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Original Research Article

Association of a body shape index with cardiovascular risk profile in subjects with type 2 diabetes mellitus: an observational hospital-based study

Maheen Erum*, Debashish Choudhury, L. H. Ghotekar, Sheikh Yasir Islam, Anu Goswami

Department of Medicine, Lady Hardinge Medical College, New Delhi, India

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***Correspondence:**
Dr. Maheen Erum,
E-mail: maheenerum@gmail.com

ABSTRACT

Background: A body shape index (ABSI), has been shown to be a better predictor of all-cause mortality in incident hypertension, diabetes mellitus (DM) and cardiovascular diseases (CVDs). However, few studies explore association between ABSI and cardiovascular risk profile in patients with DM.
Methods: This was an observational, hospital-based study conducted in the medical outpatient clinic of a tertiary-care center in Northern India. The study included diagnosed cases of type 2 DM (T2DM) (1:1 male-female ratio, aged ≥35 years). Anthropometric indices assessed included ABSI, WC, and body mass index (BMI). Primary outcome measures were HbA1c, systolic and diastolic blood pressure (SBP and DBP), and serum triglycerides (TG). The secondary outcome was urine albumin-to-creatinine ratio (UACR). Correlations between ABSI and cardiovascular risk factors were analyzed, and receiver operating characteristic (ROC) curve analysis was performed to compare the predictive ability of ABSI against WC and BMI.
Results: No significant positive correlation was found (all $p>0.05$). Weak positive and negative correlations were observed between ABSI and HbA1c, TG and systolic blood pressure, UACR respectively. A significant negative correlation ($p<0.05$) was observed between ABSI and diastolic blood pressure ($r=-0.243$, $p=0.023$) in males. On assessment of area under curve (AUC) of ROC, ABSI, fared better than WC and BMI in association with HbA1c, TG, and blood pressure.
Conclusions: Our study showed that there was no conclusive evidence to support ABSI as an accurate tool to gauge cardiovascular risks in patients with T2DM.

Keywords: A body shape index, T2DM, Cardiovascular risk

INTRODUCTION

The prevalence of diabetes is steeply rising in India. As is evident from estimates, the gap between the burden of non-communicable diseases borne by developed and developing countries, respectively, is fast diminishing. According to diabetes atlas (10th edition), the global prevalence of diabetes is estimated at 537 million, and South-east Asia alone, harbours around 90 million people with diabetes, while the numbers are expected to cross 152 million by 2045.[1] Adults with low socio-economic status are disproportionately affected by diabetes and its complications, majorly because of reduced access to recommended screening and preventive care.[2]

Obesity is one of the major risk factors of diabetes. The steep rise in the prevalence of T2DM correlates strongly with the upsurge of obesity rates. Obesity also poses a great challenge to the management of diabetes.[3] The systemic complications of obesity such as insulin resistance, hyperlipidaemia, hypertension, and atherosclerosis are linked more strongly to

intraabdominal and/or upper body fat than to overall obesity. Visceral adipose tissue, being hormonally active, is associated with higher levels of circulating inflammatory cytokines, thus causing adipose tissue inflammation leading to insulin resistance, in contrast to subcutaneous adipose tissue.[4]

The incidence of cardiovascular mortality in diabetic subjects without a clinical history of previous cardiac events is as high as the incidence in nondiabetic subjects with a history of myocardial infarction (MI).[5] A study published in 2018 estimated the overall prevalence of CVD in persons with T2DM to be a staggering 32.2%.[6] Another study reported acute coronary event, and chronic coronary disease to account for 63% of deaths in T2DM patients, placing subjects with significantly higher levels of systolic blood pressure, HbA1c, and serum TG at maximum risk.[7]

Since visceral adiposity is directly associated with increased morbidity and mortality in patients with T2DM, it is pivotal to develop anthropometric indices that measure visceral adiposity effectively, and assess its ability to estimate cardiovascular risks.

A number of indirect measures of visceral adiposity have been developed, like BMI, WC (waist circumference), WHR (waist hip ratio), or newer measures such as, ABSI. Several studies have however, indicated that although BMI and WC have been often used as surrogate markers for central adiposity, the inability, of the former to discriminate between fat and lean mass, and the latter to discriminate between subcutaneous and visceral obesity, limit their use.[8-11] However, a direct measure of visceral obesity requires the use of gold standard, expensive imaging procedures, like CT and MRI, the cost rendering them inaccessible in primary health care settings, and thus limiting their use.

A new anthropometric measure, ABSI was proposed in 2012, by Krakauer and Krakauer, which has been adjusted for WC, BMI, and height and is developed to be independent of BMI. Recent studies have demonstrated ABSI to be a robust predictor of all-cause mortality.[12,13] Several previous studies have demonstrated the significant association of ABSI with mortality, incident hypertension, diabetes, and CVD.[12-14] Recently Dhana et al demonstrated in a prospective population-based study, that ABSI was more strongly associated with total cardiovascular mortality than BMI, WC, WHtR, WHR.[14] The largest study from Europe reported that the combination of ABSI and BMI could predict risk for cardiovascular events better than any of the single measures for body composition such as WC.[11] A study published in 2021 found high ABSI values to be a strong independent predictor of endothelial dysfunction in both men and women.[15]

However, while these studies highlight the ability of ABSI to measure metabolic indices, thereby laying grounds for it to have clinical application, the conflicting conclusions in different studies fail to document a clear and consistent association of ABSI with DM and associated cardiovascular events. Therefore, this study was planned with an aim to determine ABSI and find out its association with cardiovascular risk profile in subjects with T2DM.

METHODS

Design overview

An observational, cross-sectional, hospital-based was conducted in the newly diagnosed, and previously diagnosed and documented cases of T2DM, of 35 years of age or above, of both sexes, in a tertiary care centre in India. Subjects suffering from ascites, with pendulous abdomen, morbid obesity, obstructive sleep apnoea, or any other pelvic pathology that could alter WC with an abdominal tumour or who had undergone abdominal surgery, bariatric surgeries, hip surgeries, that would interfere with WC in any way, with pre-existing stroke or any other illness that would preclude measurement of WC, those with any spinal cord injury, or other neurological deficits that would preclude height measurement and with other known chronic illnesses, or endocrinopathies were excluded from the study.

Settings and participants

The 2-month study was conducted in the medical outpatient department of a tertiary care centre in Northern India, from September 2021, to October 2021. The study was commenced after informing and obtaining approval from the institute ethics committee (IEC), (Approval number: LHMC/IEC/2020/03/16). A consecutive sampling method was used to recruit all subjects diagnosed with T2DM fulfilling the eligibility criteria from the medicine outpatient department, after explaining all details of the standard protocol in their colloquial language, and obtaining verbal and written consent. All the study participants were provided with the standard management protocol. Confidentiality of the information collected was maintained. No interventions were carried out in our study. Patients were explained the benefits of participating in the study and usefulness of the definitive diagnosis in management of their condition.

After taking a thorough history from the patient, subsequent examinations including anthropometric measurements were carried out. WC weight and height were measured to calculate the BMI, and subsequently, to calculate ABSI. All data from the history taking, examination findings, and anthropometric measurements were recorded in a predesigned proforma.

Thereafter, the association between ABSI, HbA1c, serum TG, blood pressure, and urine albumin excretion was subsequently analysed in both males and females.

Detailed history and examination (including anthropometry and thorough systemic examination) of all the cases was done and data collected entered in a pre-designed proforma. General physical examination including anthropometry was carried out. Blood pressure was measured using the right blood pressure apparatus in the right arm sitting posture after an adequate rest of approximately 10 minutes. An average of three readings was recorded at interval of 5 minutes. Mean of the three readings was taken up for consideration. Cut-off value for SBP/DBP: 130 and/or 90 mmHg. WC (to the nearest half centimetre) was taken as circumferential measurement midway between the anterior superior iliac spine and lower costal margin, at the umbilical level in the standing position, over the abdominal skin, by an end elastic, non-stretchable tape. Height (to the nearest half centimetre) was measured in the medical OPD using a stadiometer. The subject was asked to stand without shoes, in an upright standing posture, with the heels together, and the heels, buttocks, and upper part of the back touching the scale of the stadiometer. Weight (nearest to 0.5 kg) of the subjects, dressed in light clothes, and without shoes, was measured using a digital scale. BMI and ABSI were be calculated as: ABSI=(WC)/ ($BMI^{2/3}$×$height^{1/2}$), expressed in $m^{11/6}kg^{-2/3}$, whereas BMI was calculated as BMI=weight/$height^2$. Evaluation of systems including cardiovascular, respiratory, abdominal and musculoskeletal systems, central nervous examination was carried out in all the subjects. The entire laboratory data collected was entered in the proforma. The various cut-off values were considered as follows. FBG: more than or equal to 126 mg/dL (for new cases of T2DM). Albumin levels of 30-300 mcg/mg creatinine were labelled has having microalbuminuria. S. TG: Values more than 150 mg/dl were considered as having hyper-triglyceridemia. HbA1c>7.5% were considered having poor glycaemic control and a value <7.5 amounted to adequate glycaemic control.

Statistical analysis

Data presentation has been done as range and mean±SD for continuous variables and frequency and percentages for categorical variables. The data analysis was done by freely available online SPSS software. Chi square test was used to find the association between the variables. Statistical methods have been used in the form of mean, median, and mode to interpret the parametric data. The correlations of ABSI with HbA1c, serum TG, blood pressure, and urine albumin excretion, have been calculated using Pearson's/Spearman's correlation coefficient. Correlation value has been considered significant if $p<0.05$.

RESULTS

A total of 30 patients (males=15 and females=15) of DM who visited medical OPD in our tertiary care centre from September 2021 to October 2021 fulfilling the selection criteria were enrolled into the study after taking written informed consent.

Mean age of the population is 53.56±11.5 years, of which 27% subjects belonged to 35-49 year age category, 50% to 50-64 years, and 23% were ≥65 years of age. 43% of the subjects had microalbuminuria, an indicator of diabetic nephropathy, 77% had diabetic neuropathy, 27% had hypertension, and 57% of the subjects were obese (Table 1).

Table 1: Co-morbidities in the population.

Co-morbidities	Response	N	Percentages (%)
Diabetic nephropathy	No	17	56.67
	Yes	13	43.30
	Total	30	100
Diabetic neuropathy	No	7	23.30
	Yes	23	76.67
	Total	30	100
Hypertension	No	22	73.30
	Yes	8	26.67
	Total	30	100
Obesity	No	13	43.33
	Yes	17	56.67
	Total	30	100

Mean WC of subjects included 1.047±0.83 m, mean BMI 27.41±3.29 kg/m^2, mean ABSI 0.091±0.006$m^{11/6}kg^{-2/3}$, mean HbA1c 8.51±2.22, mean TG 203±98.5 mg/dl, mean systolic blood pressure 128.57±10.95 mmHg, mean diastolic blood pressure 79.93±8.65 mmHg, mean urine albumin creatinine ratio 129.21±276.26 (Table 2).

On comparative analysis of males and females, mean WC, ABSI, HbA1c, TG, diastolic blood pressure found to be higher in males than females (1.06±0.75 vs 1.03±0.09 m, 0.0913±0.005 vs 0.090±0.007 $m^{11/6}kg^{-2/3}$, 8.75±2.68 vs 8.27±1.69, 219.3±125.9 vs 187.12±60.8 mg/dl, 80.4±8.14 vs 79.46±9.39 mmHg respectively) whereas BMI, systolic blood pressure and UACR found to be higher in females than males (27.8±3.07 vs 27.03±3.56 kg/m^2, 128.67±11.9 vs 127.46±10.18 mmHg, 188.4±325.13 vs 69.99±211.81 respectively) (Table 3).

On data analysis, as depicted in Table 4 and Figure 1, in males, a very low positive correlation, not significant, observed between ABSI and HBA1c (r=0.069, p=0.604) and TG (r=0.251, p=0.77). Significant negative correlation observed between ABSI and diastolic blood pressure (r=-0.243, p=0.023). Very low negative correlation, non-significant, observed between ABSI and systolic blood pressure (r=-0.148, p=0.17), UACR (r=-0.204, p=0.77). In females, low positive correlation, non-significant observed between ABSI and HbA1c (r=0.408, p=0.41), TG (r=0.456, p=0.422), diastolic blood pressure (r=0.285, p=0.92). Non-significant, negative correlation observed between ABSI, systolic blood pressure (r=-0.6,

p=0.31) and UACR (r=-0.265, p=0.474). In males and females combined, non-significant, very low positive correlation observed between ABSI and HbA1c (r=0.215, p=0.399), TG (r=0.297, p=0.97), and diastolic blood pressure (r=0.086, p=0.133).

Very low, non-significant negative correlation observed between ABSI and systolic blood pressure (r=-0.098, p=0.086), and UACR (r=-0.250, p=0.399).

Area under ROC curves of the anthropometric indices for predicting cardiovascular risk profile in DM

The area under ROC curve (AUC) for each anthropometric index and HbA1c, TG, SBP, DBP and UACR is shown in Figure 2. The AUC of ABSI was more than 0.7 but less than 0.8 in relation to triglyceride levels suggesting fair predictive significance.

The AUCs of ABSI were larger than 0.5 but lower than 0.7, in relation to HbA1c, SBP and DBP suggesting a moderate-low predictive significance.

Overall, the AUCs of ABSI were more than WC and BMI in ROCs of HbA1c, TG, and diastolic blood pressure, albeit with moderate significance, suggesting ABSI to be a better diagnostic tool. ABSI and WC showed the largest AUCs of 0.767 and 0.702 for TG, respectively. In subjects with T2DM, anthropometric indices reflective of central adiposity, (ABSI, WC and BMI) give similar AUCs in ROCs of metabolic parameters assessing cardiovascular risk profiles.

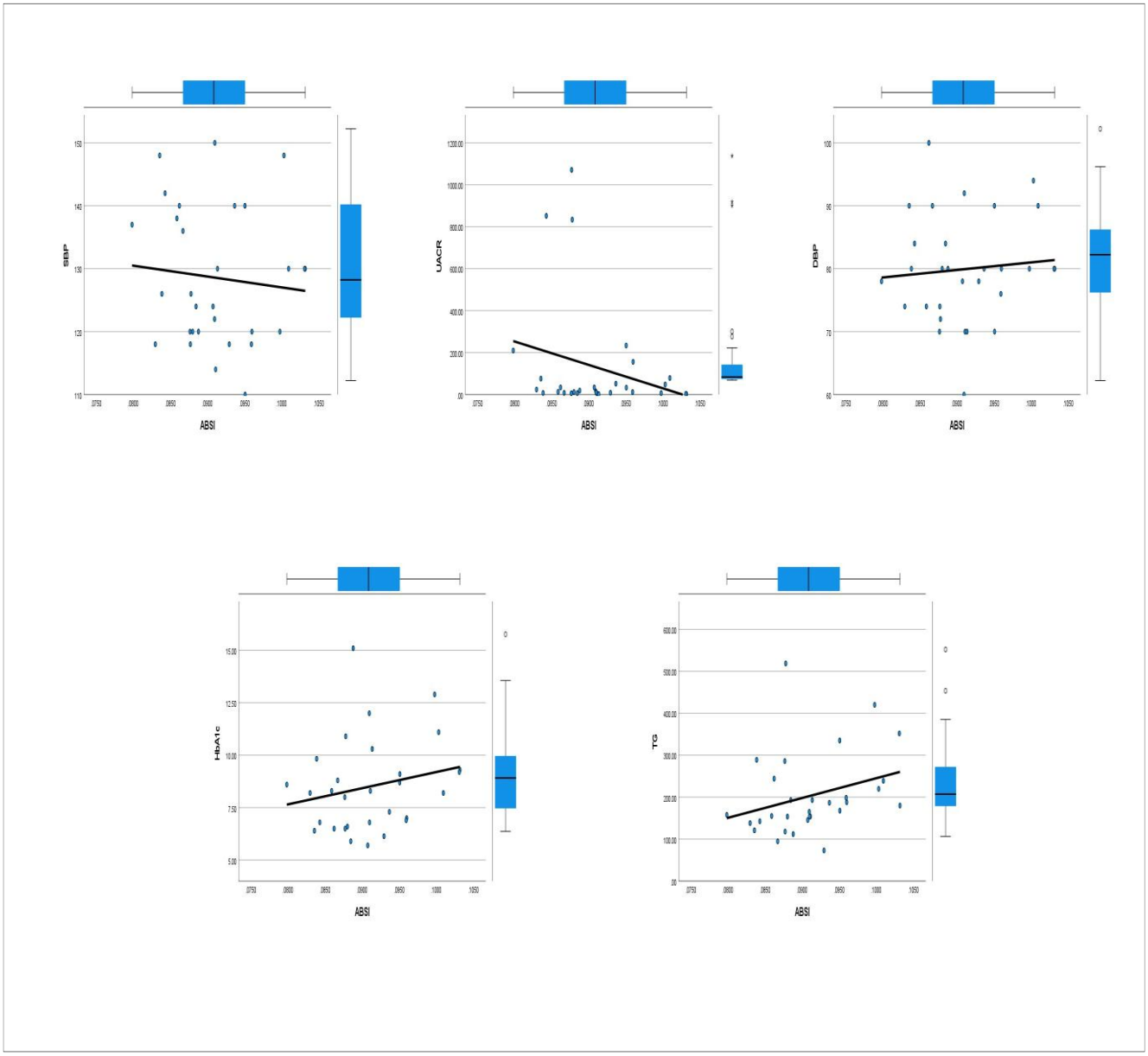
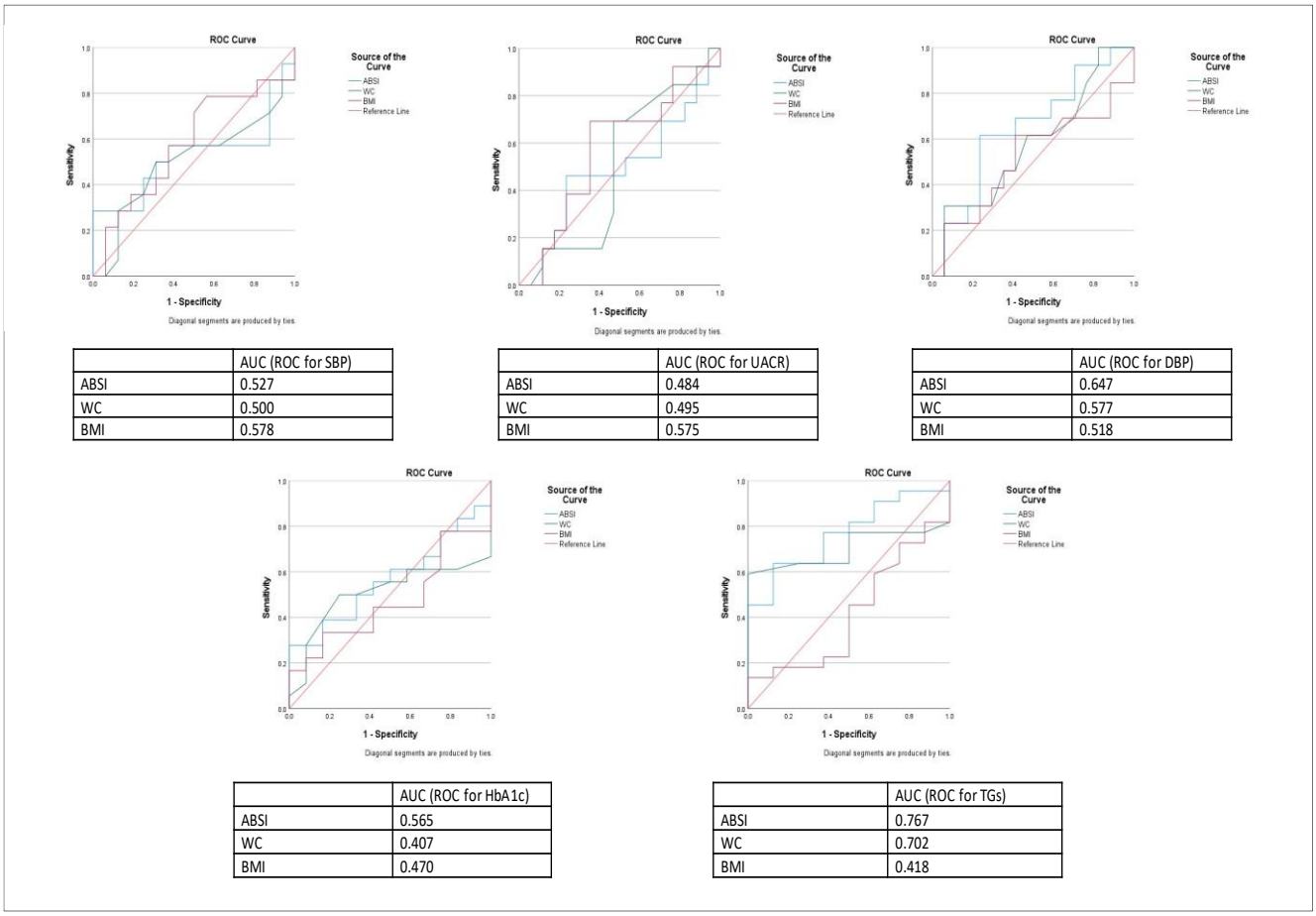


Figure 1: Linear regression plots between SBP, UACR, DBP, HbA1c, TG and ABSI.



	AUC (ROC for SBP)
ABSI	0.527
WC	0.500
BMI	0.578

	AUC (ROC for UACR)
ABSI	0.484
WC	0.495
BMI	0.575

	AUC (ROC for DBP)
ABSI	0.647
WC	0.577
BMI	0.518

	AUC (ROC for HbA1c)
ABSI	0.565
WC	0.407
BMI	0.470

	AUC (ROC for TGs)
ABSI	0.767
WC	0.702
BMI	0.418

Figure 2: Receiver operator characteristic curves of anthropometric indices and AUC of SBP, UACR, DBP, HbA1c, and TG in subjects.

Table 2: Demographic and clinical characteristics of the population.

Parameters	N	Mean	SD	Median	Min	Max
WC	30	1.047	0.83	1.04	0.89	1.2
BMI	30	27.419	3.29	26.73	21.64	36.72
ABSI	30	0.091	0.006	0.09	0.798	0.103
HbA1c	30	8.51	2.22	8.25	5.7	15.1
TG	30	203.21	98.5	173.95	73	518.7
SBP	30	128.57	10.95	126.0	110	150
DBP	30	79.93	8.65	80	60	100
UACR	30	129.21	276.26	17.0	2.3	1071

SD=standard deviation, WC=waist circumference, BMI=body mass index, ABSI=A body shape index, TG=triglycerides, SBP=systolic blood pressure, DBP= diastolic blood pressure, UACR=Urine albumin creatinine ratio.

Table 3: Comparative analysis of males and females.

Parameters	Male (mean)	Male (SD)	Female (mean)	Female (SD)
WC	1.06	0.75	1.03	0.092
BMI	27.03	3.56	27.8	3.07
ABSI	0.0913	0.005	0.09	0.007
HbA1c	8.75	2.68	8.27	1.69
TG	219.3	125.9	187.126	60.8
SBP	127.46	10.18	128.67	11.9
DBP	80.4	8.14	79.46	9.39
UACR	69.99	211.81	188.4	325.13

Table 4: Pearson's correlation coefficient and chi square tests between ABSI and HbA1c, TG, SBP and DBPs, UACR in males, females and combined.

Parameter	ABSI (M) r value	ABSI (M) p value	ABSI (F) r value	ABSI (F) p value	ABSI overall r value	ABSI overall p value
HbA1c	0.069	0.604	0.408	0.41	0.215	0.399
TG	0.251	0.77	0.456	0.422	0.297	0.97
SBP	-0.148	0.17	-0.06	0.31	-0.098	0.086
DBP	-0.243	0.023	0.285	0.92	0.086	0.133
UACR	-0.204	0.77	-0.265	0.474	-0.25	0.399

DISCUSSION

In India, the mounting prevalence of diabetes can be explained by an interplay of multiple factors, major contributors being, obesity, lack of physical activity, genetic factors, and a sedentary lifestyle. The socio-economic disparities that plague our nation, and a collapsing health infrastructure, with skewed healthcare worker to patient ratio, make it harder to make screening tools and treatment accessible to many. More so, with the rural-urban prevalence gap of diabetes fast diminishing, and reduced healthcare access in former regions, it is imperative that screening tools that work accurately in low resource settings, and help in risk stratification of patients with DM be devised.[16]

The 90-95% of diagnosed cases of T2DM in adulthood is associated with obesity. Obesity/insulin resistance in diabetes and prediabetes conditions, predispose to endothelial dysfunction by creating an imbalance between beta cell function and insulin sensitivity.[17] Visceral adipose tissue being hormonally active, affects metabolism by secreting inflammatory cytokines (TNF-alpha, IL-6), leptins, and most importantly NEFAs.[18] Increased levels of NEFAs is directly related to decreased insulin insensitivity and vice versa.[19] Another factor implicated in development of DM is beta cell dysfunction. Abnormal pancreatic beta cells, unable to adapt to insulin resistance, fail to maintain normal levels of glucose. This is thus followed by increased fasting plasma glucose (FPG) and subsequently the development of T2DM.[18]

CVD is the most prevalent cause of mortality and morbidity in diabetic population. Multiple risk factors include obesity, accelerated dyslipidaemia, diabetic cardiomyopathy, and silent myocardial ischemia owing to autonomic dysfunction.[20] People with T2DM are disproportionately affected by CVD compared with non-diabetic subjects. Haffner et al reported death rates due to cardiovascular causes over a 7-year period in patients with and without T2DM.[21] In persons with T2DM, the death rates were 15.4% for those with no prior MI and 42.0% in patients having a history of MI. In contrast, patients who did not have T2DM, the death rates due to cardiovascular causes were 2.1 and 15.9%, respectively.

ABSI is a simple indicator that requires measurement of WC, height and weight. Since it combines weight and WC, it becomes easier to gauge cardio-metabolic risks related to visceral adiposity specifically. An increase in weight, not accompanied by an increase in WC, points towards lean mass gain, and this relationship makes ABSI different from BMI in that it can differentiate between lean mass and visceral fat.

Therefore, in this hospital based, cross-sectional study conducted in our tertiary care centre, with 30 OPD subjects, who were enrolled and investigated as per a pre-designed proforma in the study period, from September 2021-October 2021, we wanted to gauge if a waist index independent of BMI, such as ABSI, would enable accurate risk stratification in patients with T2DM.

In this study, we analysed the correlation between ABSI, an anthropometric index for visceral adiposity, and cardiovascular risk profiles in subjects with T2DM, using metabolic parameters like HbA1c, TG, blood pressure, and UACR.

The average age of the subjects involved was 53.56±11.5. A high incidence of diabetic nephropathy was observed among subjects (77%). The 43% of the study population had microalbuminuria, and 27% of subjects were hypertensive. A high prevalence of obesity was observed in the study population, 57% overall, 67% in males, and 47% in females.

No significant positive correlation was found between ABSI and the metabolic parameters studied (all $p>0.05$). Weak positive correlations were observed between ABSI (combined, males, and females) and HbA1c, and TG. A study performed Wu et al concluded ABSI to have weak correlations with markers of insulin resistance.[22] Weak negative correlations were observed between ABSI (combined, males, and females), and systolic blood pressure, and UACR. However, a significant negative correlation ($p<0.05$) was observed between ABSI and diastolic blood pressure ($r=-0.243$, $p=0.023$) in males, which is a new finding, and needs to be studied on a larger sample size to prove its significance.

To study the relevance of ABSI as a diagnostic tool, and its comparison to other anthropometric indices that measure visceral adiposity, we studied the ROC curves of HbA1c, TG, SBP and DBP and urine albumin creatinine ratio. ABSI, as a predictor of cardio-metabolic abnormalities in subjects with T2DM, fared better than

WC and BMI on most indices, specifically HbA1c, TG, and blood pressure. In national health and nutrition examination survey IV (NHANES IV) ABSI was able to predict mortality better than WC and BMI.[23] On studying the ROCs, the AUC of ABSI being >0.7, in the ROC of TG, suggested fair predictive significance. In another study conducted in Iran, a positive trend was reported between ABSI and increasing adiposity indices in women with and without prior-GDM (gestational DM).[24] The AUCs of ABSI being larger than 0.5 but lower than 0.7, in ROCs of HbA1c, SBP and DBP suggested a moderate-low predictive significance. Our findings based on AUCs are consistent with a study performed in Iran by Haghighatdoost et al where ABSI was concluded to be a moderate-weak predictor of cardio-metabolic risk profile.[25]

We acknowledge the following limitations of our study, a small sample size, and recruitment of subjects from the medical OPD of a tertiary care centre in India, which may not have been representative of the entire Indian population. However, this is the first study done to find correlations between with new anthropometric index, ABSI, and metabolic parameters indicative of cardiovascular risk profile in subjects with T2DM in the Indian sub-population.

CONCLUSION

In conclusion, our study shows that ABSI may not be an accurate tool to gauge cardiovascular risks in patients with T2DM, since no significant positive correlation was found between ABSI and metabolic parameters like HbA1c, serum TG, blood pressure and UACR. Our study also concluded ABSI to be a moderate-weak predictor of CVD in T2DM patients. However, a significant negative correlation ($p<0.05$) was observed between ABSI and diastolic blood pressure ($r=-0.243$, $p=0.023$) in males, which is a new finding, and needs to be studied on a larger sample size to prove its significance. For the establishment of its efficacy as a diagnostic tool, prospective studies need to be performed on a larger sample size.

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