Men's Health Journal. 2021; 5(1): e8

OPEN ACCESS

REVIEW ARTICLE

The Pooled Cut-off Point of Waist Circumference as Core Component of Metabolic Syndrome Diagnosis among the Iranian Population: a Systematic Review and Meta-analysis

Ehsan Shojaeefar[1], Narges Malih[2], Jalil Hossieni[1], Sajjad Raeisi[3], Alireza Esteghamati[4]*

1. Men's Health and Reproductive Health Research Center, Shahid Beheshti University of Medical Sciences, Tehran, Iran.
2. Social Determinants of Health Research Center, Shahid Beheshi University of Medical Sciences, Tehran, Iran.
3. Department of Mathematical Sciences, Isfahan University of Technology, Isfahan, Iran.
4. Endocrinology and Metabolism Research Center (EMRC), Vali-Asr Hospital, School of Medicine, Tehran University of Medical Sciences, Tehran, Iran.

Received: December 2020; Accepted: January 2021; Published online: February 2021

Abstract: **Introduction:** According to a nationwide study, one-third of the Iranian population suffer from metabolic syndrome (MetS). The most controversial criteria for the diagnosis of MetS is central obesity which would be defined by waist circumference (WC) and needed to be gender and ethnic-specific. There are several national studies that reported different cut-offs for WC so the present study aimed to do a systematic review and meta-analysis to achieve an overall statistical estimate of WC for the Iranian population. **Method:** A comprehensive search was conducted in international databases from inception to June 2020. The search keywords were waist circumference AND metabolic syndrome AND cut AND Iran. We used the QUADAS-2 tool for quality assessment and the HSROC model for estimating pooled specificity, sensitivity, and the cut-off point from included studies in R software. **Result:** A total of 3571 studies were evaluated and 24 studies fulfilled the inclusion criteria. Finally, 8 studies were included. All the studies were cross-sectional. Studies with missing MetS prevalence were excluded. Most of the studies had an unclear risk of bias in patient selection. There was a wide variation among reported cut-offs for WC from national and original studies. The Pooled cut-off points of WC for the diagnosis of MetS was 90.55 cm (95%CI: 90.51-90.60) in men and 89.24 cm (95%CI: 89.13-89.36) in women. The pooled sensitivity and specificity in men were 0.67 and 0.68, respectively and the pooled sensitivity and specificity in women were 0.61 and 0.57, respectively. **Conclusion:** Our results were highly consistent with the only national study and the only consensus about WC cut-off. Further nationwide studies are suggested to be involved in a Mata-analysis for calculating more precise WC cut-off.

Keywords: Central Obesity; Iran; Metabolic syndrome; Waist circumference

Cite this article as: Shojaeefar E, Malih N, Hossieni J, Raeisi S, Esteghamati A. The Pooled Cut-off Point of Waist Circumference as Core Component of Metabolic Syndrome Diagnosis among the Iranian Population: a Systematic Review and Meta-analysis. Mens Health J. 2021; 5(1): e8.

1. Introduction

Metabolic Syndrome is an important indicator of diabetes and cardiovascular diseases (CVDs) risk factor (1, 2). CVDs with about 46% of attributable death are the leading cause of mortality in Iran (3). A most recent study has revealed that about one-third of Iranian adults have the criteria of MetS, and that the trend of this disorder is ascending (4).

There are five common well-defined criteria based on National Cholesterol Education Program Adult Treatment Panel III (NCEP-ATP III), International Diabetes Federation (IDF), and American Heart Association National Heart Lung Blood Institute (AHA-NHLBI), to label a person with MetS. This in-

***Corresponding Author:** Alireza Esteghamati; Address: Endocrinology and Metabolism Research Center (EMRC), Vali-Asr Hospital, School of Medicine, Tehran University of Medical Sciences, Tehran, Iran. Email: esteghamati@tums.ac.ir

cludes central obesity, hyperglycemia, high blood pressure, low high-density lipoprotein (HDL), and high triglyceride (TG). The World Health Organization (WHO) also suggested a definition that includes microalbuminuria in addition to the aforementioned 5 criteria. The main differences of these three famous reference definitions (NCEP-ATP III, IDF, and AHA-NHLBI) are:

1) In IDF the MetS is defined by having central obesity (waist circumference (WC) ≥94 cm in men and ≥80 cm in women) as core component plus ≥2 other criteria. In NCEP-ATP III and AHA-NHLBI, the cut-off point of WC is 102 cm and 88 cm in men and women, respectively and MetS is defined as having ≥3 out of five criteria; 2) NCEP-ATP III got the 110 mg/dl as a cut-off point for fasting blood sugar (FBS) comparing with 100mg/dl in two others (IDF and AHA-NHLBI). Otherwise, there is a "Modified NCEP-ATP III" definition also, which revised the cut-off point of FBS to 100mg/dl just like IDF and AHA-NHLBI (5).

Thus the main component of these criteria that has to be gender and ethnic-specific according to IDF (6) is central obesity which has been suggested to be defined by the WC in several studies (7, 8).

Several national and regional studies determined the best cut-off for WC among Iranian people along with the statement of the Iranian National Committee of Obesity in 2010 about the national WC cut-off (9). Each of these national studies has reported different cut-offs of WC and there are no systematic reviews and meta-analyses to achieve an overall statistical estimate. Therefore, the present study aimed to do a systematic review and meta-analysis to achieve an overall statistical estimate of WC for the Iranian population.

2. Methods

2.1. Search strategy

Two researchers with a specialty in preventive medicine and medical degree conducted independent database searches. A comprehensive search was conducted in Medline, web of science, Scopus and, Google scholar from inception to June 2020. The search keywords were waist circumference AND metabolic syndrome AND cut AND Iran. The search strategy for PubMed was: ((("waist circumference"[All Fields]) AND ("metabolic syndrome"[All Fields])) AND ("cutoff"[All Fields])) AND (Iran).

Databases in Persian were searched either, including scientific information database (SID). Authors of the studies with no full text or studies with a lack of outcomes that were needed for the analysis were contacted via email. Reference lists of obtained articles were searched manually.

2.2. Reporting of Methods

To find original articles reporting cut-off points of waist circumference for predicting metabolic syndrome in the Iranian adult population, the eligibility criteria based on PICOS (i.e., participants, interventions, comparisons, outcomes, and study design) were cross-sectional studies which: 1- recruited participants older than 20 years of age, 2- reported cut-off values for waist circumference for male, female or both, 3- reported sensitivity and specificity for waist circumference associated with MetS. We included both English and Persian language studies.

2.3. Data extraction and quality assessment

We collected the author's identification, year of publication, province of the study, MetS reference definition used for analysis, age range including mean (SD) age, type of study and sampling, sample size, men's optimum cut-off, women's optimum cut-off, sensitivity, specificity for male and female participants separately. We used the QUADAS-2 tool for quality assessment of the studies including the risk of bias and applicability concerns in terms of patient selection, index test, and reference standard and risk of bias in flow and timing of the studies. Bias in patient selection may be due to inappropriate methods of selecting the patients. Bias in the index test might be due to the variability in the WC measurement's accuracy. In reference standard (MetS) bias might be a result of using different criteria for determining metabolic syndrome. ESh and NM assessed the studies in terms of quality.

2.4. Statistical analysis and data synthesis

We analysed men's and women's data in separate analyses. Selected eligible studies were entered in RevMan software version 5 for creating a table of included study and their quality assessment. Due to the heterogeneity of reference standards in included studies, we used the Hierarchical Summary Receiver Operating Characteristic Model (HSROC) for estimating the diagnostic accuracy parameters and generation the summary ROC. This method has previously used by several studies (10-12), but the nearest one was a study about using HSROC in calculating the cut-off for Homeostasis Model Assessment (HOMA) for the diagnosis of MetS (13) which we run in R package available from (Comprehensive R Archive Network) CRAN. I2 statistical parameter was calculated based on a study by Neyeloff et al. (14) to assess the heterogeneity of the results across the included studies.

3. Results

3.1. Literature search and baseline characteristics

The Fig 1 flow chart shows the selection process of the studies. The initial search identified 3699 studies. After the removal of 128 duplications, 3571 studies were evaluated. Among them, 24 studies fulfilled the inclusion criteria. Finally, 8 studies were included in the meta-analysis. All the studies were cross-sectional. Due to the need for the prevalence of Mets in studies to calculate meta-analysis parameters, we excluded the studies with missing Mets prevalence. Studies with missing outcomes of sensitivity and specificity were also excluded. flow chart showing the selection process is presented in Fig 1.

Characteristics of the included studies are illustrated in Table 1. The cut-off values of WC in men and women ranged from 87 to 94.5 cm and 82 to 97.8 cm, respectively. The prevalence of Mets ranged between 0.11-0.61 in men and 0.24-0.51 in women. The most prevalent reference standard was ATP III.

3.2. Study quality

The Methodological quality of the studies was assessed using the QUADAS-2. Kappa coefficient to examine inter-rater agreement for our initial overall quality score was 89.3%. Methodological quality for included studies is summarized in figure 2. All studies had a low concern about the applicability of the index test. Most of the studies had an unclear risk of bias in patient selection. In the selection of patients, three studies (Sharifi et al. (2008), Talaei et al. and Shahbazian et al.) were labeled as low risk. For the other 4 studies, the risk was unclear because they did not state whether a consecutive or random sample of patients was recruited or about appropriate exclusions, Sharifi et al. 2009 study had a high risk of bias due to the convenience sampling method and small sample size. Only Talaei et al.'s study had a clear risk of bias and low applicability concerns regarding the index test. It was unclear whether the index test results were interpreted without knowledge of the reference standard results in all studies. The reference standard domain in Sharifi et al. 's, Gharipour et al. 's, Gozashti et al. 's studies were unclear because they did not state whether the investigators who performed the reference standard (ATP III/IDF) were blinded to the results of the index test (WC). In Sharifi et al. (2009), Sharifi et al, (2008), and Talaei et al. studies not all patients were included in the final analysis.

3.3. Meta-analysis

Eight studies were included in the meta-analysis had a total of 20283 participants, with a sample size of 9319 men and 10964 women. HSROC model was used in men and women separately. The pooled sensitivity of studies in men was 0.67 (95% CI 0.38 to 0.96) and the pooled specificity was 0.68 (95% CI 0.44 to 0.92). Figures 3 shows the forest plot of the sensitivity, specificity, and figure 4,5 show the SROC and HSROC plot. The pooled sensitivity of studies in women was 0.61 (95% CI 0.30 to 0.92) and the pooled specificity was 0.57 (95% CI 0.37 to 0.77). Other parameters of HSROC meta-analysis are shown in table 2. I^2 heterogeneities were reported to be 99.076% and 86.76% in men and women respectively.

Pooled cut-off points of waist circumference for predicting MetS was 90.55 cm (95%CI: 90.51-90.60) in men and 89.24 cm (95%CI: 89.13-89.36) in women.

4. Discussion

Our results showed a wide variation among reported cut-offs for WC from national and original studies. i.e., included studies reported different cut-offs for men and women ranged from 87 to 94.5 cm and 82 to 97.8 cm, respectively. So we used a statistical model to pool them and achieve an overall estimate for each of men and women.

There is sufficient evidence that supports the usage of ethnic-specific WC. The majority of studies have mentioned that Asian populations have the most priority for using ethnic-specific WC (21). Also, the distribution of fat differs with sex, women relatively have a lower central distribution of fat (22). Accordingly, international scientific societies like IDF (6) recommended the application of gender and ethnic-specific WC for the diagnosis of MetS.

Since all included original studies have ignored the WC to take into account participants as patients with MetS, the remaining source of variation in included studies was FBS which has been defined to be 110 mg/dl in NCEP-ATP III compared with 100 mg/dl in other definitions. Sub-group analysis according to this variation also revealed no significant difference in our resulted pooled WC cut-off, therefore we considered all included studies in the same meta-analysis.

As argued by several national studies, the WC cut-offs stated by international definitions do not apply to the Iranian nation and shouldn't longer be considered by research and clinical setting in Iran. Other countries also have defined their own WC cut-off, e.g. in Turkey, Sonmez et al. evaluated the demographic characteristics of 4206 adult participants in 24 provinces of Turkey, then they calculated the ideal WC cut-off as 90 cm and 80 cm for Turkish men and women, respectively (23). Gao et al. reported the optimal WC cut-off in Chinese adults as 85 cm in men and 80-85 cm in women by conducting a large population-based study in 501201 adults from the China Kadoorie Biobank (24). A preliminary study in India estimated the optimal WC cut-off of Indian individuals using data of 713 subjects from an ongoing hospital-based study on

MetS, to be 90 cm and 85 cm in men and women, respectively (25). In a study in low-income African countries, the optimal WC cut-off of 92.25 cm was yielded the highest sensitivity and specificity in ROC analysis for the diagnosis of MetS in male adults whereas in female adults it was 89.45 cm (26).

As mentioned above, there are a wide variety of WC cut-offs among different nations ranging from 90 to 102 cm in men and from 80 to 89.45 cm in women. Our results were almost in range with the study of African low-income countries (26) and highly consistent with the only Iranian national study by Delavari et al., 2009 (27), a large Iranian population-based study by Gharipour M., et al., 2013 (7), and the consensus of Iranian national committee of obesity (9). These mentioned studies and consensus have reported a cut-off around 90 cm for both men and women and we endorse their previous uses in any study and clinical setting.

Our limitations were that there wasn't any similar study which has pooled several WC cut-offs to achieve an overall estimate to be mentioned as a background method and also we had only one nationwide study in this field, however we chose to use systematic review and meta-analysis since there was a remarkable number of original studies that calculated the WC cut-off in Iran and there was a need to achieve a pooled cut-off to avoid diversity and also this method has previously reported by a study for pooling HOMA (13). Our study had some strengths in comparison to existing evidence, first that in our study a larger sample size from different parts of the country involved calculating the national cut-off, and second, our results provided the statistically confirmed cut-off, sensitivity and specificity which can be used in any research and clinical settings as precise amounts when compared to the consensus.

5. Conclusion

Our results are the first statistically confirmed precise pooled cut-off for WC that can be used in any clinical and research setting and are highly consistent with the only national study and the only consensus about WC cut-off. Further nationwide studies are suggested to be conducted for a more precise national WC cut-off.

6. Appendix

6.1. Acknowledgements

This review was a part of a project entitled:" Delineation of men's health status in Iran during 2009-2019" which is sponsored and supervised by the Men's Health and Reproductive Health Research Centre (MHRHRC). The authors are thankful to the Men's health and reproductive health research center for its support and encouragement. We are also thanking Dr. Shahrzad Nematollahi for her kind comments about the statistical points.

6.2. Conflict of interest

The authors declare that there is no conflict of interests regarding the publication of this paper.

6.3. Funding and support

None

6.4. Author contribution

E.Sh. conceived the idea, E.Sh and N.M. drafted the manuscript and N.M, S.R. and E.Sh analyzed the data all under the supervision of A.E and support of Sj.H.

References

1. Mansourian M, Babahajiani M, Jafari-Koshki T, Roohafza H, Sadeghi M, Sarrafzadegan N. Metabolic Syndrome Components and Long-Term Incidence of Cardiovascular Disease in Eastern Mediterranean Region: A 13-Year Population-Based Cohort Study. Metab Syndr Relat Disord. 2019;17(7):362-6.

2. Grundy SM. Atlas of atherosclerosis and metabolic syndrome: Springer Science & Business Media; 2011.

3. Turk-Adawi K, Sarrafzadegan N, Fadhil I, Taubert K, Sadeghi M, Wenger NK, et al. Cardiovascular disease in the Eastern Mediterranean region: epidemiology and risk factor burden. Nature Reviews Cardiology. 2018;15(2):106.

4. Farmanfarma KK, Kaykhaei MA, Adineh HA, Mohammadi M, Dabiri S, Ansari-moghaddam A. Prevalence of metabolic syndrome in Iran: A meta-analysis of 69 studies. Diabetes & Metabolic Syndrome: Clinical Research & Reviews. 2019;13(1):792-9.

5. Talaei M, Thomas GN, Marshall T, Sadeghi M, Iranipour R, Oveisgharan S, et al. Appropriate cut-off values of waist circumference to predict cardiovascular outcomes: 7-year follow-up in an Iranian population. Intern Med. 2012;51(2):139-46.

6. Alberti K, Eckel RH, Grundy SM, Zimmet PZ, Cleeman JI, Donato KA, et al. Harmonizing the metabolic syndrome: a joint interim statement of the international diabetes federation task force on epidemiology and prevention; national heart, lung, and blood institute; American heart association; world heart federation; international atherosclerosis society; and international association for the study of obesity. Circulation. 2009;120(16):1640-5.

7. Gharipour M, Sarrafzadegan N, Sadeghi M, Andalib E, Talaie M, Shafie D, et al. Predictors of metabolic syndrome in the Iranian population: waist circumference, body mass index, or waist to hip ratio? Cholesterol. 2013;2013:198384.

8. Hajian-Tilaki K, Heidari B, Hajian-Tilaki A, Firouzjahi A,

Bagherzadeh M. The Discriminatory Performance of Body Mass Index, Waist Circumference, Waist-To-Hip Ratio and Waist-To-Height Ratio for Detection of Metabolic Syndrome and Their Optimal Cutoffs among Iranian Adults. Journal of Research in Health Sciences. 2014;14(4):276-81.
9. Azizi F KD, Aghajani H, Esteghamati A, Hosseinpanah F, Delavari D, Hadaegh F. Appropriate waist circumference cut-off points among Iranian adults: the first report of the Iranian National Committee of Obesity. Arch Iran Med. 2010;13(3):243.
10. Ramesh T, Igoumenou A, Montes MV, Fazel S. Use of risk assessment instruments to predict violence in forensic psychiatric hospitals: a systematic review and meta-analysis. European psychiatry. 2018;52:47-53.
11. Sánchez-García AB, Galindo-Villardón P, Nieto-Librero AB, Martín-Rodero H, Robins DL. Toddler screening for autism spectrum disorder: A meta-analysis of diagnostic accuracy. Journal of autism and developmental disorders. 2019;49(5):1837-52.
12. Wang F, Zhang J, Yu J, Liu S, Zhang R, Ma X, et al. Diagnostic accuracy of monofilament tests for detecting diabetic peripheral neuropathy: a systematic review and meta-analysis. Journal of diabetes research. 2017;2017.
13. Arellano-Ruiz P, Garcia-Hermoso A, Cavero-Redondo I, Pozuelo-Carrascosa D, Martinez-Vizcaino V, Solera-Martinez M.
Homeostasis Model Assessment cut-off points related to metabolic syndrome in children and adolescents: a systematic review and meta-analysis. Eur J Pediatr. 2019;178(12):1813-22.
14. Neyeloff JL, Fuchs SC, Moreira LB. Meta-analyses and Forest plots using a microsoft excel spreadsheet: step-by-step guide focusing on descriptive data analysis. BMC research notes. 2012;5(1):1-6.
15. Sharifi F, Mousavinasab N, Mazloomzadeh S, Jaberi Y, Saeini M, Dinmohammadi M, et al. Cutoff point of waist circumference for the diagnosis of metabolic syndrome in an Iranian population. Obes Res Clin Pract. 2008;2(3):I-II.
16. Gozashti MH, Najmeasadat F, Mohadeseh S, Najafipour H. Determination of most suitable cut off point of waist circumference for diagnosis of metabolic syndrome in Kerman. Diabetes Metab Syndr. 2014;8(1):8-12.
17. Esteghamati A, Ashraf H, Rashidi A, Meysamie A. Waist circumference cut-off points for the diagnosis of metabolic syndrome in Iranian adults. Diabetes Res Clin Pract. 2008;82(1):104-7.
18. Shahbazian H, Latifi SM, Nouhjah S. Cut-Off Point of Waist Circumference Used for the Diagnosis of Metabolic Syndrome Among Adult Population in Ahvaz, Southwestern Iran. Jentashapir Journal of Health Research. 2015;6(4).
19. Fatemeh K. Evaluation of sensitivity and specificity of waist circumference for predicting the cardiovascular risk factors: Qazvin University Of Medical Sciences; 2014.
20. Sharifi F, Mirarefin M, Fakhrzadeh H, Zerafati N, Badamchizade Z, Edalat B, et al. Comparison of Waist Circumference and Metabolic Syndrome as a Prognostic Value of Insulin Resistance in Elderly Residents of Kahrizak. Iranian Journal of Ageing. 2009;4(3):0-.
21. Lear S, James P, Ko G, Kumanyika S. Appropriateness of waist circumference and waist-to-hip ratio cutoffs for different ethnic groups. European journal of clinical nutrition. 2010;64(1):42-61.
22. Stevens J, Katz EG, Huxley RR. Associations between gender, age and waist circumference. European journal of clinical nutrition. 2010;64(1):6-15.
23. Sonmez A, Bayram F, Barcin C, Ozsan M, Kaya A, Gedik V. Waist circumference cutoff points to predict obesity, metabolic syndrome, and cardiovascular risk in Turkish adults. International Journal of Endocrinology. 2013;2013.
24. Gao M, Wei Y, Lyu J, Yu C, Guo Y, Bian Z, et al. The cut-off points of body mass index and waist circumference for predicting metabolic risk factors in Chinese adults. Zhonghua liu Xing Bing xue za zhi= Zhonghua Liuxingbingxue Zazhi. 2019;40(12):1533-40.
25. Pratyush DD, Tiwari S, Singh S, Singh SK. Waist circumference cutoff and its importance for diagnosis of metabolic syndrome in Asian Indians: A preliminary study. Indian Journal of Endocrinology and Metabolism. 2012;16(1):112.
26. Owolabi EO, Ter Goon D, Adeniyi OV, Ajayi AI. Optimal waist circumference cut-off points for predicting metabolic syndrome among low-income black South African adults. BMC research notes. 2018;11(1):22.
27. Delavari A, Forouzanfar MH, Alikhani S, Sharifian A, Kelishadi R. First nationwide study of the prevalence of the metabolic syndrome and optimal cutoff points of waist circumference in the Middle East: the national survey of risk factors for noncommunicable diseases of Iran. Diabetes care. 2009;32(6):1092-7.

Table 1: Characteristics of the included studies in meta-analysis

Reference	MetS criteria use for analysis	Area under investigation	Age Range Mean (SD) age M/W	Type of Study and sampling	Sample size M/W	Prevalence of Mets M/W	Men's optimum cut-off	Women's optimum cut-off	Sensitivity M/W	Specificity M/W	AUC M/W
Sharifi F., et al., 2008 (15)	Modified NCEP ATP III	Zanjan city	>20 38±17/37.6±16	Cross-sectional with stratified, multistage cluster sampling	1593/1684	0.23/0.24	87	82	59.9/68.7	69.5/68	-
Gozashti MH., et al., 2013 (16)	NCEP ATP III	Kerman city	>15 47±16/45±14.7	Cross-sectional population based with single stage cluster random sampling	2366/2966	0.48/0.31	89	86	65.2/61.9	68.8/71.1	0.72/0.73
Esteghamati A., et al., 2008 (17)	IDF	Tehran city	>18 47.7±13.6/45±14.45	Cross-sectional with Convenient sampling	1046/1706	0.26/0.28	91.5	85.5	77/86	58/50	0.71/0.73
Gharipour M., et al., 2013 (7)	NCEP ATP III	Isfahan, Arak, and Najafabad cities	≥35 57.6±9.9/55.2±8.8	Cross-sectional with Two stage cluster random sampling	236/232	0.34/0.48	90	90.3	82.9/86.6	51.9/68.3	0.78/0.85
Talaei M., et al., 2012 (5)	Modified NCEP ATP III	Isfahan, Arak, and Najafabad cities	≥35 51±11.9/50.3±11.3	Population-based, prospective longitudinal with multistage random sampling	3068/3255	0.61/0.51	92.8	97.8	65.5/58.8	60.1/65.5	0.68/0.65
Shahbazian H., et al., 2015 (18)	IDF, ATP III and INCO	Ahvaz city	>20 44.2±14.2/40.5±13.5	Cross-sectional with cluster random sampling	439/491	0.14/0.28	91.5	85.5	61/61	65/65	0.65/0.72
Kalantari F., 2014 (19)	ATP III	Minoodar, Qazvin	>20	Cross-sectional with multi stage cluster random sampling	529/578	0.19/0.29	92.5	92.5	50/50	72/72	0.725/0.642
Sharifi, F., et al. 2009 (20)	IDF, NCEP	Kahrizak	>60	Cross-sectional	42/52	0.11/0.48	94.5	90.5	77/59, 75/48	83/63, 79/57	0.83/0.7

NCEP ATP: National Cholesterol Education Program's Adult Treatment Panel; IDF: international diabetes federation; INCO: Iranian National Committee of Obesity; AUC: Area under ROC curve; M/W: Men/Women

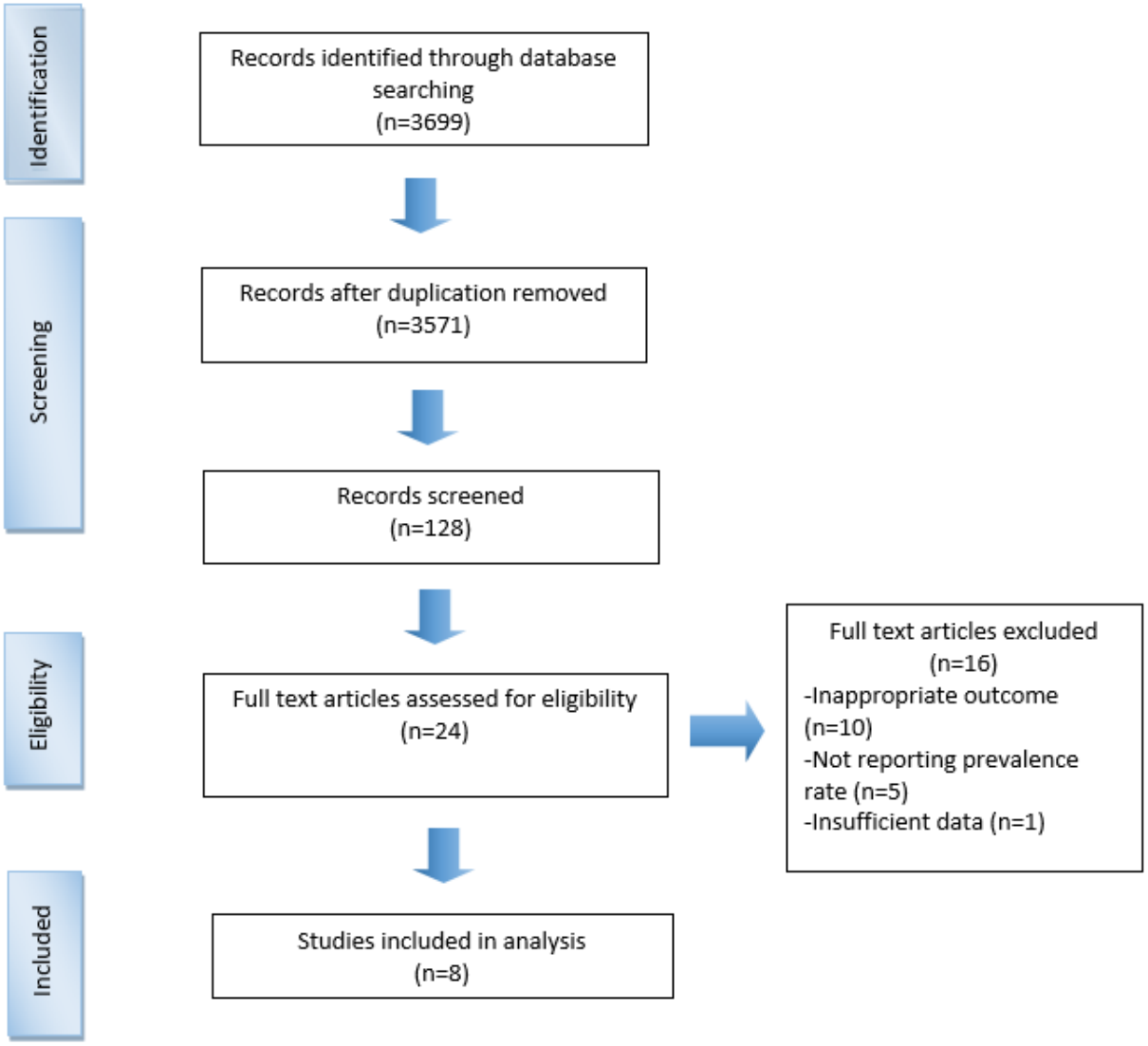


Figure 1: Flow chart of study selection following PRISMA guidelines.

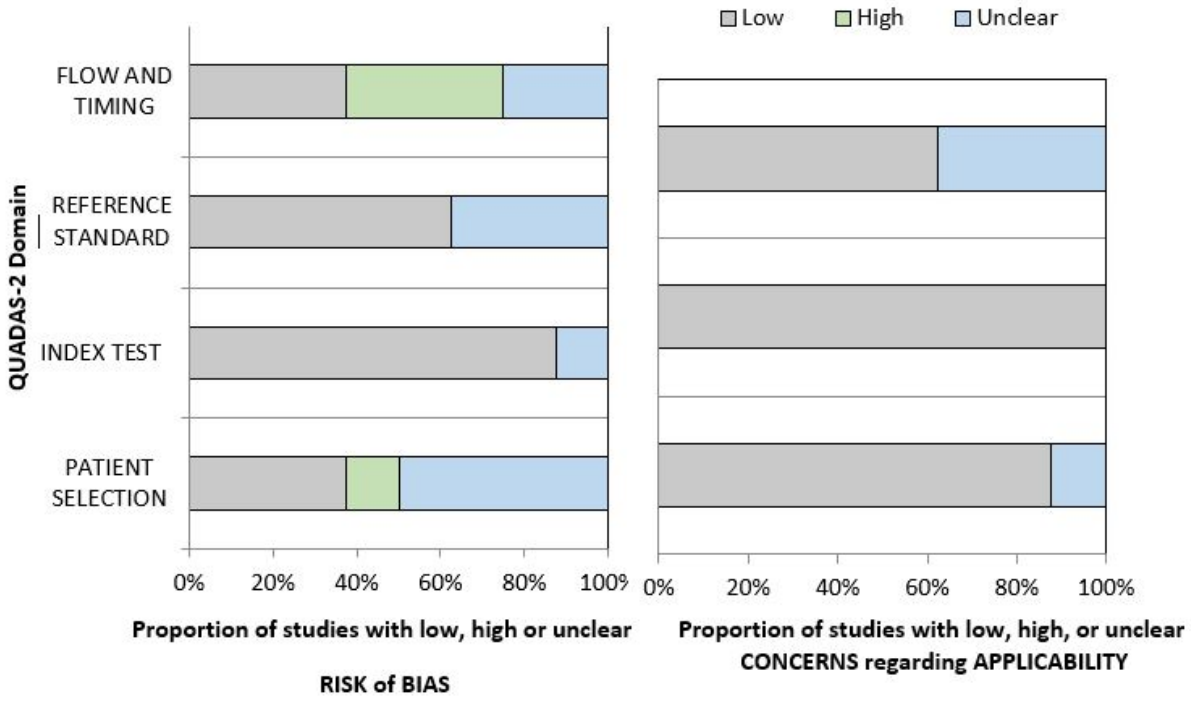
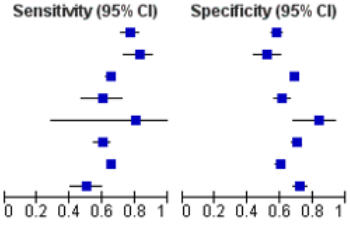


Figure 2: Methodological quality graph depicting the cumulative findings of the methodological quality analysis.

Study	TP	FP	FN	TN	cut-off value	Sensitivity (95% CI)	Specificity (95% CI)
Esteghamati AR., et al., 2008	217	321	65	443	91.5	0.77 [0.72, 0.82]	0.58 [0.54, 0.62]
Gharipour M., et al., 2013	68	74	14	80	90.0	0.83 [0.73, 0.90]	0.52 [0.44, 0.60]
Gozashti MH., et al., 2013	751	379	401	835	89.0	0.65 [0.62, 0.68]	0.69 [0.66, 0.71]
Shahbazian H., et al., 2015	38	149	25	234	91.5	0.60 [0.47, 0.72]	0.61 [0.56, 0.66]
Sharifi, F et al. kahrizak	4	6	1	31	87.0	0.80 [0.28, 0.99]	0.84 [0.68, 0.94]
Sharifi F., et al., 2008	229	364	153	846	94.5	0.60 [0.55, 0.65]	0.70 [0.67, 0.72]
Talaei M., et al., 2012	1229	476	647	716	92.5	0.66 [0.63, 0.68]	0.60 [0.57, 0.63]
Kalantari F., 2014	52	119	52	307	92.5	0.50 [0.40, 0.60]	0.72 [0.68, 0.76]



Study	TP	FP	FN	TN	cut-off value	Sensitivity (95% CI)	Specificity (95% CI)
Esteghamati AR., et al., 2008	411	614	67	614	85.5	0.86 [0.83, 0.89]	0.50 [0.47, 0.53]
Gharipour M., et al., 2013	97	38	15	82	90.3	0.87 [0.79, 0.92]	0.68 [0.59, 0.77]
Gozashti MH., et al., 2013	57	59	35	145	86.0	0.62 [0.51, 0.72]	0.71 [0.64, 0.77]
Shahbazian H., et al., 2015	87	122	55	227	85.5	0.61 [0.53, 0.69]	0.65 [0.60, 0.70]
Sharifi, F et al. kahrizak	12	12	13	15	90.5	0.48 [0.28, 0.69]	0.56 [0.35, 0.75]
Sharifi F., et al., 2008	28	41	13	87	82.0	0.68 [0.52, 0.82]	0.68 [0.59, 0.76]
Talaei M., et al., 2012	98	55	69	104	97.8	0.59 [0.51, 0.66]	0.65 [0.57, 0.73]
Kalantari F., 2014	86	114	86	293	92.5	0.50 [0.42, 0.58]	0.72 [0.67, 0.76]

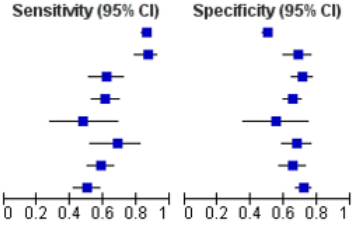


Figure 3: Forest plot of sensitivity and specificity of each index test reviewed studies and their confidence intervals in men (up) and Women (down).

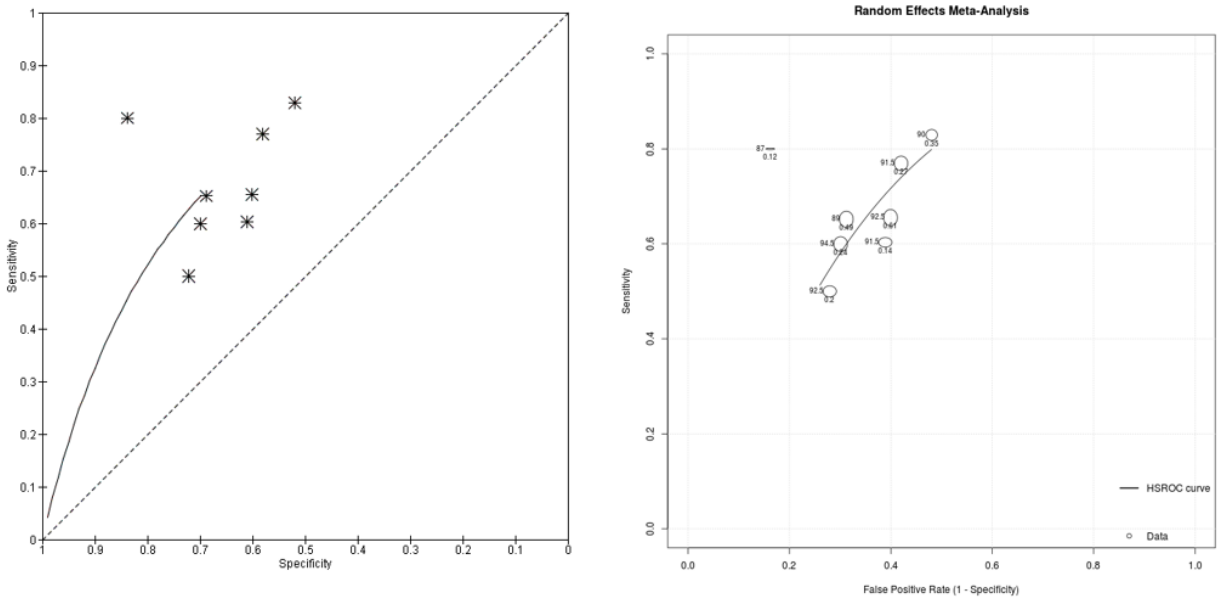


Figure 4: (Left) Hierarchical summary receiver operating characteristic (HSROC) curves summarizing the ability of Waist Circumference measurement to identify metabolic syndrome in men. (Right) ROC ellipses plot with confidence regions in men, which describe the uncertainty of the pair of sensitivity and false-positive rate. The size of the circles indicates the weight of each study. Studies indicated by cut points.

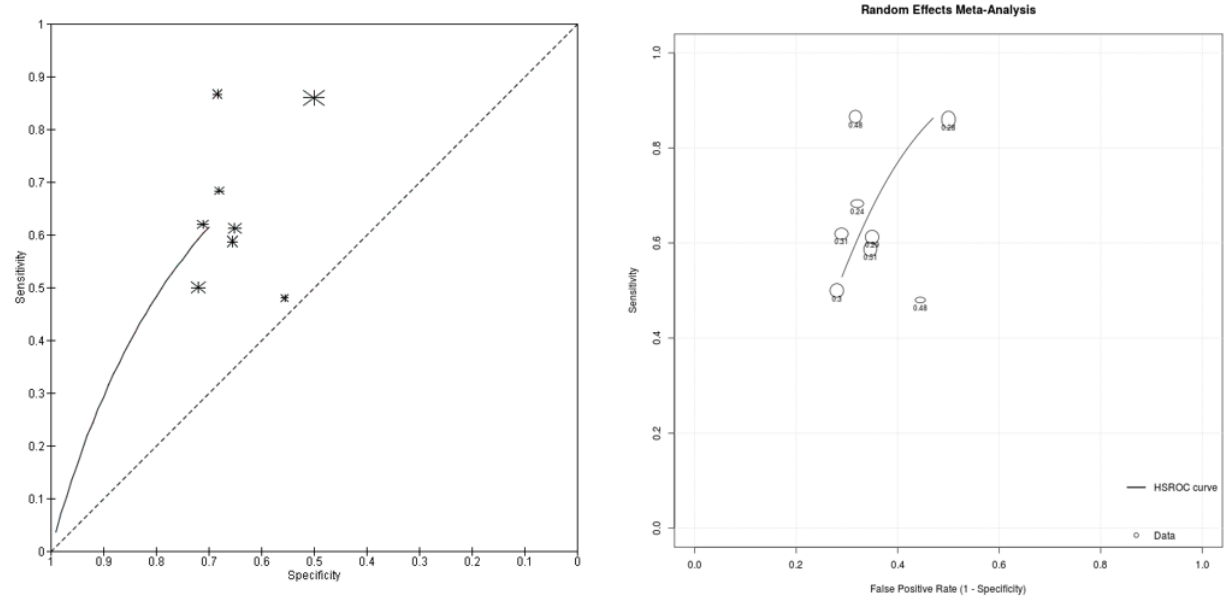


Figure 5: (Left) Hierarchical summary receiver operating characteristic (HSROC) curves summarizing the ability of Waist Circumference measurement to identify metabolic syndrome in women. (Right) ROC ellipses plot with confidence regions in women, which describe the uncertainty of the pair of sensitivity and false positive rate. The size of the circles indicates the weight of each study. Studies indicated by cut points.

Table 2: Meta-analysis of diagnostic accuracy under the HSROC model in men and women

	Women			Men		
	estimate	**Lower limit 95% CI**	**Upper limit 95% CI**	**estimate**	**Lower limit 95% CI**	**Upper limit 95% CI**
WC cut-off (cm)	89.24	89.13	89.36	90.55	90.51	90.60
Sensitivity	0.672	0.563	0.765	0.658	0.583	0.726
Specificity	0.651	0.599	0.701	0.647	0.593	0.697
False Positive Rate	0.349	0.299	0.401	0.353	0.303	0.407
Random Effects Correlation	-0.826			-0.913		
theta	-0.226			-0.074		
lambda	1.413			1.27		
beta	-0.8			-0.316		
sigma_theta	0.161			0.121		
sigma_alpha 0.061			0.022			
Diagnostic Odds Ratio	3.827	2.698	5.427	3.532	2.945	4.236
Likelihood Ratio +ve	1.927	1.712	2.169	1.865	1.716	2.026
Likelihood Ratio -ve	0.504	0.387	0.656	0.528	0.454	0.614
logit(sensitivity)	0.717	0.254	1.18	0.656	0.336	0.977
logit(specificity)	0.625	0.4	0.85	0.606	0.377	0.834