Original Article

A body shape index in a small sample of Saudi adults with type 2 diabetes

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Abstract

Context: Overweight and obesity are assessed clinically using the body mass index (BMI), but the index is criticized as a crude measure of relative fat-muscle composition. The recently introduced a body shape index (ABSI) is an independent and more accurate predictor of mortality than other anthropometric measures. **Aims:** Describe ABSI in relation to other clinical and cardiometabolic risk factors in Saudi patients with type 2 diabetes. **Settings and Design:** Cross-sectional, armed forces diabetes clinic. **Materials and Methods:** Demographic and clinical data were obtained from randomly sampled patients with type 2 diabetes. **Statistical Analysis:** The t test, analysis of variance, or Chi-square test as appropriate, and contingency table analysis. **Results:** The 120 patients with type 2 diabetes (60 males, 60 females) had a mean (SD) age of 52.5 (9.3) years and BMI of 31.8 (5.5). Comparisons of ABSI and ABSI mortality risk categories with clinical and cardiovascular risk factors were statistically nonsignificant. Patients with below-average BMI ($z < 0$) ($n = 33$) were more likely to have above-average ABSI ($z > 0$) (27.5%) than a below-average ABSI z score (17.5%). **Conclusion:** These data provide a baseline assessment useful in further studies using larger datasets to confirm whether the ABSI can prove to be clinically useful and serve as a better predictor of mortality risk in the Saudi population. These local data should be of interest to the primary care practitioner who may be thinking of applying these new measures in their primary care practice.

Keywords: A Body Shape Index, body mass index, cardiovascular risk, obesity, type 2 diabetes mellitus

Introduction and Background

The rapid economic development of Saudi Arabia in the last 4 decades has been accompanied by lifestyle changes that have led to soaring rates of chronic diseases such as diabetes and overweight/obesity. In the eighth edition of the Diabetes Atlas of the International Diabetes Federation, Saudi Arabia is among the countries with the highest age-adjusted prevalence of diabetes in the world.[1] The Saudi DM study, a nationwide cross-sectional study with over 50,000 participants, estimated the prevalence of diabetes as 40% in persons older than 45 years of age for the period 2007--2009.[2] The prevalence of diabetes is significantly higher in the overweight and obese.[3] Overweight and obesity begins in childhood with about 1 in 10 children being overweight and more than 1 in 20 obese.[4] In adults, about half of participants in a cross-sectional study in Alkharj were overweight or obese.[5] The World Health Organization estimates that overweight increased from 38% in 1975 to 70% in 2016 in Saudi Arabia.[6]

Overweight and obesity is usually been assessed clinically using body mass index (BMI), as recommended in a 1998 US National Institutes of Health guidelines,[7] but over the years the index has become recognized as a crude measure because it does not reflect relative fat-muscle composition.[8] High BMI due to higher muscle mass can actually reduce the risk of premature death.[9] A systematic review and meta-analysis concluded that commonly used cut-off values for BMI are highly specific, but have poor

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sensitivity in identifying adiposity, or excess body fat, failing to identify about half of people with excess body fat.[10] While a BMI greater than 30 is usually associated with greater mortality from diabetes, recent studies have shown that some newly diagnosed normal weight diabetic patients actually have a higher risk of cardiovascular and all-cause mortality.[11,12] Other anthropometric measures of obesity are also controversial with respect to how well they measure the risk of mortality. Waist circumference (WC) correlates too closely with BMI and is indistinguishable as a risk factor.[13] A body shape index (ABSI), introduced in 2012, is an independent and more accurate predictor of mortality than other anthropometric measures.[14] In a systematic review of 38 studies that have assessed ABSI in cohort and cross-sectional studies in 15 countries, ABSI was more predictive of all-cause mortality than BMI and WC. No study has yet evaluated ABSI in an Arab population. This study is the first to measure ABSI in a small cohort of Saudi patients with type 2 diabetes.

Patients and Methods

We randomly sampled patients with type 2 diabetes who were attending the family medicine clinic at the Armed Forces Hospital in Jazan over a period of 2 months in April and May 2018. About 650 patients booked appointments during those two months. After choosing the first patient by simple random selection with stratification by gender, every fifth patient was subsequently enrolled in this cross-sectional study. The investigator completed a structured questionnaire to collect demographic and relevant clinical history (family history of diabetes, family history of cardiovascular disease, and smoking). Height (H), weight (W), waist circumference (WC), and waist to height ratio (WHtR) were determined at the time of interview. WC was measured by the National Health and Nutrition Survey (NHANES) protocol.[15] Laboratory values were taken from the medical record or ordered as necessary. The study was approved by the local institutional review board and patients provided written informed consent.

Cardiovascular risk was assessed by calculating the body mass index, the Framingham Risk Score,[16] and atherosclerotic cardiovascular diseases risk score.[17] ABSI was calculated according to the equation published by Krakauer and Krakauer.[14] Patients were classified into ABSI mortality risk categories based on the ABSI quintiles in the Krakauer publication using the *z* scores for the study population (very low: -0.868 and lower, low: -0.868 to < -0.272, average: -0.272 to <0.229, high: +0.229 to <0.798, very high: +0.798 and higher).

Statistical analysis was done with IBM SPSS (version [24])(IBM, Armonk, NY, USA) and the statistical software language R with graphs made using the R package ggplot2.[18] Data are presented as mean and standard or median (minimum, maximum). Statistical comparisons were made using the t test of analysis of variance for continuous variables or the Chi-square test of independence for categorical variables. Correlation of variables was test tested by Pearson correlation coefficient. Other methods are noted in tables or figures.

Results

The study population consisted of 120 patients with type 2 diabetes (60 males, 60 females) with a mean (SD) age of 52.5 (9.3) years and BMI of 31.8 (5.5) [Table 1]. ABSI was distributed similarly by gender [Figure 1]. ABSI was lower in males but the difference from females was not statistically significant. The duration of diabetes ranged widely with a median of 5 years in females and 6 years in males. A total of 16 (27%) of the males were current smokers. Exercise more than 120 min per week was reported by 11 males (18.6%) and by no females. There were no differences in clinical and laboratory parameters by ABSI mortality risk category [Table 2]. There were no differences in ABSI for either gender between Framingham risk score categories [Figure 2] ($P = 0.245$). As expected, BMI and weight differed significantly when compared by Framingham risk score categories, but not ABSI, WC and WHtR [Table 3]. Table 4 shows a contingency table distribution of patients by z scores for BMI and ABSI above and below zero. Patients with below-average BMI ($z < 0$) ($n = 33$) who would be considered at low risk under the WHO obesity guidelines were more likely to have above-average ABSI ($z > 0$) (27.5%) than a below-average ABSI z score (17.5%).

When categorized by ABSI mortality risk category based on the quintiles from Krakauer and Krakauer 2012, most subjects were in the highest ABSI risk quintile [Figure 3]. Consistent with other data, there were only weak correlations of ABSI with BMI, waist circumference, and height. ABSI was weakly and negatively correlated with BMI ($r = -0.26$, $P = 0.005$). There were also no significant correlations of ABSI and cardiometabolic risk factors, but WHtR correlated with more risk factors than others.

Discussion

Although new biochemical and genomic methods are providing new means of assessing health risks, simple, and low-cost anthropomorphic measurements are needed both for routine clinical use and to assess associations in epidemiological studies.

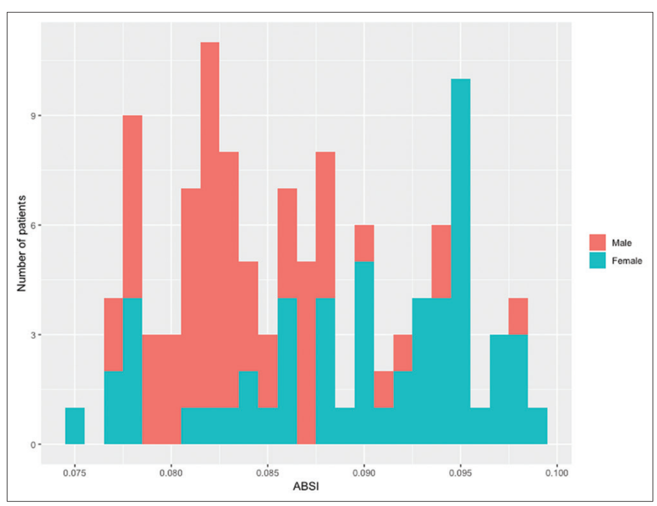

Figure 1: Distribution of ABSI by gender

Table 1: Characteristics of the study subjects by gender

Variables	Male			Female		
	n	Mean	SD	*n*	Mean	SD
Age (y)	60	51.1	9.9	60	53.9	8.6
Diabetes duration (y)*	60	6.0	(1, 27)	59	5.0	(1, 37)
Anthropomorphic measures						
Weight (kg)	60	81.3	12.6	60	73.9	10.7
Height (cm)	60	163.2	5.5	60	151.8	5.4
Body mass index (kg/cm^2)	60	30.4	4.2	60	32.1	4.8
Waist circumference (cm)	60	104.8	10.3	60	112.4	11.4
Waist-to-height ratio	60	0.635	0.059	60	0.734	0.073
Risk indices						
ABSI	60	0.084	0.0045	60	0.090	0.0065
Framingham risk score	60	19.2	8.92	60	15.7	8.88
ASCVD risk score*	50	12.6	(1.3, 43.5)	58	5.8	(1.1, 27.4)
Clinical measures						
Systolic blood pressure (mm Hg)	60	126.27	15.24	60	134.57	15.66
Diastolic blood pressure (mm Hg)	60	76.87	7.83	60	78.85	9.32
Total cholesterol (mg/dL)	60	180.1	48.9	60	197.5	46.3
Low-density lipoprotein	59	109.00	39.78	60	115.50	38.15
High-density lipoprotein (mg/dL)	60	44.3	8.5	60	50.4	12.1
Triglycerides (mg/dL)	59	152.70	103.91	60	138.15	63.20
Random blood sugar (mg/dL)	37	197.89	69.69	25	225.96	126.57
Fasting blood sugar (mg/dL)	21	170.81	70.33	37	178.95	71.53
Glycosylated hemoglobin (%)	53	8.88	2.12	54	10.61	13.43

*Median (minimum, maximum). ABSI: A body shape index, ASCVD: atherosclerotic cardiovascular disease

Table 2: Characteristics of study subjects by a body shape index mortality risk category

	Low		Average		High		*P*
	Mean	SD	Mean	SD	Mean	SD	
Age (y)	51.9	8.6	52.4	8.5	51.7	9.8	0.931
Diabetes duration (y)*	10	1.20	5.5	1.15	5	1.21	0.484
Systolic blood pressure (mm Hg)	130.00	15.67	123.28	14.58	131.73	16.19	0.182
Diastolic blood pressure (mm Hg)	79.27	6.32	75.43	8.11	77.83	9.33	0.409
Total cholesterol (mg/dL)	171.56	42.66	185.37	43.99	195.70	49.48	0.079
Low-density lipoprotein	43.79	9.18	49.22	9.62	48.17	11.46	0.161
High-density lipoprotein (mg/dL)	103.12	28.61	110.49	39.21	115.61	41.65	0.362
Triglycerides (mg/dL)	162.83	135.71	141.90	84.98	140.23	62.40	0.504
Random blood sugar (mg/dL)	202.00	68.48	207.00	81.04	212.84	110.92	0.929
Fasting blood sugar (mg/dL)	171.70	57.97	175.17	122.24	177.14	66.04	0.977
Glycosylated hemoglobin (%)	8.84	2.13	8.08	1.81	10.35	11.74	0.652
Framingham risk score	19.30	7.77	17.58	10.51	16.95	9.00	0.510
ASCVD Risk Score	12.56	8.22	12.91	11.90	9.99	8.21	0.315

*Median (minimum, maximum). ASCVD: atherosclerotic cardiovascular disease

Table 3: Mean (standard deviation) of anthropomorphic measures by Framingham risk score categories

	Low	Intermediate	High	*P*
A body shape index ($m^{11/6}$ $kg^{-2/3}$)	0.085 (0.007)	0.087 (0.007)	0.087 (0.006)	0.656
Waist circumference (cm)	112.3 (11.23)	108.8 (12.3)	106.3 (10.4)	0.098
Waist-to-height ratio	0.71 (0.085)	0.70 (0.094)	0.67 (0.083)	0.172
Body mass index (kg/m^2)	34.5 (5.8)*	31.2 (5.9)	30.6 (4.1)	0.008
Weight (kg)	85.7 (15.6)*	76.7 (14.7)	76.4 (10.8)	0.009

*Low category differed significantly from intermediate and high categories by the Scheffe multiple comparisons test

Numerous studies have come to the conclusion that ABSI is more effective in predicting cardiovascular disease (CVD) and all-cause mortality than other anthropometric indices, but ABSI is a relatively new measure. Studies of its usefulness in predicting mortality as well as onset of chronic disease are ongoing and will continue to be reported for different populations.

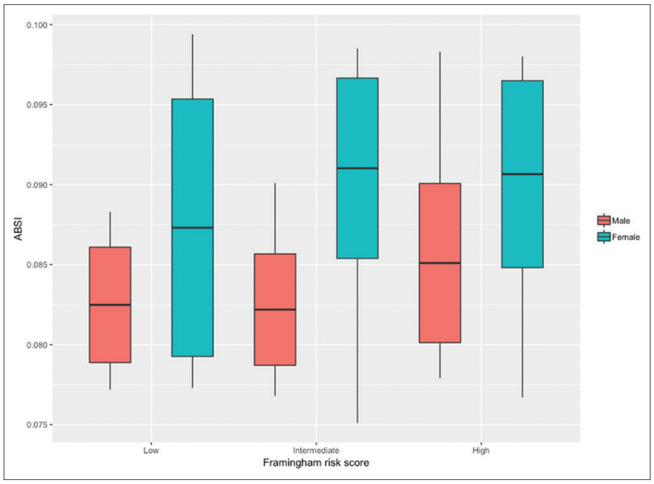

Figure 2: The differences of ABSI by gender regarding Framingham risk score categories

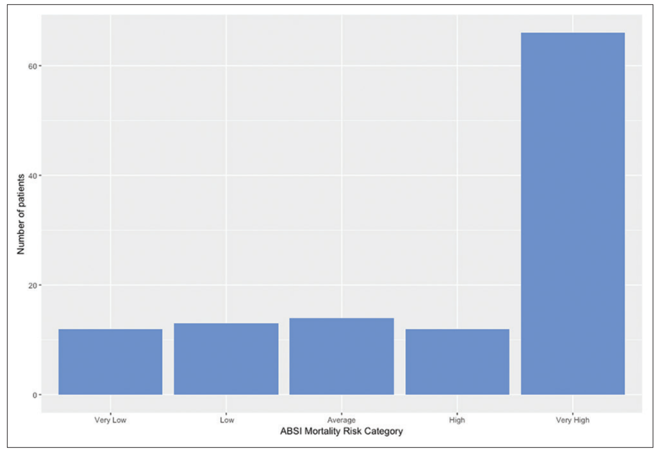

Figure 3: Distribution of ABSI mortality risk categories

Table 4: Distribution of study population by above- versus below-average BMI and ABSI

	BMI *z* score >0	BMI *z* score <0
ABSI *z* score >0	43 (35.8%)	33 (27.5%)
ABSI *z* score <0	14 (11.7%)	21 (17.5%)

Chi-square: 2.0148, *P*=0.1558

Krakauer and Krakauer introduced ABSI using data from the large national NHANES in the US.[14] ABSI showed a positive linear relationship with CVD and all-cause mortality. These results were confirmed with data from the Health and Lifestyle Survey (HALS) in the UK, a large dataset with a longer follow-up.[19] ABSI strongly and consistently predicted mortality hazard over several years of follow-up. In a large, population-based study involving data from four European countries, BMI, WHtR, and WC, showed J-shaped relationships with mortality, while ABSI and other measures showed linear relationships.[20] In another large European study that compared ABSI with traditional anthropomorphic indices (BMI, WC), the strongest association was CVD risk was found for ABSI and estimated total body fat, a sex-specific formula derived from hydrostatic weighing.[21]

Studies have yet to confirm that ABSI is as strong in other populations. In the first study in a Chinese population, He and colleagues assessed the predictive ability of ABSI for mortality in 780 Chinese men followed up for 15 years.[22] A Cox multivariate regression analysis suggested that ABSI might not be predictive of mortality in middle-aged Chinese men. Asians differ in body fat composition, having a higher BMI at lower percentage body fat,[23] so the predictive ability of ABSI in European populations may not hold for Asians. Differences in visceral adipose tissue have been found between aboriginal Canadians, African, Chinese, Europeans, and South Asians.[24] BMI significantly underestimates visceral fat in non-European populations. In a population-based cross-sectional study of 9555 Iranians, ABSI was only a weak predictor overall for CVD mortality and metabolic syndrome.[25]

In the Tehran Lipid and Glucose Study, ABSI was more strongly predictive of mortality over a median of 10 years than other anthropometric indices in men. In women, the waist-to-hip ratio was more predictive in multivariable analyses.[26]

The 38 studies in the systematic review and meta-analysis included 15 different countries, including China, the US, and Iran.[27] A total of 14 were cross-sectional studies. A total of 27 used national health survey data. Some involved people with specific diseases: type 2 diabetes, chronic kidney disease, and hemodialysis patients. ABSI was more effective in predicting overall mortality, but underperformed BMI and WC in predicting chronic diseases. However, predictability was not uniform across subgroups. CVD predictability also varied across groups in this and other studies. The authors noted that ABSI values had little variance, meaning that it would be hard to find definite cut-off values for predicting disease risk using ABSI.

Studies have also evaluated the association of ABSI with risk categories such as the Framingham Risk Score, the European SCORE, and the ASCVD score (American College of Cardiology/American Heart Association). In a Spanish population, ABSI was good but waist-to-height ratio achieved higher values for area under the receiver operating curves, thus more accurately predicting risk on all three scoring systems.[28] In the Tehran Lipid and Glucose Study, the addition of ABSI to the Framingham risk score algorithm failed to improve its ability to predict cardiovascular risk.[26]

Based on the findings of improved prediction mortality risk in American and European studies, several Asian studies have examined whether ABSI might identify metabolic syndrome, insulin resistance, and diabetes. In a cross-sectional study of individuals older than 35 years of age, ABSI showed no association with metabolic syndrome and insulin resistance in a Chinese population.[29] Fujita *et al.* found the same result in a Japanese population in a retrospective cohort study.[30] In another Chinese cross-sectional study of individuals without diabetes, ABSI failed to predict insulin resistance.[31] In a

Korean population, ABSI showed no association with type 2 DM incidence and was not better than WC in predicting the onset of type 2 DM in a prospective cohort study with 4 years of follow-up.[32]

The limitation of BMI is that it fails to measure visceral adiposity. The ABSI is a ratio of the actual WC to the expected WC obtained from an allometric regression. A high ABSI indicates a greater than expected WC. Allometric regression is a form of statistical shape analysis used in biology to analyze changes in growth rates of different body parts in living organisms.[33] The components of ABSI were chosen to "disentangle the independent contributions of BMI and WC cardiometabolic outcomes."[34] In fact, the lack of correlation of BMI and WC with ASBI allows the two indices to be used in conjunction. Bertoli *et al.* studied the joint contribution of BMI and ABSI to the components of the metabolic syndrome using a predictive linear model incorporating BMI and ASBI. The combination was more predictive of high triglycerides, low high-density lipoprotein (HDL), and high fasting glucose than BMI alone in a population of European adults. The Karkauers tested a combined ABSI/BMI calculation of relative risk in a series of 282 patients (https://nirkrakauer.net/sw/absi-calculator.html).[35] The results suggested that the combination discriminates risk better than either ABSI or BMI alone. In a contingency table analysis, patients with BMI *z* scores below zero, and thus considered at low risk by WHO guidelines, were as likely as not to have ABSI scores above zero. In our study, patients with a BMI *z* score below zero were more likely to have an ABSI z score above zero. The Krakauers emphasize that they intend the ABSI to be used in combination with the BMI, not in place of it.

Bertoli *et al.* also found that the combined ABSI/BMI was associated with visceral abdominal tissue thickness (VAT), defined as the distance between the anterior wall of the aorta and the posterior surface of the rectus abdominis muscle measured by ultrasonography.[34] They confirmed that ABSI was directly associated with VAT, which also supports its association with other cardiometabolic risk factors. ABSI has previously been correlated with visceral adiposity independently of BMI, using bioelectrical impedance analysis.[36]

ABSI has been studied as a means of identifying sarcopenic obesity in patients with type 2 diabetes.[37] Sarcopenic obesity is a decrease in fat-free mass relative to fat mass that occurs with aging. One cross-sectional study of 199 elderly type 2 diabetic patients found that a cut-off ABSI value of 0.083 $m^{11/6}\ kg^{-2/3}$ best identified patients categorized as sarcopenic.[38] A total of 60% of our study population ($n = 72$) would be defined as sarcopenic by this definition. The mean BMI in that group was 30.3 compared with 32.8 for the nonsarcopenic patients, which seems to further support the notion that BMI is an unreliable measure of overweight and obesity.

In summary, our data present a snapshot of a small sample of Saudi type 2 diabetic patients, with equal numbers of each gender, who were mostly overweight and obese as defined by BMI (BMI ≥ 30 in 86%). This data should serve as a baseline assessment useful in further studies using larger datasets to confirm whether the ABSI can prove to be clinically useful and serve as a better predictor of risk in the Saudi population. These local data should also be of interest to the primary care practitioner who may currently be using or thinking of applying these new measures in their primary care practice, especially the finding of identifying a possible reversal of risk in some patients with low BMI.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form, the patient (s) has/have given his/her/their consent for his/her/their clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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