) or Mean ± SD. Chi-squared test and one-way analysis of variance (ANOVA) were used to compare categorical and continuous variables, respectively. Post hoc Tukey's test was performed to find association of diabetes, obesity with AIP and other parameters. Pearson's correlation was applied to check the strength of the relationship between various parameters. Multiple logistic regression was used to determine the associated factors of high-risk atherosclerosis. Statistical significance was set at P-value<0.05.

4. Results

A total of 10,834 people participated in the second NDSP 2016–2017 with an 87% response rate (12,486 individuals targeted). The data regarding lipid parameters were available in 7351 individuals (40.6% males and 59.4% females). Based on OGTT diagnostic criteria, 3722 (50.6%) individuals were found non-diabetic, 1122 (15.26%) as pre-diabetic, 686 (9.5%) were newly diagnosed diabetes, and 1821 (24.8%) with known diabetes, respectively. Participants mean age was 44.02 ± 14.07 years and was found significant in all four groups ($p < 0.0001$), indicative of increased middle age patient's vulnerability towards risk of cardiovascular diseases. The mean BMI was 27.12 ± 5.96 kg/m2, a systolic blood pressure of 126.39 ± 18.95 mmHg, diastolic blood pressure of 84.14 ± 14.6 mmHg, and waist circumference was measured as 93.9 ± 13.88 cm respectively with highly statistically significant difference ($p < 0.0001$). Results indicated majority of the study participants were in the range of overweight and obese category. The mean value of cholesterol was recorded as 5.01 ± 1.59 mmol/L, triglycerides as 2.17 ± 1.48 mmol/L, HDL-cholesterol as 0.83 ± 0.32 mmol/L, and LDL-cholesterol as 3.19 ± 1.01 mmol/L was found with highly statistically significant difference among all the groups ($p < 0.0001$). Mean AIP score was calculated as 0.38 ± 0.31 with statistically significant difference among all groups ($p < 0.0001$). The association of diabetes status with weight, height, BMI, waist circumference, and blood pressure were demonstrated in Table 1.

We observed an association of obesity with AIP and LCI and results showed all derived parameters including AIP, Log LCI, TC/HDL, LDL/HDL and Non-HDL/HDL ratios were higher than the normal range and with statistically significant difference ($p < 0.0001$). Additionally, this significance is noted not only in over weight and obese people but also in the normal weight people as depicted in Table 2. According to the AIP risk categorization, the 4756 individuals (64.7%) being the majority, fell in the high-risk category of developing CVD, while 1226 individuals (16.7%) were in moderate and 1369 (18.6%) individuals were found in the low-risk category as revealed in Fig. 1.

The results of multiple logistic regression analyses showed that as compared to females, males were significantly associated with the risk of CVD based on the AIP score (OR = 1.728, 95%CI = 1.247–2.396); $p < 0.0001$). In comparison to non-diabetic individuals, odds of CVD as risk factor according to AIP score was found more in pre-diabetic (OR = 1.728, 95%CI = 1.086–2.752; $p < 0.0001$), newly diagnosed diabetic (OR = 2.992, 95%CI = 1.071–8.36; $p = 0.001$), and known diabetic individuals (OR = 2.663, 95%CI = 1.488–4.764; $p < 0.0001$) respectively. Furthermore, factors such as overweight, obesity, waist circumference, and HbA1c also showed an independent association with a significantly high atherosclerosis risk, as shown in Table 3.

All lipid-derived parameters, such as ratio between LDL-C and HDL-C, TG and HDL-C, lipoprotein combined index (LCI) showed strong correlation with AIP. However, age, weight, height, waist

Table 1
Association of Diabetes status with various parameters.

Parameters	Non-diabetes	Pre-diabetes	Newly diabetes	Known diabetes	P-value	Overall
n	3722	1122	686	1821	–	7351
Gender						
Male	1413(40.2%)	433(39.3%)	306(47.4%)	725(39.9%)	0.003	2877(40.6%)
Female	2100(59.8%)	668(60.7%)	339(52.6%)	1094(60.1%)		4201(59.4%)
Age (years)	39.45 ± 13.87	44.91 ± 13.86[a]	48.74 ± 13.29[ab]	50.63 ± 11.31[abc]	<0.0001	44.02 ± 14.07
Weight (kg)	66.76 ± 15.41	69.36 ± 14.55[a]	71.06 ± 15.65[a]	72.3 ± 14.79[ab]	<0.0001	68.99 ± 15.32
Height (cm)	160.01 ± 11.61	160.3 ± 11.9	160.89 ± 12.37	159.57 ± 11.05	0.111	160.02 ± 11.58
Body Mass Index (kg/m^2)	26.23 ± 5.92	27.15 ± 5.9[a]	27.7 ± 5.97[a]	28.51 ± 5.79[abc]	<0.0001	27.12 ± 5.96
Waist Circumference (cm)	90.43 ± 13.41	94.61 ± 12.94[a]	96.55 ± 13.46[a]	99.07 ± 13.57[abc]	<0.0001	93.9 ± 13.88
Systolic Blood Pressure (mmHg)	121.88 ± 16.74	126.9 ± 17.76[a]	129.38 ± 20.08[a]	133.86 ± 20.66[abc]	<0.0001	126.39 ± 18.95
Diastolic Blood Pressure (mmHg)	81.52 ± 13.22	84.09 ± 13[a]	86.05 ± 14.53[a]	88.63 ± 16.77[abc]	<0.0001	84.14 ± 14.6
Fasting Blood Sugar (mg/dl)	82.23 ± 12.17	97.65 ± 14.71[a]	177.73 ± 77.28[ab]	186.59 ± 81.27[abc]	<0.0001	119.32 ± 67.12
Random Blood Sugar (mg/dl)	106.86 ± 17.9	153.67 ± 20.88[a]	245.04 ± 89.8[ab]	163.67 ± 60.18[ac]	<0.0001	130.94 ± 54.76
HbA1c (%)	5.18 ± 0.9	5.47 ± 1.09[a]	6.95 ± 2.16[ab]	7.43 ± 1.99[abc]	<0.0001	5.96 ± 1.73
Cholesterol (mmol/L)	4.89 ± 1.56	5.04 ± 1.54[a]	5.06 ± 1.57[a]	5.23 ± 1.65[ab]	<0.0001	5.01 ± 1.59
TC (mmol/L)	1.89 ± 1.21	2.08 ± 1.29[a]	2.55 ± 1.77[ab]	2.66 ± 1.77[ab]	<0.0001	2.17 ± 1.48
HDL (mmol/L)	0.86 ± 0.32	0.82 ± 0.3[a]	0.78 ± 0.31[ab]	0.8 ± 0.31[a]	<0.0001	0.83 ± 0.32
LDL (mmol/L)	3.11 ± 0.98	3.26 ± 1.04[a]	3.2 ± 1.04	3.3 ± 1.04[a]	<0.0001	3.19 ± 1.01
Non-cholesterol HDL (mmol/L)	4.03 ± 1.48	4.22 ± 1.47[a]	4.28 ± 1.48[a]	4.44 ± 1.59[ab]	<0.0001	4.18 ± 1.52
Atherogenic Index of Plasma	0.31 ± 0.3	0.37 ± 0.3[a]	0.47 ± 0.31[ab]	0.48 ± 0.31[ab]	<0.0001	0.38 ± 0.31
log LCI	1.45 ± 0.43	1.54 ± 0.43[a]	1.63 ± 0.44[ab]	1.67 ± 0.44[ab]	<0.0001	1.54 ± 0.45
TC/HDL	6.42 ± 3.12	6.84 ± 2.95[a]	7.32 ± 3.55[ab]	7.35 ± 3.24[ab]	<0.0001	6.8 ± 3.2
LDL/HDL	4.22 ± 2.31	4.53 ± 2.26[a]	4.72 ± 2.57[a]	4.71 ± 2.29[a]	<0.0001	4.44 ± 2.33
Non-cholesterol HDL/HDL	5.42 ± 3.12	5.84 ± 2.95[a]	6.32 ± 3.55[ab]	6.35 ± 3.24[ab]	<0.0001	5.8 ± 3.2

TC: Triglyceride, HDL: High Density Lipid, LDL: Low Density Lipid, LCI: lipoprotein combined index.
Data presented as mean ± SD; P-value <0.05 considered as statistically significant.
[a] Significantly different from non-diabetes.
[b] Significantly different from pre-diabetes.
[c] Significantly different from newly diagnosed diabetes.

Table 2
Association of obesity with atherosclerosis index of plasma and lipoprotein combined index.

Parameters	Normal weight	Over weight	Obese	P-value
	BMI< 23.0	23.0 >BMI< 24.9	BMI≥25.0	
n	1429	868	3622	
AIP	0.27 ± 0.31	0.37 ± 0.32[a]	0.41 ± 0.31[ab]	<0.0001
Log LCI	1.4 ± 0.44	1.53 ± 0.44[a]	1.59 ± 0.44[ab]	<0.0001
TC/HDL	6.14 ± 2.77	6.85 ± 2.97[a]	6.99 ± 3.19[a]	<0.0001
LDL/HDL	3.97 ± 2.07	4.41 ± 2.21[a]	4.57 ± 2.37[a]	<0.0001
Non-cholesterol HDL/HDL	5.14 ± 2.77	5.85 ± 2.97[a]	5.99 ± 3.19[a]	<0.0001

TC: Triglyceride, HDL: High Density Lipid, LDL: Low Density Lipid, LCI: Lipoprotein Combined Index, AIP: Atherogenic Index of Plasma; Data presented as mean ± SD; [a] Significantly different from normal weight, [ab] Significantly different from overweight.

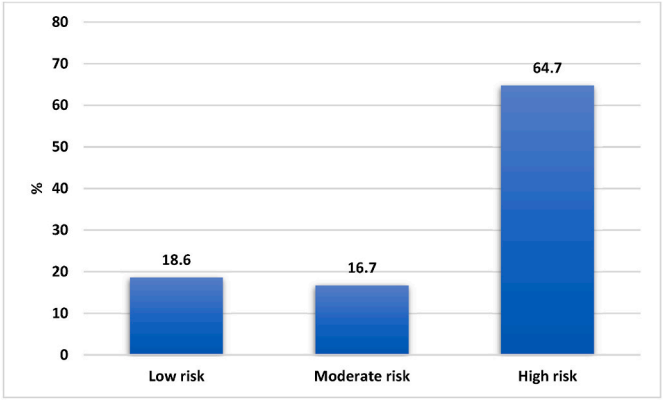

Figure:1. Atherosclerosis risk categorization.
Based on AIP values < 0.1, 0.1 to 0.24, >0.24, people were divided into three categories.
low, moderate and high-risk groups, respectively.
According to the AIP risk categorization, the 4756 individuals (64.7%) being the majority, fell in the high-risk category of developing CVD, while 1226 individuals (16.7%) were in moderate and 1369 (18.6%) individuals were found in the low-risk category as revealed in Fig. 1.

circumference, BMI, systolic and diastolic blood pressures, FPG, 2-hPGL, and HbA1c values were weakly correlated with AIP, as shown in Table 4.

5. Discussion

In the current study, we evaluated the relationship between AIP and other lipid-derived parameters for CVD risk assessment and concluded that AIP is a significant, convenient, independent, and better predictor for CVD risk in the Pakistani population than other lipid-derived parameters and lipid ratios. While, it has been observed that male gender, diabetes, obesity, and high waist circumference are independently associated with the risk of atherosclerosis.

The present study noted a positive and significant association of AIP with several risk factors for CVD including, weight, BMI, waist circumference, age, diabetes status, systolic and diastolic blood pressures. Kumar et al. also showed that AIP significantly correlates with atherosclerosis indexes such as LDL-C.[15] Similarly, Shen et al. found a positive correlation of AIP with waist circumference,[16] however it was negatively correlated with insulin sensitivity in diabetic subjects in another study.[17] An important finding which was observed in this study was that although the association of WC with AIP was positive and significant, it was relatively weak(r = 0.24). While, WC showed an independent association with high atherosclerosis risk. This relatively unusual result is assumed to be affected by the impact of cofounding variables and the excluded data due to missing and incomplete values.

It is observed in the present study that AIP is strongly associated with

Table 3
Multiple logistic regression to determine risk factors for Atherosclerosis.

Factors		OR (95% C.I)	P-value
Gender	Female	1	
	Male	1.41 (1.18–1.70)	<0.0001
Diabetes status by OGTT	Non-DM	1	
	Pre-DM	1.61 (1.25–2.08)	<0.0001
	Newly DM	2.17(1.4–3.36)	0.001
	Known DM	2.21 (1.67–2.92)	<0.0001
Obesity (by Asian BMI categorization)	Normal weight	1	
	Overweight	1.27 (0.97–1.66)	0.085
	Obese	1.51 (1.22–1.88)	<0.0001
Waist circumference		1.03 (1.02–1.03)	<0.0001
HbA1c		1.16 (1.07–1.26)	<0.0001

OGTT:Oral Glucose Tolerance Test, DM: Diabetes Mellitus, BMI: Body Mass Index.
Reference category: Low/moderate risk, backward elimination Wald method was used. Parameters entered into the model include; age, gender, diabetes status, obesity, waist circumference, HbA1c, hypertension, physical activity, tobacco use, and family history of DM. P-value<0.05 considered as significance.

various lipid-derived ratios like log LCI, TC/HDL, LDL/HDL, and Non-HDL/HDL. This may indicate AIP as a strong predictor of CVD. These findings are consistent with the previous study that indicated AIP as a strong and independent predictor for CVD in other populations.[18]

Obesity is a major risk factor for developing several diseases along with T2DM, and CVD.[19] In the present study it is found that BMI, weight, and waist circumference are higher in the study population and increased significantly from non-diabetic to diabetic group. We also found a significant association of obesity with AIP, Log LCI, TC/HDL, LDL/HDL, and Non-HDL/HDL. Previous researches are in line with our findings and signified the association of obesity with an abnormal concentration of lipids in the blood i.e., dyslipidemia that consequently develops CVD.[20,21]

It has been reported that abnormal concentration of lipids in the blood is the major risk factor for CVD and the association between conventional lipid measures such as; TC, LDL-C, and TG, with the incidence of CVD, is well recognized. Moreover, lipid ratios, such as TC/HDL-C, LDL-C/HDL-C, AI, and LCI, are also considered as predictors for CVD. However, it is a revelation that small density LDL (sdLDL) more easily invades and deposits on the arterial wall than LDL due to its small size and is easily oxidized to oxidized Low-Density Lipoproteins (oxLDL). This oxidized LDL (Ox LDL) particles are phagocytized and converted to foam cells by macrophages, thereby aggravating atherosclerosis and CVD. Recently, several studies also validated this mechanism and revealed sdLDL is an important marker for predicting arteriosclerosis.[22,23] However, the detection of sdLDL is limited in clinical applications because of the complicated and expensive detection method. The primary benefit of AIP assessment over other lipid parameters is due to its strong association with sdLDL.[14] Other lipoprotein abnormalities have also been found in patients with cardiovascular diseases including low HDL-C, elevated LDL, and elevated TGY, the LDL/HDL-C ratio and the TGY/HDL-C ratio.[24,25] However, few studies showed that these lipid parameters are not associated with symptomatic CVD in cohort regression models.[23,26] Yet, multiple studies have shown an association between the sdLDL and AIP with CVD in symptomatic and asymptomatic individuals.[15,27] Our findings are in the line with these reports. Similarly, in 2015 a meta-analysis explored the relationship between lipid parameters and risk for the development of diabetes mellitus (DM). They exhibited that AIP has a significant association with

Table 4
Pearson's correlation.

Parameters	AIP	log LCI	TC/HDL	LDL/HDL	Non-HDL/HDL	Weight	BMI	WC	Age	FBS	RBS	SBP	DBP	HbA1c
AIP	1	0.814**	0.703**	0.580**	0.703**	0.184**	0.161**	0.240**	0.137**	0.213**	0.147**	0.123**	0.090**	0.218**
log LCI	0.814**	1	0.740**	0.641**	0.740**	0.151**	0.172**	0.212**	0.139**	0.189**	0.137**	0.142**	0.100**	0.222**
TC/HDL			1	0.865**	01.000**	0.094**	0.105**	0.137**	0.068**	0.100**	0.080**	0.112**	0.022	0.109**
LDL/HDL				1	0.865**	0.087**	0.105**	0.094**	0.042**	0.068**	0.065**	0.074**	0.030*	0.042**
Non-cholesterol HDL/HDL					1	0.094**	0.105**	0.137**	0.068**	0.100**	0.080**	0.112**	0.022	0.109**
Weight						1	.770**	0.628**	0.083**	0.100**	0.082**	0.169**	0.204**	0.107**
BMI							1	0.518**	0.090**	0.134**	0.089**	0.131**	0.179**	0.118**
WC								1	0.231**	0.140**	0.141**	0.168**	0.210**	0.209**
Age									1	0.229**	0.210**	0.126**	0.192**	0.249**
FBS										1	0.783**	0.044	0.165**	0.608**
RBS											1	0.079*	0.116**	0.501**
SBP												1	−0.011	0.105**
DBP													1	0.146**
HbA1c														1

AIP:Atherogenic Index of Plasma, LCI: lipoprotein combined index, TC: Triglyceride, HDL: High Density Lipid, LDL: Low Density Lipid, BMI: Body Mass Index, WC: Waist Circumference, FBS: Fasting Blood Sugar, RBS: Random Blood Sugar, SBP: Systolic Blood Pressure, DBP: Diastolic Blood Pressure.
** Significant at P-value<0.01.
*Significant at P-value< 0.05.

DM than traditional lipid parameters.[7] Similarly, in the current study, lipid ratios were shown significantly higher in the study population. Earlier studies documented TC/HDL-C, LDL-C/HDL-C, AI, and LCI, as predictors for CAD. However, a study from India indicated significantly higher values of AIP, TG/HDL-c, LDL/HDL-c, and HDL/VLDL among type 2 diabetes subjects as compared to healthy individuals.[28] Elevated levels of AIP and other lipid parameters were also found in the study participants having diabetes.

In the determination of risk factors for CVD such as atherosclerosis through multiple linear regression analysis, we found that people with diabetes either newly diagnosed diabetes, pre-diabetes, or subjects with full-blown diabetes were at higher risk of atherosclerosis.[29] This finding is consistent with the previous report which narrated that diabetes, aging, and chronic kidney disease were associated with arteriosclerosis.[12] On the contrary, some found high LDL-C levels, smoking, and hypertension as determined causes for atherosclerosis.[13] We also found that study subjects that were obese with higher weight and waist circumference were more prone to atherosclerosis. It was also determined in the present study that male participants were at higher risk of atherosclerosis in comparison to females. Our results are similar to the previous study on the Asian population which revealed that concerning AIP, the incidence of CVD events in men is higher while negligible in women.[30]

Concerning AIP levels, our study found that 95.2% of study participants were at high risk of atherosclerosis that exhibited AIP levels above 0.24. Moderate or low risk of atherosclerosis at less than 0.1, while between 0.1 and 0.24 AIP levels were found. The ratio of atherosclerosis prevalence became lower as AIP levels decreased. These findings are in line with the previous research done by Mayat et al. Influence of genetic factors in subjects with cardiovascular disease was not investigated in the present study.

To the best of our knowledge, this study is among the few studies that have identified AIP as a potential risk factor for the prediction of future cardiovascular events, in Pakistani population. This would create better opportunities to deliver greater preventive measures in this regard. Moreover, AIP may also be a relevant screening method in circumstances where all other CVD risk factors are in the normal range. However, some limitations still existed in our study. First, due to budget constraints we were unable to look at the prevalence of CVD in the underlying population, and the follow up data of CVD events was not obtained. Second, a number of participants were excluded owing to the incomplete data, which could have improved the results of study. Although this study was done on a national level, it will be conducive on incremental findings and studies. Hence, more longitudinal studies are required to validate the findings of this study.

6. Limitations

Present study was only conducted in individuals greater than 20 years of age and young patients who had higher chances of type 1 diabetes were not considered. Future studies are required to examine CVD risk factors among pediatrics and gestational patients. Moreover, in present study, AIP significance was not only found in overweight and obese people but also in the normal weight individuals. A more recent survey needs to be conducted to determine the present pattern of diabetes and CVDs among Pakistani population. Our study diagnosed reported already diagnosed patients with diabetes taking oral anti-diabetic drugs. Future randomized control trails and experimental studies are required to examine the impact of other medications (anti-hypertensive, anti-psychotics, cholesterol lowering agents) on lipid metabolism. Additionally, impact of comorbid conditions on lipid metabolism needs to be explored among Pakistani population. Our study due to limitation of available resources and expected variation of HbA1c results among anemic patients and patients with haemoglobinopathies did not use HbA1c as diagnostic criteria.

7. Conclusion

We concluded that a significant association between AIP and CVD risk factors exists. High levels of AIP in the Pakistani population may be an alarming sign of developing cardiovascular disease. Additionally, AIP might be used as a convenient marker in the risk assessment of CVD.

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The funding source for the study remained same as in the second NDSP [2016–2017].

Author's contribution

Fawwad A: Literature search, interpretation of data, wrote and approved the manuscript.

Mehmood Y: Literature search, interpretation of data, wrote and approved the manuscript.

Askari S: Interpretation of data, Edited and approved the manuscript.

Butt A: Concept, design, edited and approved the manuscript.

Basit A: Literature search, interpretation of data, edited and approved the manuscript.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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