Anthropometric and central obesity indices as predictors of long-term cardiometabolic risk among Saudi young and middle-aged men and women

Mahmoud M. A. Abulmeaty, MD, Ali M. Almajwal, PhD, Najwa K. Almadani, BSc, Mona S. Aldosari, BSc, Ahmed A. Alnajim, BSc, Saeed B. Ali, PhD, Heba M. Hassan, BSc, Hany A. Elkatawy, MD.

ABSTRACT

الأهداف: بحث امكانية التنبؤ بالمخاطر القلبية الأيضية بعيدة المدى بواسطة بعض القياسات الجسدية ومؤشرات السمنة المركزية لدى السعوديين.

الطريقة: أجريت هذه الدراسة المسحية في جامعة الملك سعود بين اغسطس 2014 و يناير 2016وقد تم تسجيل 390 من الرجال والنساء السعوديين المقيمين في مدينة الرياض، المملكة العربية السعودية تتوسط أعمارهم بين 18و 50 عام. وقد تم توجيه كل المشاركين الى الصيام لمدة 12 ساعة قبل أخذ عينات الدم لتحليل مستوى الجلوكوز ودهنيات الدم وتم قياس ضغط الدم و اخذ القياسات الجسدية وتحليل تركيب الجسم بأجهزة المقاومة الكهروحيوية. تم حساب العديد من مؤشرات السمنة المركزية والقياسات الجسدية ودراسة مدى اقترانها مع مقياس فرامنجهام لخطورة الاصابات القلبية الحادة بعد 30 عام و أيضاً مع مقياس الكلية الامريكية للقلب وجمعية القلب الامريكية. وباستخدام منحنيات خاصية التشغيل المتلقي تم اختيار أفضل المتنبئات من حيث الحساسية والنوعية.

النتائج: من بين كل المؤشرات التي درست وُجد أن أفضل محددات لخطر الاصابة بالاعتلالات القلبية الايضية بعيدة المدى بين الرجال هو مؤشر الشحوم الحشوية ومؤشر المخروطية و مساحة عضلات منتصف الذراع وبالنسبة للنساء كان مؤشر الكتلة ومحيط الخصر وناتج تراكم الدهن من أفضل المحددات استناداً الى المساحة تحت منحنى خاصية التشغيل المتلقي. اوضح مؤشر كابا أن التوافق بين تلك المؤشرات ومقاييس خطورة الإصابات القلبية ضعيف الى متوسط.

الخاتمة: خطر الإصابات القلبية الايضية بعيدة المدى قد يتم التنبؤ بها باستخدام قياسات جسدية بسيطة أو بعض مؤشرات السمنة المركزية وهذه المتنبئات لها قيم قاطعة وقد كانت قيما مختلفة بين الرجال والنساء.

Objectives: To investigate the prediction of long-term cardiometabolic risk using anthropometric and central obesity parameters.

Methods: A total of 390 Saudi subjects (men 42.8%) aged 18-50 years were enrolled in a cross-sectional study in King Saud University, Riyadh, Kingdom of Saudi Arabia between August 2014 and January 2016. All participants were instructed to fast for 12 hours before taking blood samples for glucose and lipid panel analyses. A full anthropometric measurement and bioelectric impedance analysis was performed. The anthropometric and central obesity parameters were used for correlation with 30-year Framingham and life-time American College of Cardiology/American Heart Association risk scores. We used receiver operator characteristic curves to select the best predictors with the highest sensitivity and specificity.

Results: The best discriminators of the long-term cardiometabolic risk among all the studied variables in men were the visceral adiposity index (VAI) (AUC=0.767), conicity index (CI) (AUC=0.817), and mid-arm muscular area (MAMA) (AUC=0.639). The best predictors for women were body mass index (AUC=0.912), waist circumference (AUC=0.752), and lipid accumulation product (AUC=0.632). The Kappa coefficient and 95% confidence interval ranged from 0.1 to 0.35, which suggests that there is a poor to fair agreement between these indices and cardiovascular risk scores.

Conclusion: Long-term cardiometabolic risk can be predicted using simple anthropometric and central obesity indices, and these discriminators were not the same in Saudi men and women.

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From the Department of Clinical Nutrition Program, Community Health Sciences (Abulmeaty, Almajwal, Almadani, Hassan), the Clinical Nutrition Department (Aldosari, Alnajim) King Saud University, the Directorate General of Nutrition (Ali), Ministry of Health, Riyadh, Kingdom of Saudi Arabia and the Obesity Research and Management Unit (Abulmeaty, Elkatawy), Faculty of Medicine, Zagazig University, Zagazig, Egypt.

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Address correspondence and reprint request to: Dr. Mahmoud M. A. Abulmeaty, Clinical Nutrition Program, Department of Community Health Sciences, King Saud University, Riyadh, Kingdom of Saudi Arabia.
E-mail: dr.abulmeaty@gmail.com / mabulmeaty@ksu.edu.sa
ORCID: http://orcid.org/0000-0002-1779-0091

Cardiometabolic health status is a major public health concern due to the high prevalence of cardiometabolic diseases locally and worldwide.[1] There are several scoring systems available to quantify the risk of developing cardiovascular disease (CVD). The evaluation of the cardiovascular risk is the most appropriate and clinically useful way to discriminate between individuals with high risk who require intensive control and the low risk cases.[2] By definition, cardiovascular risk scores are clinical prediction equations based on predictive multivariate models created from large-scale prospective epidemiological studies.[3] The 10-year and 30-year Framingham risk scoring system (FS) are the most common used scores and were designed using 2 models; one based on blood lipid panel (FS30 Lipid) and the other based on body mass index (FS30 BMI). The major cardiovascular risk factors in the FS are based on the following variables: age, gender, systolic blood pressure, antihypertensive treatment, diabetes, abnormal total and High density lipoprotein cholesterol (HDL), and body mass index.[4] The 30-year Framingham risk score (FS30) reclassified a larger number of subclinical patients and young individuals because it discriminated between those with or without evidence of carotid plaque. As a result, its prediction power is superior to the 10 years FS. Furthermore, FS30 may set the basis for introduction of earlier prevention strategies in asymptomatic individuals.[2,5] Another recent lifelong CVD scoring system was developed jointly by the American College of Cardiology and the American Heart Association (ACC/AHA) to detect the atherosclerotic cardiovascular disease (lifetime ASCVD risk). Similar to FS, the data required to estimate ASCVD risk includes age, gender, race, total cholesterol, HDL cholesterol, systolic blood pressure, blood pressure lowering medication use, diabetes status, and smoking status.[6] The close relationship between obesity and cardiometabolic health is a well-known issue and central obesity represents the cornerstone of metabolic syndrome diagnosis. Both obesity and the metabolic syndrome are associated with increased risk of CVD and type-2 diabetes.[7] The published literature has several examples of obesity related parameters with variable degrees of correlation and predictive power for cardiometabolic risk. These parameters include direct anthropometric measures, such as the waist circumference and body weight. There are also simple relationships between 2 anthropometric measures, such as the BMI, waist hip ratio (WHR), waist height ratio (WHtR), and so on. Additionally, there are complex formulae based on anthropometric parameters, such as the conicity index (CI), mid arm muscular area (MAMA), and abdominal volume index (AVI). There are also indices based on the anthropometric and biochemical measures, such as the visceral adiposity index (VAI) and lipid accumulation product (LAP). There are other indices based on the measured fat mass, such as the fat mas index (FMI) and fat free mass index (FFMI).[8,9] The relationship of these indices with the cardiometabolic health is still underinvestigated in our population. This study was conducted to investigate the prediction of long-term cardiometabolic risk using anthropometric parameters and central obesity indices in the young and middle-aged adult Saudi population living in Riyadh, Kingdom of Saudi Arabia (KSA).

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Methods.

Study population. The study subjects were recruited by advertising on social media in many locations in King Saud University (KSU), Riyadh, KSA. These locations included the collage of Applied Medical Sciences in boys and girls sections, main plaza in men and women sections, and the medical city. The study was conducted between August 2014 and January 2016. There were 390 subjects aged 18-50 years enrolled in a cross-sectional study. The subjects with present or past history of cardiovascular diseases, heart failure, cancer, severe disability, or being hospitalized for any medical condition were excluded. We obtained informed consent from each participant before the study. The research ethics committee of the Collage of Applied Medical Sciences, KSU approved the study protocol and all investigations were according to principle of Helsinki declaration. Each participant signed a written consent for approval of the study protocol and publication of the collected data with strict privacy.

Anthropometric measures. The anthropometric measurement collected included weight, height, waist circumference (WC), hip circumference (HC), triceps skin-fold thickness (TST), mid-arm circumference (MAC), and wrist circumference. The body weights and heights were measured using a Seca digital scale with a non-stretchable stadiometer (Seca co, Germany). The TST was measured using a Holtain caliper (Holtain limited, UK). The BMI was calculated as body weight in kilograms divided by the square of height in meters.

The WC was determined by measuring waist diameter at a midpoint between the iliac crest and lower border of the tenth rib. An average of 2 measurements was considered the WC. The HC was assessed on the lateral position by measuring the circumference at the most prominent point and an average of 2 measurements was used as HC. The values for WHR and WHtR were calculated by dividing WC on HC and height. The MAMA was recorded according to Teo et al[10] using the following equation: {MAMA= (MAC - π x TSF)^2 / 4π}. The conicity index was calculated using the equation (CI=WC (m)/ [0.109 x $\sqrt{}${weight (kg)/ Height (m)}] where 0.109 is a constant that results from the conversion of units of volume and mass into units of length.[11] The AVI formula was AVI = [2 x (WC)^2+0.7x (waist-hip)^2]/1,000.[12]

Biochemical analysis. The fasting blood glucose was screened by digital glucometer (ACCU-CHEK, Hoffmann-La Roche Ltd, USA) and lipid panel was screened by CardioChek PA lipid analyzer (Polymer Technology Systems, Inc., Indianapolis, IN, USA).[13] The CardioChek is reported to be accurate and is clinically validated.[14] The components of the lipid panel and other anthropometric parameters were used to calculate the central obesity indices, such as the visceral adiposity index and lipid accumulation product. The VAI for males = [WC/(39.68+(1.88 x BMI)] x [$TG_{(mg/dl)}$/1.03] x [1.31/$HDL_{(mg/dl)}$], and the VAI for females = [WC/(36.58+(1.89 x BMI)] x [$TG_{(mg/dl)}$/0.81] x [1.52/$HDL_{(mg/dl)}$].[15] The LAP was calculated as [{WC(cm) – 65} × {$TG_{(mmol)}$}] for men and [{$WC_{(cm)}$ – 58} × {$TG_{(mmol)}$}] for women.[16]

Bioelectrical impedance analysis. FM and FFM were measured using BIA analysis (Tanita BC-418, Tanita Corporation, Japan). The fat mass index (FMI) was calculated by dividing FM in kg by square of height in meters and the results are expressed in Kg/m^2. The FFMI was calculated using a previously reported equation (FFM $_{(kg)}$/wt^2 $_{(m2)}$).[17]

Cardiovascular risk scoring. We calculated 5 versions of long-term CVD risk scoring systems for all participants. The FS30 is based on BMI of hard cardiovascular disease (FS30 BMI Hard CVD), where hard CVD is defined as acute myocardial infarction, death due to coronary cause, and stroke. The second FS30 is based on the lipid profile of hard cardiovascular disease (FS30 Lipid Hard CVD). The third Framingham 30- year risk score is based on BMI and full cardiovascular disease, including hard CVD or other events, such as coronary insufficiency, angina pectoris, and transient ischemic attack (FS30 BMI Full CVD). The fourth FS30 is based on the lipid profile of full cardiovascular disease (FS30 Lipid Full CVD).[4] The fifth score was lifetime atherosclerotic cardiovascular disease risk (lifetime ASCVD), which was created by ACC/AHA[6] by using a white population or other race for the calculation. The cutoff values used in this study for FS30 was 12%[2] namely participants with scores ≤12% were classified as low risk. The patients with more than 12% were classified as high risk. The lifetime ASCVD risk cutoff values were ASCVD-percentage for a subject aged 50 with optimal risk factor levels (namely, 5% for men and 8% for women). All these tools required the following common set of risk factors: age, gender, systolic blood pressure, BMI or lipid profile, smoking, and presence of diabetes or treatment for hypertension. If the measurements were less than or more than the allowed range of a risk factor then the lower or upper limit was used.

Statistical analysis. Statistical analysis was performed using the Statistical Package for the Social Sciences (SPSS Inc., Chicago, IL, USA) version 22. The study data are summarized as the mean and standard deviation (SD). The statistical significance between groups was tested by and independent sample t-test. Pearson's correlation coefficient was used to demonstrate the relationship between the following anthropometric and central obesity indices: BMI, WC, WHR, WHtR, MAMA, CI, AVI, FMI, VAI, LAP, and cardiovascular risk. The $p<0.05$ was considered statistically significant. The receiver operating characteristic (ROC) curves were used to identify new cutoff values of the anthropometric discriminators with a higher sensitivity (true positive rate) and specificity (true negative rate). A Kappa analysis was performed to study the agreement among different discriminators and CVD risk scores with 95% confidence interval (95% CI).

Results. All of the descriptive characteristics and gender comparisons of all of the study populations are shown in **Table 1**. Men represented 42.8% of the study population, and the overall mean of their BMI was 28.05±6.52 kg/m^2. There were no significant differences between men and women using the independent sample t-test with respect to BMI, height-wrist ratio, glucose, total cholesterol levels, and VAI. However, other continuous variables showed significant differences.

Table 2 shows the Pearson correlation coefficients for several anthropometric parameters and central obesity indices with cardiometabolic parameters, such as systolic blood pressure, glucose, total cholesterol, LDL and HDL cholesterol, and long-term risk of cardiovascular disease risk.

The ROC curves analysis of these anthropometric

Table 1 - Descriptive statistics of the study population.

Variables	Total study population Mean±SD (n=390)	Men Mean±SD (n=167)	Women Mean±SD (n=223)	*P*-value
Age (year)	28.53±7.45	26.00±7.56	30.43±6.78	0.000
Height (cm)	163.48±8.23	170.42±5.63	158.28±5.62	0.000
Weight (Kg)	75.26±19.60	83.65±21.55	68.97±15.26	0.000
BMI (Kg/m^2)	28.05±6.52	28.77±7.30	27.50±5.83	0.057
WC (cm)	86.47±15.06	92.45±17.06	81.98±11.52	0.000
Waist-hip ratio	0.83±0.09	0.89±0.11	0.79±0.06	0.000
Waist-height ratio	0.53±0.09	0.54±0.10	0.52±0.08	0.005
Midarm muscle area (cm^2)	39.00±14.88	36.38±12.23	40.97±16.34	0.002
Corrected arm muscle area (cm^2)	29.00±14.88	26.38±12.23	30.97±16.34	0.002
Midarm muscle circumference (cm)	21.80±3.90	21.11±3.44	22.31±4.14	0.002
Conicity index	1.18±0.15	1.21±0.12	1.15±0.17	0.000
Abdominal volume index	15.66±5.46	17.81±6.46	14.05±3.87	0.000
Height-wrist ratio	10.82±4.88	11.18±1.55	10.56±6.30	0.215
Fat mass index	9.17±4.30	7.67±4.22	10.29±4.01	0.000
Fat free mass index	19.11±10.96	21.67±16.25	17.19±2.07	0.000
Systolic blood pressure (mmHg)	107.64±15.07	118.07±11.75	99.83±12.31	0.000
Diastolic blood pressure (mmHg)	74.35±11.14	80.62±8.63	69.66±10.48	0.000
Glucose level (mg/dl)	95.21±12.60	94.35±9.32	95.84±14.58	0.249
Total cholesterol (mg/dl)	156.71±34.09	154.10±31.21	159.38±36.76	0.234
High density lipoprotein (mg/dl)	50.64±14.65	45.50±11.19	55.91±15.91	0.000
Low density lipoprotein (mg/dl)	85.18±30.68	89.57±30.55	80.69±30.28	0.026
Triglycerides (mg/dl)	107.56±57.00	99.06±49.10	116.27±63.12	0.020
Visceral adiposity index	3.37±2.20	2.89±1.82	3.87±2.44	0.251
Lipid accumulation product index	69.68±58.13	62.17±54.64	77.37±60.78	0.044

BMI - body mass index, WC - waist circumference

Table 2 - Correlation of some anthropometric and central obesity indices with the long-term risk of cardiovascular disease using Pearson correlation coefficient.

Variables	Glucose		Cholesterol		LDL		HDL		SBP		FS30 BMI Hard CVD		FS30 Lipid Hard CVD		FS30 BMI Full CVD		FS30 Lipid Full CVD		Lifetime risk of ASCVD	
	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F
BMI	0.282†	0.263†	0.243†	0.083	0.327†	0.064	-0.316†	-0.093	0.214†	0.302†	0.194*	0.574†	0.069	0.408†	0.218†	0.605†	0.086	0.394†	0.176	0.045
WC	0.321†	0.229†	0.340†	0.142	0.404†	0.090	-0.340†	-0.046	0.058	0.227†	0.360†	0.477†	0.206†	0.356†	0.396†	0.535†	0.240†	0.353†	0.147	0.089
WHR	0.226†	0.080	0.269†	0.182*	0.302†	0.158	-0.216*	-0.015	-0.051	0.001	0.242†	0.089	0.152	0.185*	0.273†	0.139*	0.190*	0.218*	0.076	0.116
WHtR	0.350†	0.257†	0.349†	0.154	0.409†	0.101	-0335†	-0.022	0.072	0.222†	0.343†	0.451†	0.199*	0.360†	0.380†	0.503†	0.235†	0.357†	0.149	0.074
MAMA	0.029	0.064	0.010	0.121	0.089	0.080	-0.061	0.025	0.062	0.093	0.286†	0.401†	0.108	0.190*	0.309†	0.422†	0.144	0.169	0.259†	0.029
CI	0.268†	-0.018	0.306†	0.178	0.316†	0.110	-0.206*	0.046	-0.130	-0.056	0.394†	.012	0.277†	0.133	0.436†	0.034	0.322†	0.142	0.035	0.106
AVI	0.310†	0.240†	0.333†	0.138	0.397†	0.084	-0.330†	-0.042	0.055	0.232†	0.350†	0.490†	0.198*	0.350†	0.383†	0.546†	0.229*	0.345†	0.132	0.087
FMI	0.278†	0.232†	0.316†	0.057	0.365†	0.042	-0287†	-0.077	0.154*	0.297†	0.213†	0.568†	0.138	0.387†	0.237†	0.597†	0.157	0.382†	0.150	0.029
VAI	0.254†	0.038	0.265†	-0.014	0.163	-0.153	-0.571†	-0.377†	0.056	-0.148	371†	-0.058	0.402†	0.009	0.387†	-0.005	0.412†	0.005	0.196*	-0.009
LAP	0.350†	0.187*	0.349†	0.244†	0.409†	-0.016	-0.335†	-0.027	0.072	-0.002	0.343†	0.204*	0.199*	0.184*	0.380†	0.293†	0.235†	0.181	0.149	0.122

BMI - body mass index, WC - waist circumference, WHR - waist hip ratio, WHtR - waist height ratio, MAMA - mid arm muscle area, CI - conicity index, AVI - abdominal volume index, FMI - fat mass index, VAI - visceral adiposity index, LAP - lipid accumulation product index, LDL - low-density lipoprotein, HDL - high-density lipoprotein, and SBP - systolic blood pressure. FS30 BMI Hard CVD - Framingham 30 years risk score based on BMI of hard cardiovascular disease (namely, acute myocardial infarction, death due to coronary cause, and stroke). FS30 Lipid Hard CVD - Framingham 30 years risk score based on lipid profile of hard cardiovascular disease. FS30 BMI Full CVD - Framingham 30 years risk score based on BMI of full cardiovascular disease (namely, hard CVD or coronary insufficiency, angina pectoris, transient ischemic attack, etc.). FS30 Lipid Full CVD - Framingham 30 years risk score based on lipid profile of full cardiovascular disease. ASCVD - atherosclerotic cardiovascular disease. M - males, F - females, * Correlation is significant at the 0.05 level, and †Correlation is significant at the 0.01 level.

and central obesity indices as discriminators of FS30 and life-time ASCVD risk showed variable degrees of predictability. In the male group (**Table 3**), the greatest area under the curve (AUC) of a discriminator that predict FS30 BMI-Hard CVD was 0.755 of VAI. Similarly, for FS30 Lipid-Hard CVD, the greatest AUC was 0.767 of VAI, and for FS30 BMI-Full CVD the greatest AUC was 0.783 of CI, while the greatest AUC for FS30 Lipid-Full CVD was 0.817 of CI. Furthermore, the AUC of MAMA (0.639) was the best of all studied predictors of Life-Time ASCVD risk. In the female group (**Table 4**), there were no high risks (namely >12%) regarding the FS30 Lipid-Hard CVD. Therefore, no ROC curves were created. The AUCs of the best discriminators for the remaining CVS risk scores were the following: 0.912 for BMI of FS30 BMI-Hard

Table 3 - Receiver operating characteristic (ROC) analysis of the commonly used anthropometric indices in detecting the long-term cardiovascular risk among men (n=167) by using five different risk scores.

Discriminator	FS30 BMI-Hard CVD				FS30 LIPID-Hard CVD				FS30 BMI-Full CVD				FS30 LIPID-Full CVD				Life-Time ASCVD risk			
	AUC	Cutoff value	Sens %	Spec %	AUC	Cutoff value	Sens %	Spec %	AUC	Cutoff value	Sens %	Spec %	AUC	Cutoff value	Sens %	Spec %	AUC	Cutoff value	Sens %	Spec %
BMI	0.668	28.55	65.40	61.70	0.590	28.36	71.40	61.10	0.611	27.68	64.20	56.10	0.646	27.68	70.60	57.30	0.637	26.54	60.30	59.50
WC	0.715	96.5	65.40	64.50	0.584	89.50	71.40	61.10	0.707	92.50	69.80	61.40	0.735	89.50	76.50	65.00	0.589	84.50	60.30	57.10
WHR	0.748	0.915	73.10	70.90	0.568	0.875	57.1	59.30	0.776	0.895	75.50	71.10	0.803	0.895	82.40	78.60	0.544	0.855	59.00	54.80
WHtR	0.693	0.545	69.20	56.70	0.561	0.515	71.40	54.00	0.696	0.545	67.90	62.30	0.729	0.535	70.60	67.00	0.589	0.495	61.50	54.80
MAMA	0.639	35.91	61.5	57.40	0.535	31.46	57.10	54.90	0.659	34.90	64.20	58.80	0.545	31.46	58.80	56.30	0.639	29.56	62.80	59.50
CI	0.733	1.265	69.20	68.10	0.599	1.175	71.40	56.60	0.783	1.235	77.40	67.50	0.817	1.215	82.40	72.80	0.517	1.155	55.10	50.00
AVI	0.717	17.71	69.20	60.30	0.590	16.08	71.40	61.10	0.706	17.45	64.20	63.20	0.736	17.27	70.60	69.90	0.593	14.31	62.80	57.10
HtWrR	0.384	10.24	53.80	31.90	0.560	11.97	71.40	52.20	0.434	10.51	50.90	34,20	0.554	11.90	64.70	51.50	0.465	11.55	60.30	0.50
FMI	0.669	7.64	61.50	60.30	0.619	7.76	57.10	61.90	0.629	7.335	58.50	57.00	0.691	7.595	64.70	62.10	0.605	6.305	62.80	59.50
FFMI	0.664	20.95	65.40	61.70	0.496	19.68	57.10	42.50	0.603	20.28	60.40	55.30	0.563	20.18	52.90	52.40	0.635	19.33	70.50	54.80
VAI	0.755	2.87	71.40	65.10	0.767	2.90	71.40	63.70	0.663	2.56	60.70	58.70	0.778	2.87	76.50	67.00	0.598	2.28	56.40	52.40
LAP	0.740	72.37	71.40	67.00	0.664	58.60	71.40	56.60	0.690	56.53	67.90	60.90	0.775	73.25	76.50	69.90	0.628	45.07	60.30	61.90

FS30 BMI Hard CVD - Framingham 30 years risk score based on BMI of hard cardiovascular disease (acute myocardial infarction, death due to coronary cause, and stroke). FS30 Lipid Hard CVD - Framingham 30 years risk score based on lipid profile of hard cardiovascular disease. FS30 BMI Full CVD - Framingham 30 years risk score based on BMI of full cardiovascular disease (hard CVD or other events such as coronary insufficiency, angina pectoris, transient ischemic attack, and so forth). FS30 Lipid Full CVD - Framingham 30 years risk score based on lipid profile of full cardiovascular disease. ASCVD - atherosclerotic cardiovascular disease. BMI - body mass index, WC - waist circumference, WHR - waist hip ratio, WHtR - waist height ratio, MAMA - mid arm muscle area, CI - conicity index, AVI - abdominal volume index, HtWrR - height wrist index, FMI - fat mass index, FFMI - fat free mass index, VAI - visceral adiposity index, and LAP - lipid accumulation product index.

Table 4 - Receiver operating characteristic (ROC) analysis of the commonly used anthropometric indices in detecting the long-term cardiovascular risk among women (n=223) by using different risk scores.

Discriminator	FS30 BMI-Hard CVD				FS30 BMI-Full CVD				FS30 LIPID-Full CVD				Life-Time ASCVD risk			
	AUC	Cutoff value	Sens %	Spec %	AUC	Cutoff value	Sens %	Spec %	AUC	Cutoff value	Sens %	Spec %	AUC	Cutoff value	Sens %	Spec %
BMI	0.912	31.50	100.00	80.40	0.849	29.71	73.90	74.00	0.736	29.33	66.70	60.40	0.535	27.60	55.00	51.90
WC	0.813	90.90	75.00	79.00	0.798	85.20	73.90	68.00	0.752	88.50	66.70	71.20	0.592	82.50	62.50	59.70
WHR	0.406	0.795	50.00	51.60	0.570	0.795	65.20	53.50	0.710	81.50	66.70	71.20	0.578	0.785	62.50	54.50
WHtR	0.821	0.555	75.00	70.80	0.803	0.545	73.90	72.50	0.727	0.545	66.70	67.60	0.586	0.505	72.50	53.20
MAMA	0.806	54.68	75.00	86.30	0.681	40.55	69.60	60.50	0.541	35.77	66.70	45.00	0.525	37.67	55.00	50.60
CI	0.447	1.135	50.00	49.80	0.559	1.135	56.50	50.50	0.637	1.135	66.70	56.80	0.569	1.125	60.00	57.00
AVI	0.824	16.91	75.00	79.50	0.802	14.91	73.90	68.00	0.744	15.98	66.70	70.30	0.588	13.82	62.50	59.70
HtWrR	0.110	9.565	25.00	21.50	0.247	9.805	30.40	26.50	0.360	10.37	50.00	62.20	0.486	10.11	52.50	49.40
FMI	0.908	14.16	75.00	84.90	0.840	11.87	82.60	72.50	0.746	11.87	66.70	65.80	0.535	9.73	60.00	48.10
FFMI	0.894	18.93	75.00	84.00	0.832	17.66	82.60	73.00	0.690	17.66	66.70	63.10	0.530	17.22	52.50	48.10
VAI	0.336	2.623	100.00	33.60	0.532	3.135	58.80	51.00	0.607	3.468	66.70	58.60	0.540	3.086	55.00	50.60
LAP	0.431	51.02	100.00	43.10	0.677	54.13	70.6	50.00	0.640	53.73	83.30	46.80	0.632	59.92	65.00	58.40

FS30 BMI Hard CVD - Framingham 30 years risk score based on BMI of hard cardiovascular disease (acute myocardial infarction, death due to coronary cause, and stroke). FS30 BMI Full CVD - Framingham 30 years risk score based on BMI of full cardiovascular disease (hard CVD or other events such as coronary insufficiency, angina pectoris, transient ischemic attack, and so forth). FS30 Lipid Full CVD - Framingham 30 years risk score based on lipid profile of full cardiovascular disease. ASCVD - atherosclerotic cardiovascular disease. BMI - body mass index, WC - waist circumference, WHR - waist hip ratio, WHtR - waist height ratio, MAMA - mid arm muscle area, CI - conicity index, AVI - abdominal volume index, HtWrR - height wrist index, FMI - fat mass index, FFMI - fat free mass index, VAI - visceral adiposity index, and LAP - lipid accumulation product index.

Table 5 - The selected discriminators of CVD risk with their AUC, cutoff value, kappa coefficient and odd ratio at 95% confidence interval.

Discriminator	AUC	Cutoff value	Kappa coefficient (95%CI)	Odd ratio (95%CI)
Men				
VAI for FS30 BMI-Hard CVD	0.755	2.87	0.18	4.66
VAI for FS30 Lipid-Hard CVD	0.767	2.90	0.10	4.39
CI for FS30 BMI-Full CVD	0.783	1.24	0.35	5.48
CI for FS30 Lipid-Full CVD	0.817	1.22	0.21	4.26
MAMA for Life-Time ASCVD risk	0.639	29.56	0.21	2.49
Women				
BMI for FS30 BMI-Hard CVD	0.912	31.50	0.05	0.25
BMI for FS30 BMI-Full CVD	0.849	29.71	0.25	5.60
WC for FS30 Lipid-Full CVD	0.752	88.50	0.11	4.94
LAP for Life-Time ASCVD risk	0.632	59.92	0.21	2.61

AUC - area under the ROC curve. VAI - visceral adiposity index, FS30 BMI Hard CVD - Framingham 30 years risk score based on BMI of hard cardiovascular disease. CI - conicity index, FS30 BMI Full CVD - Framingham 30 years risk score based on BMI of full cardiovascular. FS30 Lipid Full CVD - Framingham 30 years risk score based on lipid profile of full cardiovascular disease. MAMA - mid arm muscle area, ASCVD - atherosclerotic cardiovascular disease. BMI - body mass index, WC - waist circumference, and LAP - lipid accumulation product index.

CVD, 0.849 for BMI of FS30 BMI-Full CVD, 0.752 for WC of FS30 Lipid-Full CVD, and 0.632 for LAP of Life-Time ASCVD risk.

Table 5 shows cutoff values of the selected discriminators and the agreement with the long-term CVD risk scores by kappa analysis at the 95% CI in addition to their OR. Paradoxically, the kappa analysis showed poor to fair agreement between the selected parameters using their new cutoff values and long term cardiovascular risk scores (range of k=0.05-0.35). The highest agreement was between CI and FS30 BMI-Full CVD (k=0.35, 95% Confidence Interval) using the CI's new cutoff value at 1.24.

Discussion. The prediction of cardiometabolic risk in young to middle-aged men or women is essential to preventive health issues and is the basis for selecting candidates requiring early preventive strategies and their intensity level. The variation in the intensity levels of CVD prevention (namely, primordial, primary, and secondary) lead to the concept that CVD risk occurs continuously throughout life with great variability and begins at a young age.[18] The healthy cases with obesity may have variable degrees of CVD risk. This study investigated the relationship between these items and long-term CVD risk. We found 2 major sets of correlations in the data. The first correlation was for anthropometric and obesity indices with the indicators of cardiometabolic health, such as glycemia, lipid panel, and systolic blood pressure (SBP). The second correlation was with long-term CVD risk scores, such as 30FS and life-time ASCVD. The WC showed a moderate positive correlation with glucose, total cholesterol, LDL, and a negative correlation with HDL levels in males (p<0.01) (**Table 2**). The BMI showed a less positive correlation with the same indicators (**Table 2**). The SBP was correlated significantly with BMI, but was not correlated with WC (r= 0.214 versus r= 0.058). These finding among Saudi men are consistent with the results by Al-Ajlan.[19] The WHR and WHtR showed significant correlations with glucose, cholesterol, LDL and HDL rather than SPB among men. This result is not consistent with the findings of Gharakhanlou et al[20] with respect to glycemia and was similar with regards to the lipid panel. In addition, Vásquez et al[21] reported that WHtR was significantly associated with body fat from the age 7-10 years onward and could be used as a marker of cardiometabolic health. In females, both WC and BMI correlated significantly with glucose level and SPB. The WHR showed insignificant correlations, but the WHtR correlated with glucose and SPB. These finding are consistent with those of Saeed and Al-Hamdan[22] and partially different from Gharakhanlou et al.[20] The CI showed a significant correlation with glucose, cholesterol, LDL and HDL in men, but not women (p<0.01) (**Table 2**). These findings

contrast previous data from elderly women.[23] The AVI, FMI, VAI and LAP showed significant correlations with glucose, cholesterol, LDL and HDL in men. These findings are consistent with prior data worldwide.[24-26] In women, only AVI and VAI correlated significantly with glucose and SPB and agree with results from Gowda et al[27] and Ehsani et al.[28] In Korean women,[29] LAP was correlated with total cholesterol rather than glycemia among Saudi women.

The female BMI showed strong positive correlations with scores of FS30 in the BMI and Lipid models for hard and full CVD (**Table 2**). However, there was no significant correlation in males. Conversely, the WC showed a strong positive correlation with these scores among men and women (**Table 2**). These findings for WC and WC-based indices were consistent with Goh et al,[30] while those of BMI were not. The study by de-Oliveira [31] reported that WC showed no correlation with CVD risk assessed by Framingham score. This discrepancy may due to the small sample size in the study of de-Oliveira et al.[25] The CI showed significant correlations with scores of FS30 BMI and lipid for hard and full CVD among males and AVI showed a significant positive correlation with the long-term CVD risk scores in both men and women. The FMI was significantly correlated with scores of all versions of FS30 among women and the VAI was correlated for men only. Furthermore, the LAP index showed significant correlations with scores of FS30 among both men and women. Paradoxically, lifetime ASCVD risk score showed an insignificant correlation with all measured indices in both men and women except for MAMA and VAI in males (r=0.259, p<0.01) (r=0.196, p<0.05).

The ROC curves analyses showed the best discriminator of FS30 BMI-Hard CVD was VAI among men (AUC= 0.755) and BMI among women (AUC=0.912). The FS30 BMI-full CVD was the best CI in men (AUC=0.783) and BMI was the best in women (AUC=0.849). For FS30 lipid-full CVD the best predictor was CI among men (AUC=0.817) and WC among women (AUC=0.752). In addition, the best predictor of life-time ASCVD risk was MAMA in males (AUC=0.639) and LAP in females (AUC=0.632). In contrast to our finding, Fauziana et al[32] reported that WHR was better associated with hypertension and diabetes than BMI in elderly Malays. However, our results regarding WC as a predictor of FS30 Lipid-full CVD among Saudi women are consistent with the data for Australian women[30] regarding the WC as a predictor of 10-year FS and SCORE (Systematic COronary Risk Evaluation) scores. In addition, a Brazilian study[33] classified the WC as a good predictor of metabolic syndrome in women with polycystic ovary syndrome at a cutoff value of 95 cm (our cutoff value of WC was 88.5 cm). The cutoff value with the best sensitivity and specificity of VAI for prediction of FS30 BMI-hard CVD among Saudi men was 2.87 and FS30 Lipid-hard CVD was 2.90. The OR at the 95% confidence interval was 4.66 and 4.39, while, the kappa coefficient was 0.18 and 0.10. There were slightly different cutoff values for young Caucasian Sicilian population of 2.52 (age <30 years) and 2.23 (age ≥30 and <42 years) were reported by Amato et al.[34] Motamed et al[35] stated the same finding for the discriminatory accuracy of CI for 10-years FS and ASCVD scores among men. However, the accuracy of CI among women was not consistent with our results. This study found LAP was a classifier of CVD risk in women only. Chiang et al[16] reported that LAP had significantly higher predictability than other obesity indices for prediction of metabolic syndrome among Taiwanese population older than 50 years of age. Additionally, Hosseinpanah et al[36] concluded that LAP was an independent predictor of cardiovascular disease among individuals with normal BMI. Conversely, BMI, high C-reactive protein, and insulin resistance were better than LAP for the prediction of prediabetic status and cardiovascular risk in women with polycystic ovary syndrome.[37] The paradox in this study was the low agreement (measured by Kappa coefficient) and high predictability (measured by area under the ROC) between the selected obesity indices and long-term CVD risk scores. This paradox might be due to a limitation in the Kappa test itself. McHugh[38] examined the level of kappa that is acceptable for health research and stated that Cohen (the developer of Kappa) suggested the kappa interpretation should be too permissive for health studies. Thus, a score as low as 0.41 might be acceptable. However, further studies in the Saudi population are required. Similarly, Dantas et al[39] reported poor and variable agreement when assessing risk for cardiovascular diseases using anthropometric parameters.

This study included several limitations, such as the cross sectional nature of the study without a prospective follow-up or validation against clinical indicators of CVD in subclinical stages. In addition, the investigation of multiple measures and indices, the collection of a multiplicity of measures, and indices aiming to minimize the underestimation of CVD risk that may be somewhat unfeasible are also limitations of this study.

In conclusion, long-term cardiometabolic risk in our sample can be highly discriminated by some simple

anthropometric and central obesity indices (such as VAI, CI, BMI, WC, LAP, and MAMA) with distinct cutoff values that we identified for the first time in the Saudi population. These discriminators were not the same in men and women, and this finding might be due to different adiposity distributions and gender-specific endocrinal factors. There was poor to fair agreement with the long-term cardiovascular risk scores despite the high predictability of these discriminators. Thus, future research is needed for further clinical validation of these results.

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Statistics

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