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Optimal waist:height ratio cut-off point for cardiometabolic risk factors in Turkish adults

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Abstract

Objective: To identify the optimal waist:height ratio (WHtR) cut-off point that discriminates cardiometabolic risk factors in Turkish adults.
Design: Cross-sectional study. Hypertension, dyslipidaemia, diabetes, metabolic syndrome score ≥2 (presence of two or more metabolic syndrome components except for waist circumference) and at least one risk factor (diabetes, hypertension or dyslipidaemia) were categorical outcome variables. Receiver-operating characteristic (ROC) curves were prepared by plotting 1 − specificity on the *x*-axis and sensitivity on the *y*-axis. The WHtR value that had the highest Youden index was selected as the optimal cut-off point for each cardiometabolic risk factor (Youden index = sensitivity + specificity − 1).
Setting: Turkey, 2003.
Subjects: Adults (1121 women and 571 men) aged 18 years and over were examined.
Results: Analysis of ROC coordinate tables showed that the optimal cut-off value ranged between 0·55 and 0·60 and was almost equal between men and women. The sensitivities of the identified cut-offs were between 0·63 and 0·81, the specificities were between 0·42 and 0·71 and the accuracies were between 0·65 and 0·73, for men and women. The cut-off point of 0·59 was the most frequently identified value for discrimination of the studied cardiometabolic risk factors. Subjects classified as having WHtR ≥ 0·59 had significantly higher age and sociodemographic multivariable-adjusted odds ratios for cardiometabolic risk factors than subjects with WHtR < 0·59, except for diabetes in men.
Conclusions: We show that the optimal WHtR cut-off point to discriminate cardiometabolic risk factors is 0·59 in Turkish adults.

Keywords
Waist:height ratio
Anthropometry
Cardiometabolic risk factors

From a public health perspective, identification of the best anthropometric discriminator of cardiometabolic risk factors would provide a simple, cheap and useful tool. Measurement of waist circumference (WC) is recommended by the US National Cholesterol Education Program (NCEP) Adult Treatment Panel III (ATP III) to diagnose the metabolic syndrome and to assess central obesity[1]. The metabolic syndrome is important, because it is associated with a threefold increase in CVD risk, a fivefold increased risk of diabetes mellitus (DM) and a twofold increase in all-cause mortality[2–5]. Based on data from a large prospective study with 10 years of follow-up of 359 387 subjects, Pischon *et al.* recommended using WC or waist:hip ratio (WHpR) in addition to BMI in assessing future risk of mortality[6]. Global acceptance of WC as the best anthropometric index would imply that a 186 cm tall man with a WC of 117 cm has the same cardiometabolic risk as a 168 cm tall man with a WC of 117 cm, considering all classical cardiovascular risk factors like age, smoking habit, blood pressure and lipids are equal. In contrast, it has been shown that height has an inverse association with CVD and total mortality[7–9]. In a recent meta-analysis, Lee and co-workers found that central obesity markers, especially waist:height ratio

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(WHtR), are superior to BMI for predicting cardiovascular risk factors (hypertension, type 2 DM and/or dyslipidaemia) in both men and women[10]. Other investigators have also proposed the use of WHtR to predict CVD risk and metabolic syndrome[11–18]. In a previous issue of this journal, we reported that WHtR is the best anthropometric index in Turkish adults[19]. To enable this information to be practical and helpful, we now aim to identify the optimal WHtR cut-off point for discrimination of cardiometabolic risk factors in Turkish men and women.

Methods

The current report is a continuation of our previous publication[19]. Information about subject characteristics, informed consent, compliance with the Helsinki Declaration, laboratory methods, definitions of cardiovascular risk factors and limitations of the study can be found in our earlier paper[19]. The Central Ethics Committee of the Turkish Ministry of Health approved the study and granted permission for its conduct. There were 571 men and 1121 women in this cross-sectional epidemiological survey that was performed in 2003. Subjects who were more than 17 years old were recruited from neighbourhood groups and with local advertisements in Istanbul, an urban area and in villages of Kayseri, a rural area. The survey was not nationally representative. Information on education, income, past medical history, smoking, alcohol consumption and physical activity was collected through face-to-face physician interview. Monthly family income was categorized as <125€, 125–250€, 250–500€ and >500€. Subjects were classified as low education level if they were illiterate, literate only or had ≤5 years of elementary school education. Subjects who had >5 years of education were classified as high education level. Physical activity was categorized as >4 h, 1–4 h, <1 h and no physical activity per week and was based on self-report. Subjects who consumed at least one alcoholic beverage per month were assigned into the drinker category. Smoking was categorized as ex-, never and current smoker status.

Height was measured to within 0·5 cm with a measuring stick, weight to within 0·1 kg with a digital scale, WC and hip circumference (HC) to the nearest 0·5 cm with a non-elastic measuring tape. WC was measured at the midpoint between the last rib and the superior iliac crest during mild expiration. HC was measured at the level of the greater trochanter. All measurements were taken when subjects wore light clothing and after shoes were taken off. BMI was calculated as weight in kilograms divided by the square of height in metres (kg/m^2). Blood pressure (BP) was measured on the right arm with an automated sphygmomanometer (Omron automatic blood pressure monitor with IntelliSense®, Bannockburn, IL, USA) after 15 min of rest with the subject in the sitting position. A 10 h fasting blood sample was obtained from the subjects. Total cholesterol (TC), HDL cholesterol (HDL-C), LDL cholesterol (LDL-C), TAG, glucose and insulin levels were measured with standard commercial methods[19]. Insulin resistance was estimated with the homeostasis model assessment insulin resistance index (HOMA-IR), calculated from the equation[20]: HOMA-IR = [fasting serum insulin (μU/ml) × fasting plasma glucose (mmol/l)]/22·5.

Definitions of cardiometabolic risk factors

Hypertension was defined as systolic BP ≥ 140 mmHg, diastolic BP ≥ 90 mmHg or concurrent use of anti-hypertensive medications[21]. In accordance with the NCEP ATP III criteria, dyslipidaemia was defined if any of the following was present: serum TC ≥ 240 mg/dl, HDL-C < 40 mg/dl, LDL-C ≥ 160 mg/dl or serum TAG ≥ 200 mg/dl[1]. DM was diagnosed either from concurrent use of antidiabetic medications or if fasting plasma glucose was ≥126 mg/dl[22]. The cut-off points for abnormal metabolic syndrome components are illustrated in Table 1. Metabolic syndrome was diagnosed if three or more abnormal modified NCEP ATP III criteria were present[1,23]. If a subject had two or more abnormal metabolic syndrome components, except for the WC component, he or she was categorized into the metabolic syndrome score ≥2 (MSS ≥ 2) group. MSS ≥ 2 was a state variable in receiver-operating characteristic (ROC) curve analysis and a dependent variable in logistic regression analysis. Inclusion of WC in the MSS ≥ 2 category would cause multicollinearity between the independent variable (WHtR) and the dependent variable (metabolic syndrome); therefore it was appropriate to exclude WC from the definition of the metabolic syndrome. If subjects had hypertension or dyslipidaemia or diabetes, they were categorized into at least one risk factor (ALORF) positive

Table 1 Cut-off points for abnormal metabolic syndrome components

Component	Cut-off point for men	Cut-off point for women
WC	≥102 cm	≥88 cm
Blood pressure†	SBP ≥ 130 or DBP ≥ 85 mmHg	SBP ≥ 130 or DBP ≥ 85 mmHg
TAG†	≥150 mg/dl (≥1·69 mmol/l)	≥150 mg/dl (≥1·69 mmol/l)
HDL-C†	<40 mg/dl (<1·03 mmol/l)	<50 mg/dl (<1·29 mmol/l)
Glucose†	≥100 mg/dl (≥5·56 mmol/l)	≥100 mg/dl (≥5·56 mmol/l)

WC, waist circumference; HDL-C, HDL cholesterol; SBP, systolic blood pressure; DBP, diastolic blood pressure.
Metabolic syndrome is diagnosed if an individual has three or more abnormal components according to modified US National Cholesterol Education Program Adult Treatment Panel III criteria[1, 23].
†If a subject is on drug therapy for the component, he or she is assigned to an abnormal component status.

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status. ALORF and MSS ≥ 2 were categorical variables with a binary (yes/no) outcome like hypertension, diabetes and dyslipidaemia, the other dependent variables.

Statistical methods

The SPSS statistical software package version 15·0 (SPSS Inc., Chicago, IL, USA) was used for statistical analyses. Continuous variables with a normal distribution are presented as means and standard deviations. Continuous variables with a positively skewed distribution are presented as median, 25th and 75th percentiles. Categorical variables are presented as percentage and 95 % confidence interval. ROC curves were prepared by plotting 1 − specificity on the x-axis and sensitivity on the y-axis. WHtR was rounded to two decimals in ROC analyses. The difference between area under the curve (AUC) of WHtR for each cardiometabolic risk factor and the value of 0·50, the area under the line of no discrimination, was compared[24]. The optimal WHtR cut-off was found by calculating the Youden index, J[25]: J = sensitivity + specificity − 1. The WHtR value that had the highest J was selected as the best cut-off point for each cardiometabolic risk factor. We identified the cut-offs using the Youden index for the reasons delineated by Perkins and Schisterman[26]. Cut-offs estimated from the alternative method, closest to the coordinate of sensitivity = 1 and 1 − specificity = 1 in ROC curve analysis (closest to the ideal marker), were within −0·04 to +0·05 of the cut-offs estimated by J. Cut-offs identified by J and closest to the ideal marker were the same 50 % of the time when ROC curves were constructed separately for each gender. Cut-offs identified by J and closest to the ideal marker were the same 60 % of the time when ROC curves were constructed separately for each gender and age tertile. As per Perkins and Schisterman[26] the point on the ROC curve closest to the ideal marker attempts to find the cut-off point that discriminates the presence of the condition from the absence of the condition perfectly, but involves a quadratic term with unknown clinical meaning. J is the maximum vertical distance on the curve from the line of no discrimination and reflects the discriminatory capability furthest from chance[26]. J attempts to maximize correct classification and minimize incorrect classification[26]. The most frequently occurring cut-off was arbitrarily selected as optimal in order to conclude a single cut-off instead of multiple optimal cut-off points for various cardiometabolic risk factors.

The sensitivities and specificities were obtained from the coordinate tables of ROC curves. The following formulas were used in calculating the positive predictive value (PPV), negative predictive value (NPV) and accuracy of the identified cut-offs[27]:

$$\text{PPV} = \text{prevalence} \times \text{sensitivity}/[\text{prevalence} \times \text{sensitivity} + (1 - \text{prevalence}) \times (1 - \text{specificity})]$$

$$\text{NPV} = [(1 - \text{prevalence}) \times \text{specificity}]/[(1 - \text{prevalence}) \times \text{specificity} + \text{prevalence} \times (1 - \text{sensitivity})]$$

and

$$\text{Accuracy} = 1 - [\text{prevalence} \times (1 - \text{sensitivity}) + (1 - \text{prevalence}) \times (1 - \text{specificity})].$$

Subjects were classified as under *v.* at or above the optimal WHtR cut-off point, creating a categorical variable with a binary outcome. A multivariable logistic regression model was used to test the predictive ability of the cut-off identified in discriminatory ROC curve analysis. The model included age, rural *v.* urban residence, smoking, alcohol consumption, physical activity, income, education level and WHtR category as independent variables and hypertension, dyslipidaemia, diabetes, MSS ≥ 2 and ALORF as dependent variables. Adjusted odds ratios of cardiometabolic risk factors for being at or above the optimal WHtR cut-off *v.* being below the optimal WHtR cut-off were calculated.

Results

Clinical characteristics of the study sample are presented in Tables 2 and 3. The age range of women was between 18 and 90 years. The age range of men was between 19 and 80 years. ROC curves were constructed to measure the degree of discrimination of WHtR for hypertension, dyslipidaemia, diabetes, MSS ≥ 2 and ALORF. The AUC of WHtR for cardiometabolic risk factors are presented in Table 4 and are significantly different from the AUC value of 0·500 ($P < 0·01$), the area under the line of no discrimination. In women, the relationship between WHtR and dyslipidemia seems to be weaker. Cut-off points with

Table 2 Clinical characteristics of the study sample: Turkish men and women aged 18 years and over, 2003

	Men (*n* 571)		Women (*n* 1121)	
Characteristic	Mean	SD	Mean	SD
Age (years)	45	13	46	13
Height (cm)	170·7	7·3	155·7	6·7
Weight (kg)	82·6	12·8	73·1	13·4
BMI (kg/m²)	28·3	3·7	30·2	5·4
WC (cm)	99·6	10·3	92·7	12·6
WHpR	0·92	0·06	0·83	0·08
WHtR	0·58	0·06	0·60	0·09
SBP (mmHg)	133	20	135	26
DBP (mmHg)	85	12	86	13
Glucose (mmol/l)	5·49	1·74	5·28	1·74
Insulin (pmol/l)†	53·1	36·1, 78·8	52·4	36·2, 73·5
HOMA-IR†	1·74	1·14, 2·67	1·58	1·08, 2·47
TC (mmol/l)	4·71	0·93	4·81	1·08
HDL-C (mmol/l)	1·00	0·25	1·22	0·31
LDL-C (mmol/l)	2·91	0·81	2·95	0·92
TAG (mmol/l)†	1·47	1·04, 2·13	1·21	0·88, 1·68

WC, waist circumference; WHpR, waist:hip ratio; WHtR, waist:height ratio; SBP, systolic blood pressure; DBP, diastolic blood pressure; HOMA-IR, homeostasis model assessment of insulin resistance; TC, total cholesterol; HDL-C, HDL cholesterol; LDL-C, LDL cholesterol.
Summarized from Table 1 of our previous publication[19].
Results are presented as arithmetic mean and standard deviation, or as †median and 25th, 75th percentile for continuous variables with a positively skewed distribution.

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the highest Youden index are presented in Table 5. The sensitivities of the identified cut-off points for detecting cardiometabolic risk factors are between 0·72 and 0·81 in women and between 0·63 and 0·70 in men. The specificities of the identified cut-off points range between 0·42 and 0·71 in women and between 0·48 and 0·67 in men. The accuracies of the cut-offs to discriminate diabetes and dyslipidaemia are lower. The accuracies of the cut-offs for hypertension, MSS ≥ 2 and ALORF range between 0·65 and 0·73, in men and women. Table 5 shows that the best cut-off point is between 0·56 and 0·60. Cut-off values for cardiometabolic risk factors are almost equal between men and women. The cut-off of 0·59 is the most frequently identified value in Table 5.

In the next step, subjects were grouped according to age tertiles and the same analyses were repeated. Table 6 shows that the AUC for diabetes in women ≤38 years old, the AUC for dyslipidaemia in women ≥51 years old and the AUC for diabetes in men are not different from the chance line (AUC = 0·500), meaning that WHtR has no discriminatory capability for dyslipidaemia and diabetes in these groups. Table 7 shows optimal WHtR cut-off points for cardiometabolic risk factors by gender and age tertile. Optimal WHtR cut-offs range between 0·50 and 0·67. The sensitivities of the identified optimal cut-offs range between 0·40 and 0·91, specificities between 0·31 and 0·89 and accuracies between 0·46 and 0·78. The optimal WHtR cut-off seems to increase as age advances. As in Table 5, 0·59 is also the most frequent cut-off value in Table 7. When the prevalence of the studied cardiometabolic risk factor is low, as in diabetes, the PPV of the cut-off is low and the NPV is high. When the prevalence is high, as in ALORF, the PPV is high and the NPV is low (Table 7). If diabetes and ALORF are omitted from Table 7, PPV ranges between 0·32 and 0·88 and NPV ranges between 0·35 and 0·93. The scientific conclusion from Tables 5 and 7 is to employ different optimal cut-off values for different cardiometabolic risk factors that vary by age tertile and gender. However, as 0·59 is the most frequent number in Tables 5 and 7, it was pragmatically selected as the optimal cut-off point for discrimination of cardiometabolic risk factors.

Table 3 The frequency of cardiometabolic risk factors, diabetes and CHD in the study sample: Turkish men and women aged 18 years and over, 2003

	Men (*n* 571)			Women (*n* 1121)		
Risk factor	*n*	%	95 % CI	*n*	%	95 % CI
Hypertension	254	45	41, 49	518	46	43, 49
Diabetes	40	7	5, 9	79	7	6, 8
Dyslipidaemia	383	67	63, 71	478	43	40, 46
Metabolic syndrome	250	44	40, 48	525	47	44, 50
MSS ≥ 2	332	58	54, 62	598	53	50, 56
ALORF	469	82	79, 85	726	65	62, 68
CHD	36	6	4, 8	75	7	6, 8

Metabolic syndrome, subjects with three or more abnormal modified US National Cholesterol Education Program (NCEP)-defined metabolic syndrome components[1, 23]; MSS ≥ 2, subjects with two or more abnormal modified NCEP-defined metabolic syndrome components excluding waist circumference; ALORF, at least one risk factor (hypertension, diabetes or dyslipidaemia) is present; CHD, self-reported CHD history.
Summarized from Table 1 of our previous publication[19].

Table 4 Area under the receiver-operating characteristic curves (AUC) and 95 % confidence intervals of waist:height ratio for cardiometabolic risk factors: Turkish men and women aged 18 years and over, 2003

	Women (*n* 1121)		Men (*n* 571)	
Risk factor	AUC	95 % CI	AUC	95 % CI
Hypertension	0·776	0·749, 0·803	0·686	0·642, 0·730
Dyslipidaemia	0·630	0·598, 0·662	0·608	0·558, 0·657
Diabetes	0·732	0·684, 0·780	0·606	0·515, 0·696
MSS ≥ 2	0·763	0·735, 0·791	0·697	0·653, 0·740
ALORF	0·757	0·727, 0·787	0·693	0·637, 0·748

MSS ≥ 2, subjects with two or more abnormal modified US National Cholesterol Education Program-defined metabolic syndrome components excluding waist circumference[1, 23]; ALORF, at least one risk factor (hypertension, dyslipidaemia or diabetes) is present.
Summarized from our previous publication[19].
All areas under the receiver-operating characteristic curves are significantly different from 0·500, the value that indicates the area under the line of no discrimination ($P < 0·05$).

Table 5 Optimal waist:height ratio cut-offs for cardiometabolic risk factors and the sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV) and accuracy of the cut-offs: Turkish men and women aged 18 years and over, 2003

	Cut-off†	Sensitivity	Specificity	PPV	NPV	Accuracy
Women (*n* 1121)						
Hypertension	0·60	0·72	0·71	0·68	0·75	0·71
Dyslipidaemia	0·56	0·79	0·42	0·51	0·73	0·58
Diabetes	0·60	0·81	0·53	0·11	0·97	0·55
MSS ≥ 2	0·58	0·78	0·65	0·72	0·72	0·72
ALORF	0·56	0·81	0·59	0·79	0·63	0·73
Men (*n* 571)						
Hypertension	0·59	0·68	0·63	0·60	0·71	0·65
Dyslipidaemia	0·57	0·69	0·48	0·73	0·43	0·62
Diabetes	0·59	0·70	0·51	0·10	0·96	0·52
MSS ≥ 2	0·59	0·63	0·67	0·73	0·57	0·65
ALORF	0·57	0·69	0·63	0·89	0·31	0·68

MSS ≥ 2, subjects with two or more abnormal modified US National Cholesterol Education Program-defined metabolic syndrome components excluding waist circumference[1, 23]; ALORF, at least one risk factor (hypertension, dyslipidaemia or diabetes) is present.
†Optimal cut-off is identified as the value that has the highest Youden index, J: J = sensitivity + specificity − 1.

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Table 6 Area under the receiver-operating characteristic curves (AUC) and 95 % confidence intervals of waist:height ratio for cardio-metabolic risk factors by age tertile and gender: Turkish men and women aged 18 years and over, 2003

	Age ≤38 years		Age 39–50 years		Age ≥51 years	
Risk factor	AUC	95 % CI	AUC	95 % CI	AUC	95 % CI
Women	(*n* 342)		(*n* 400)		(*n* 379)	
Hypertension	0·777	0·715, 0·838	0·717	0·668, 0·767	0·703	0·643, 0·763
Dyslipidaemia	0·681	0·624, 0·738	0·641	0·588, 0695	0·539*	0·481, 0·597
Diabetes	0·605*	0·000, 1·000	0·718	0·621, 0·814	0·618	0·543, 0·694
MSS ≥ 2	0·765	0·710, 0·820	0·734	0·683, 0·784	0·657	0·597, 0·717
ALORF	0·726	0·673, 0·779	0·712	0·659, 0·765	0·672	0·597, 0·747
Men	(*n* 195)		(*n* 191)		(*n* 185)	
Hypertension	0·673	0·587, 0·759	0·665	0·587, 0·743	0·654	0·568, 0·741
Dyslipidaemia	0·597	0·514, 0·680	0·622	0·532, 0·711	0·598	0·512, 0·683
Diabetes	0·567*	0·291, 0·844	0·610*	0·447, 0·773	0·545*	0·418, 0·672
MSS ≥ 2	0·673	0·597, 0·749	0·705	0·627, 0·783	0·674	0·595, 0·753
ALORF	0·640	0·556, 0·724	0·696	0·596, 0·796	0·663	0·514, 0·813

MSS ≥ 2, subjects with two or more abnormal modified US National Cholesterol Education Program-defined metabolic syndrome components excluding waist circumference[1, 23]; ALORF, at least one risk factor (hypertension, dyslipidaemia or diabetes) is present.
*$P > 0{\cdot}05$ compared with 0·500; unmarked areas under the receiver-operating characteristic curves are significantly different from 0·500, the value that indicates the area under the line of no discrimination ($P < 0{\cdot}05$).

Table 7 The prevalence of cardiometabolic risk factors, optimal waist:height ratio (WHtR) cut-offs and the sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV) and accuracy of the cut-offs by age tertile and gender: Turkish men and women aged 18 years and over, 2003

	Prevalence	Cut-off†	Sensitivity	Specificity	PPV	NPV	Accuracy
Women, age ≤38 years (*n* 342)							
Hypertension	0·16	0·57	0·72	0·71	0·32	0·93	0·71
Dyslipidaemia	0·35	0·50	0·91	0·39	0·45	0·89	0·57
Diabetes	0·01	NA	NA	NA	NA	NA	NA
MSS ≥ 2	0·30	0·56	0·70	0·73	0·53	0·85	0·72
ALORF	0·42	0·55	0·64	0·70	0·61	0·73	0·67
Women, age 39–50 years (*n* 400)							
Hypertension	0·44	0·58	0·77	0·55	0·57	0·75	0·65
Dyslipidaemia	0·42	0·58	0·72	0·50	0·51	0·71	0·59
Diabetes	0·05	0·61	0·79	0·59	0·09	0·98	0·60
MSS ≥ 2	0·57	0·58	0·75	0·62	0·72	0·65	0·69
ALORF	0·63	0·55	0·88	0·44	0·73	0·68	0·72
Women, age ≥51 years (*n* 379)							
Hypertension	0·77	0·63	0·59	0·73	0·88	0·35	0·62
Dyslipidaemia	0·50	NA	NA	NA	NA	NA	NA
Diabetes	0·15	0·65	0·64	0·60	0·22	0·90	0·61
MSS ≥ 2	0·71	0·59	0·83	0·40	0·77	0·49	0·71
ALORF	0·88	0·67	0·40	0·89	0·96	0·17	0·46
Men, age ≤38 years (*n* 195)							
Hypertension	0·26	0·59	0·54	0·72	0·40	0·82	0·67
Dyslipidaemia	0·64	0·57	0·53	0·67	0·74	0·45	0·58
Diabetes	0·03	NA	NA	NA	NA	NA	NA
MSS ≥ 2	0·47	0·57	0·63	0·69	0·64	0·68	0·66
ALORF	0·73	0·57	0·53	0·74	0·85	0·37	0·59
Men, age 39–50 years (*n* 191)							
Hypertension	0·41	0·61	0·56	0·72	0·58	0·70	0·65
Dyslipidaemia	0·73	0·55	0·89	0·31	0·78	0·51	0·73
Diabetes	0·07	NA	NA	NA	NA	NA	NA
MSS ≥ 2	0·67	0·59	0·65	0·67	0·80	0·49	0·66
ALORF	0·83	0·59	0·60	0·70	0·91	0·26	0·62
Men, age ≥51 years (*n* 185)							
Hypertension	0·68	0·60	0·66	0·65	0·80	0·47	0·66
Dyslipidaemia	0·64	0·59	0·71	0·49	0·71	0·49	0·63
Diabetes	0·11	NA	NA	NA	NA	NA	NA
MSS ≥ 2	0·61	0·60	0·67	0·63	0·74	0·55	0·65
ALORF	0·91	0·56	0·81	0·50	0·94	0·21	0·78

MSS ≥ 2, subjects with two or more abnormal modified US National Cholesterol Education Program-defined metabolic syndrome components excluding waist circumference[1, 23]; ALORF, at least one risk factor (hypertension, dyslipidaemia or diabetes) is present; NA, not applicable because the area under the receiver-operating characteristic curve of WHtR is not significantly different from 0·500, the area under the line of no discrimination (see Table 6).
†Optimal cut-off is identified as the value that has the highest Youden index, J: J = sensitivity + specificity − 1.

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Table 8 Odds ratios and 95 % confidence intervals for cardiometabolic risk factors in subjects classified as having waist:height ratio (WHtR) ≥ 0·59† *v.* subjects with WHtR < 0·59 (where OR = 1·00) after controlling for age, rural *v.* urban residence, smoking, alcohol consumption, physical activity, income and education level: Turkish men and women aged 18 years and over, 2003

	Women		Men	
Risk factor	OR	95 % CI	OR	95 % CI
Hypertension	3·00	2·22, 4·07	3·09	2·08, 4·61
Dyslipidaemia	1·70	1·29, 2·24	2·03	1·37, 3·01
Diabetes	2·21	1·16, 4·21	1·91	0·93, 3·92
MSS ≥ 2	3·66	2·75, 4·86	3·87	2·62, 5·72
ALORF	2·50	1·84, 3·39	2·94	1·73, 4·99

MSS ≥ 2, subjects with two or more abnormal modified US National Cholesterol Education Program-defined metabolic syndrome components excluding waist circumference[1, 23]; ALORF, at least one risk factor (hypertension, dyslipidaemia or diabetes) is present.
†Fifty-one per cent of women and 47 % of men had WHtR ≥ 0·59.

The AUC of WHtR for self-reported history of CHD was 0·606 (95 % CI 0·540, 0·672) in women. WHtR was not a significant discriminator of CHD in men. The optimal cut-off value of WHtR for CHD was 0·62 in women. When ROC curves for CHD were constructed by age tertile, the AUC was significant only in women in the age group of ≥51 years. The AUC of WHtR for CHD in women in the age group ≥51 years was 0·609 (95 % CI 0·530, 0·689). The prevalence of CHD was 13 % and the optimal cut-off value of WHtR for CHD was 0·63 in women who were ≥51 years of age.

Forty-seven per cent of men (*n* 266) and 51 % of women (*n* 575) had WHtR ≥ 0·59. The age- and socio-demographic variable-controlled odds ratios of subjects with WHtR ≥ 0·59 for hypertension, dyslipidaemia, diabetes, MSS ≥ 2 and ALORF were calculated by logistic regression *v.* those with WHtR < 0·59 (Table 8). The status of having WHtR ≥ 0·59 significantly increased the risk of having cardiometabolic risk factors, except for diabetes in men. Age, rural *v.* urban residence, smoking and alcohol consumption were also significant contributors to the studied cardiometabolic risk factors.

Discussion

Ashwell and Hsieh suggested global use of WHtR as a rapid screening tool for cardiometabolic risk factors with this simple public health message[28]: ‘Keep your waist circumference to less than half your height’. In the following, the first sentence is from Ashwell and Hsieh’s arguments to defend the superiority of WHtR over other anthropometric indices and the second sentence reflects our opinion based on our data or literature review.

1. WHtR is more sensitive than BMI as an early warning of health risks. We confirmed previously that WHtR is the best anthropometric index for discriminating cardiometabolic risk factors in Turkish adults[19].
2. WHtR is cheaper and easier to measure and calculate than BMI. A measuring tape is cheaper than a scale and there is a need to square the height as when calculating BMI, therefore this statement is true.
3. A cut-off point of WHtR = 0·50 indicates increased risk for men and women. We agree with the second part of this statement; based on our data, cut-off values of WHtR are close in men and women.
4. A cut-off point of WHtR = 0·50 indicates increased risk for people in different ethnic groups. We disagree; our data show that the cut-off value of 0·59 is optimal in Turkish men and women.

Although WHtR seems the best anthropometric index for discrimination of cardiometabolic risk factors, there is a disparity in the optimal cut-off points between ethnic groups. In a recent meta-analysis, Lee and co-workers discussed the utility of universal *v.* ethnic-specific WHtR cut-off points and found that the optimal WHtR cut-off ranged from 0·46 to 0·62 in studies from different countries[10]. Our findings are in favour of ethnic-specific cut-offs. Although a WHtR cut-off of ≥0·50 is the best for Eastern Asia[13,29–31], a cross-sectional study reported that the optimal WHtR cut-off value is between 0·54 and 0·59 in Germany[14]. From a cross-sectional study in Iran, Mirmiran and co-workers reported that the optimal WHtR cut-off should be between 0·47 and 0·56 for men, and between 0·50 and 0·63 for women[32]. From a cross-sectional study in Iraq, Mansour and Al-Jazairi reported a WHtR cut-off value of 0·55 for men and 0·59 for women for discrimination of hypertension[33]. Except for the studies of Aekplakorn *et al.*[29], Fuchs *et al.*[18], Hadaegh *et al.*[34] and Gelber *et al.*[35], all studies that suggest the superiority of WHtR are cross-sectional[11–17,30–33]. Cross-sectional design and risk factors as dependent variables are major limitations of those studies, as is the case with our study. A prospective cohort study with 17 years of follow-up found WHtR as the best predictor of future CHD in Thai men who were 35 to 59 years of age at baseline[29]. A prospective study from Iraq reported the WHtR cut-off to predict incident diabetes as 0·52 for males and 0·57 for females[36]. Of note, WHpR, not WHtR showed the strongest association with incident diabetes in that study. More prospective studies with clinical end points are needed to establish the superiority of WHtR as an anthropometric index and the validity of our and others’ suggested cut-off points.

We have previously shown that WC, WHpR, BMI and HC are worse than WHtR in discriminating cardiometabolic risk factors[19]. The vast majority of AUC in Tables 4 and 6 are significantly different from the AUC value of 0·50, indicating that using anthropometric indices is better than chance to guess the presence or absence of cardiometabolic risk factors in a patient. The AUC in Tables 4 and 6 are not very close to the AUC value of 1·00, meaning that anthropometric indices are not perfect

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discriminators of cardiometabolic risk factors and nevertheless cannot replace the clinical and laboratory evaluation of cardiometabolic risk factors.

An easy-to-remember cut-off value is an advantage for both health-care professionals and lay people. In our opinion, there is no question that individuals should be able to achieve self-diagnosis by using the globally – or at least nationally – applicable anthropometric index and its cut-off point. A WHtR cut-off point of ≥0·50 as action level one, and ≥0·60 as action level two, have been suggested[10]. Eighty-eight per cent of our sample had WHtR ≥ 0·50, 50 % had WHtR ≥ 0·59 and 45 % had WHtR ≥ 0·60. For both men and women, the sensitivities of the WHtR ≥ 0·50 cut-off for cardiometabolic risk factors were over 0·94, but the specificities ranged between 0·07 and 0·29 and the accuracies between 0·13 and 0·79 (data not shown). As the specificities, PPV and accuracies of the WHtR ≥ 0·50 cut-off for cardiometabolic risk factors are worse than those of the WHtR ≥ 0·59 cut-off, we think that categorizing cut-off values as action level one and two for action and alarm has the potential for error and miscommunication. A single WHtR cut-off value could be more easily adopted and remembered by health-care professionals, media and the public.

Conclusions

We have previously identified WHtR as the best anthropometric index to screen for cardiometabolic risk factors in Turkish adults[19]. In the current report, we show that the optimal WHtR cut-off point to predict cardiometabolic risk factors is 0·59, for both Turkish men and women.

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