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The Association Normal Weight Central Obesity Hypertension in Adult – A Systematic Review and Meta-analysis

Yuanda Putri Rizki Ramadhani[1], Fahrani Husnun Nabila[2*], Canneysha Lathiefa Az zahra[3], Dini Ririn Andrias[4]

[1]Universitas Airlangga
[2]Universitas Airlangga
[3]Universitas Airlangga
[4]Universitas Airlangga

**Corresponding Author: yuanda.putri.rizki-2024@fkm.unair.ac.id*

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Abstrak (Times New Roman 10 pt, bold, centre)

Obesitas merupakan masalah kesehatan global yang signifikan dan umumnya dinilai menggunakan indeks massa tubuh. Namun, indikator ini memiliki keterbatasan dalam merefleksikan distribusi lemak tubuh, khususnya obesitas sentral yang berasosiasi kuat dengan risiko kardiometabolik. Individu dengan berat badan normal tetapi memiliki akumulasi lemak abdominal berlebih, yang dikenal sebagai normal weight central obesity (NWCO), memiliki risiko hipertensi yang meningkat meskipun sering tidak teridentifikasi. Penelitian ini bertujuan untuk melakukan tinjauan sistematis dan sintesis bukti terkini mengenai hubungan antara NWCO dan risiko hipertensi pada populasi dewasa, dengan penekanan pada perbedaan berdasarkan jenis kelamin. Penelusuran literatur dilakukan secara komprehensif melalui basis data utama menggunakan kata kunci yang relevan, dengan kriteria inklusi meliputi populasi dewasa, definisi NWCO berdasarkan indikator lingkar pinggang, serta pelaporan risiko hipertensi. Hasil analisis menunjukkan adanya hubungan yang signifikan antara NWCO dan hipertensi pada pria maupun wanita, dengan estimasi risiko yang lebih tinggi pada pria. Perbedaan ini diduga berkaitan dengan mekanisme biologis, termasuk aktivitas lemak viseral dan faktor hormonal. Meskipun demikian, interpretasi hasil perlu mempertimbangkan keterbatasan seperti variasi definisi dan desain studi. Secara keseluruhan, NWCO berasosiasi dengan peningkatan risiko hipertensi, sehingga pengukuran lingkar pinggang memiliki implikasi penting dalam praktik klinis serta diperlukan penelitian lanjutan untuk memperkuat bukti kausalitas.

Keywords:
Hypertension, NWCO, NWO, Adult

Abstract *(Times New Roman 10 pt, bold, italics)*

Obesity is a significant global health problem and is commonly assessed using body mass index. However, this measure has limitations in reflecting body fat distribution, particularly central obesity, which is strongly associated with cardiometabolic risk. Individuals with normal body weight but excessive abdominal fat accumulation, known as normal weight central obesity (NWCO), have an increased risk of hypertension despite often remaining undetected. This study aims to conduct a systematic review and synthesize current evidence on the association between NWCO and the risk of hypertension in adult populations, with a focus on sex-based differences. A comprehensive literature search was performed using major databases with relevant keywords, applying inclusion criteria of adult populations, definitions of NWCO based on waist-related indicators, and reported hypertension risk. The analysis indicates a significant association between NWCO and hypertension in both men and women, with a higher estimated risk observed in men. These differences are likely related to underlying biological mechanisms, including visceral fat activity and hormonal factors. Nevertheless, the findings should be interpreted with caution due to limitations such as

variability in definitions and study designs. Overall, NWCO is associated with an increased risk of hypertension, highlighting the importance of waist circumference assessment in clinical practice and the need for further research to strengthen causal evidence.

Introduction

Obesity is recognized as one of the leading causes of morbidity and mortality worldwide. Traditionally, obesity has been defined using body mass index (BMI), with a BMI of ≥30 kg/m² classified as obese (1). However, recent findings have highlighted the limitations of BMI as a sole indicator of obesity, particularly its inability to capture fat distribution and body composition. Emerging evidence suggests that individuals with a normal BMI (18.5–24.9 kg/m²) but with increased abdominal fat a condition referred to as Normal Weight Central Obesity (NWCO) may face elevated risks for cardiometabolic disorders, including hypertension (2).

NWCO represents a unique and often overlooked phenotype in which individuals appear to be of normal weight according to BMI, but have excess visceral fat, particularly around the waist (3). Unlike general adiposity, visceral fat has been shown to play a more significant role in elevating blood pressure through mechanisms beyond standard metabolic pathways, such as activation of the sympathetic nervous system and the renin–angiotensin–aldosterone system (RAAS) (4). These pathways contribute to vascular resistance and sodium retention, thus increasing the risk of developing hypertension.

The rising prevalence of sedentary lifestyles, high consumption of processed foods, and stress-related behaviors have led not only to an increase in general obesity but also in hidden forms of adiposity such as NWCO (5). Despite their normal BMI, individuals with NWCO may remain undiagnosed and untreated because BMI screening fails to reflect their true cardiovascular risk (6). Consequently, these individuals are often excluded from early intervention programs, allowing the condition to progress to more severe forms of cardiovascular disease.

At the moment, few systematic reviews and meta-analyses have comprehensively examined the association between NWCO and hypertension. This study aims to fill that gap by synthesizing current evidence on the risk of hypertension among individuals with normal BMI but elevated waist circumference, compared to those with normal BMI and healthy fat distribution. The findings are intended to inform public health policy and encourage the routine inclusion of waist circumference measurements alongside BMI in clinical and community health assessments.

Methods

Study Design and Search Strategy

This study was conducted as a systematic review and meta-analysis following established methodological standards. A comprehensive literature search was performed in PubMed and

Scopus to identify relevant studies on the association between normal weight central obesity (NWCO) and hypertension. Predefined keywords and MeSH terms were used, including "adult", "central obesity", "abdominal obesity", "visceral adiposity", "waist circumference", "normal weight", and "hypertension", combined using Boolean operators (AND/OR). Additional studies were identified through manual screening of reference lists.

Eligibility Criteria

Studies were included if they: (1) involved adults aged 18–65 years, (2) defined NWCO based on normal BMI (18.5–24.9 kg/m²) with central obesity assessed using waist-related indicators, and (3) reported the association between NWCO and hypertension. Studies were excluded if they did not report effect estimates, involved non-adult populations, or were reviews, case reports, or animal studies.

Study Selection and Data Extraction

Two reviewers independently screened titles, abstracts, and full texts against the eligibility criteria. Disagreements were resolved through discussion. Data were extracted using a standardized form, including study characteristics, participant demographics, and hypertension outcomes. Effect estimates (odds ratios or relative risks) with 95% confidence intervals were recorded.

Statistical Analysis

A random-effects model was applied to pool effect estimates. Relative risks were converted to odds ratios where necessary. Heterogeneity was assessed using the I^2 statistic, with values >50% indicating substantial heterogeneity. Subgroup and sensitivity analyses were conducted to explore heterogeneity and assess robustness. Publication bias was evaluated using funnel plots and Egger's test. The overall quality of evidence was assessed using the GRADE approach. Statistical analyses were performed using R and Stata, with $p < 0.05$ considered statistically significant.

Results

Characteristics of The Included Study

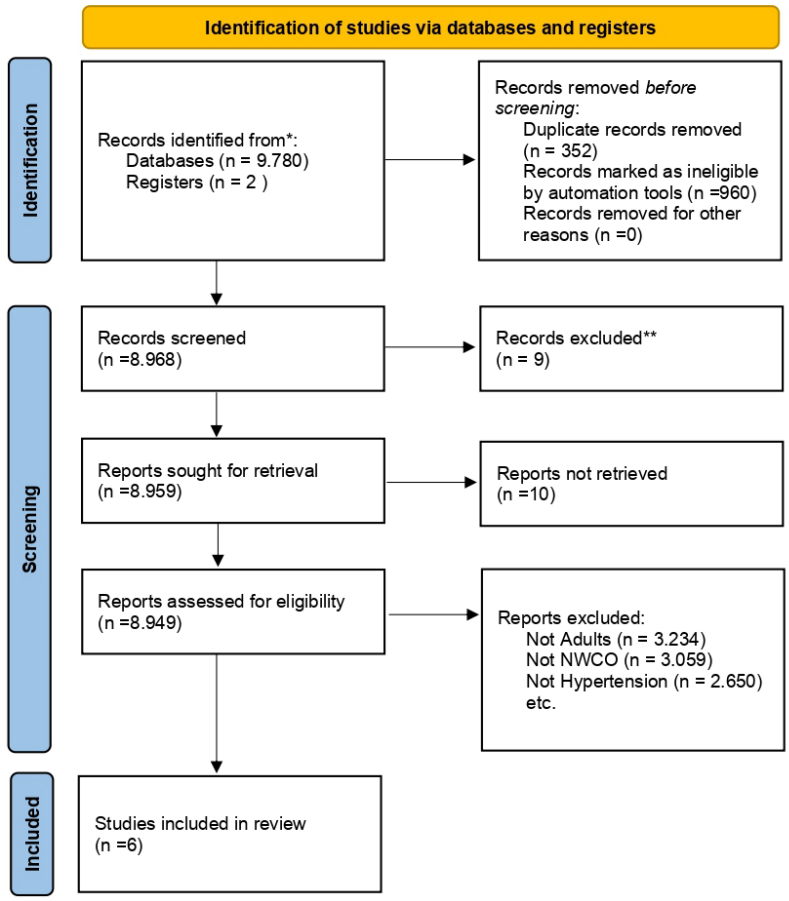

Figure 1. Prisma Included of Study

The process of selecting studies for this meta-analysis began with the identification of a total of 9,782 records, which were sourced from databases (9,780) and registers (2). Following the removal of duplicate records (352) and those marked as ineligible by automation tools (960), 8,968 records remained for screening. After an initial screening of titles and abstracts, 9 records were excluded due to irrelevant content or other factors, leaving 8,959 reports for retrieval. However, 10 reports were not retrievable, and after assessing eligibility, 8,949 reports were reviewed for inclusion in the meta-analysis.

The eligibility assessment led to the exclusion of several studies. A significant number of records were excluded for not meeting the adult population requirement (3,234 records), while others were excluded for not focusing on normal weight central obesity (NWCO) (3,059 records) or hypertension (2,650 records). These exclusions ensured that only studies that examined the association between NWCO and hypertension in adults were included in the final analysis.

After applying these rigorous inclusion and exclusion criteria, 6 studies were deemed eligible and were included in the final review. These studies represent the most relevant and high-quality evidence on the relationship between NWCO and hypertension in adults, providing a foundation for the subsequent meta-analysis.

Table 1. Data Extraction Form for Included Systematic Reviews & Meta-Analysis

No	Author	Country	Study Population	Study Design	Sample Size	Type of Measurement	Pooling Data	Outcome	Result
1.	Ahmed et al. (2025)	Autralia	Adults (≥18 tahun)	Cross-sectional	4,864	● BMI normal (18.5–24.9). BB diukur menggunakan timbangan digital portable dan TB diukur dengan stadiometer portable. ● WC ≥ 102 cm (♂) / ≥88cm (♀)	OR	Cardiometabolic disorders (T2DM, hypertension, cholesterol, heart disease)	• ♀ NWCO: Hypertension OR=3.29 (1.95–9.62). • ♂ NWCO: Hypertension OR= 4.81 (1.80-12.81)
2.	Das et al. (2023)	India	Adults (≥45 tahun)	Cross-sectional	54,016	• BMI normal: 18.5–24.9 kg/m² (digital scale) • WC ≥ 102 cm (♂) / ≥88cm (♀)	OR	Hypertension	• ♂ NWCO: OR=1.57 (95% CI: 1.45–1.67) • ♀ NWCO: OR=1.53 (95% CI: 1.43–1.63)
3.	Das Gupta (2025)	India	Dewasa usia 20–54 tahun (NFHS-5 2019–2021)	Cross-sectional	637,891 (78.832 pria, 559.059 wanita)	• BMI normal: 18.5–24.9 kg/m²	OR	Hypertension	• ♂ NWCO: OR=4.71 (95% CI: 4.60-4.82) • ♀ NWCO: OR= 1.46

						• WHR >0.90 (pria), >0.85 (wanita).			(95% CI: 1.43–1.49)
4.	Gao (2016)	China	Adults ≥35 tahun	Cross-sectional	1,275	• BMI normal: 18.5–24.9 kg/m² • WHR >0.90 (pria), >0.85 (wanita).	OR	Hypertension	• ♂ NWCO: OR= 62.18 (18.37-210.42) • ♀ NWCO: OR= 1.13 (95% CI: 1.06–1.21)
5.	Gupta (2024)	Afghanistan, Bangladesh, Bhutan, Nepal, Sri Lanka	Dewasa 18–69 tahun (WHO STEPS data)	Cross-sectional (national surveys)	24,413	• BMI (Asia cutoff: Normal (18.5–22.9 kg/m²) • WC: ♂ ≥90 cm, ♀ ≥80 cm	OR	Hypertension	• ♂ NWCO: OR= 5.42 (95% CI: 3.26–9.00) • ♀ NWCO: OR= 1.97 (95% CI: 1.44–2.70)
6.	Yogesh (2024)	India	20-60 years	Cross-Sectional	490	• BMI normal: 18.5–24.9 kg/m² • WHR >0.90 (pria), >0.85 (wanita).	OR	Hypertension	• ♂ NWCO: OR= 33.12 (95% CI: 12.43-88.23) • ♀ NWCO: OR= 1.60 (95% CI: 0.55–4.64)

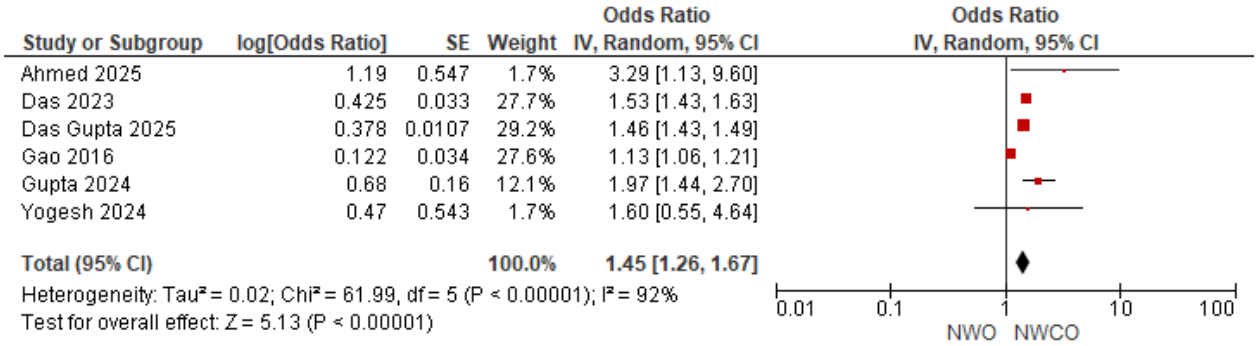

Figure 2. Forest Plot OR value on Female

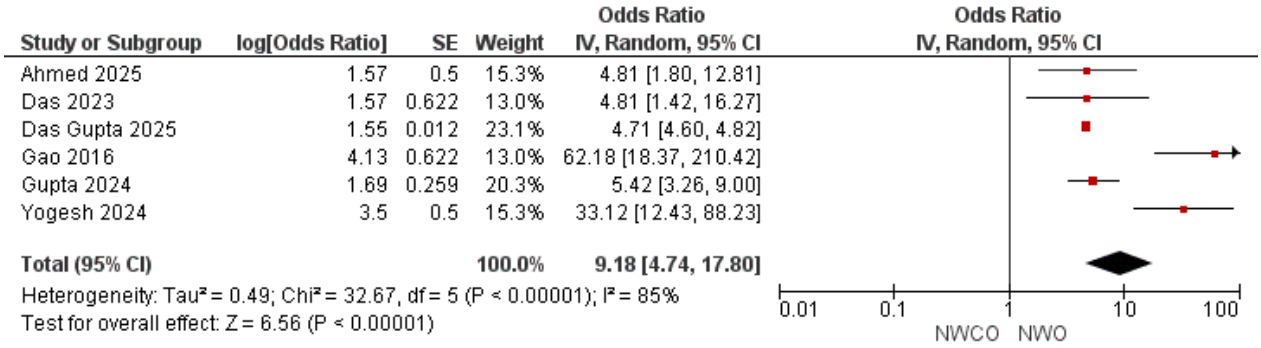

Figure 3. Forest Plot OR value on Male

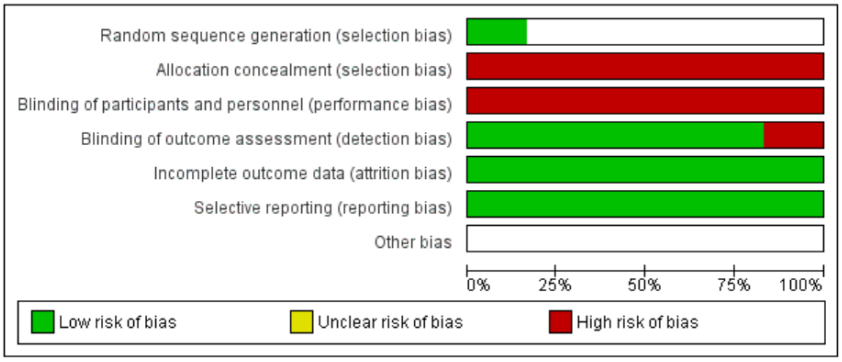

Figure 4. Risk of Bias Graph

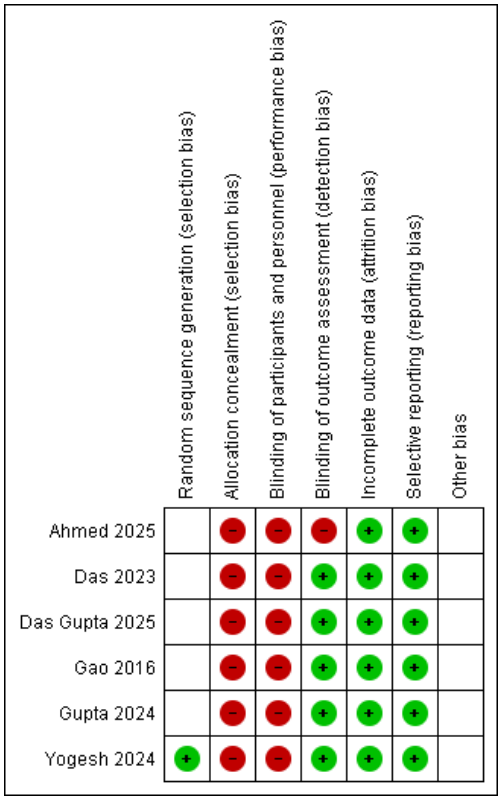

Figure 5. Risk of Bias Summary

Associations Between Norwal Weight Central Obesity and Hypertesion in Female

Figure 2 presents the forest plot summarizing the odds ratios (ORs) for the association between normal weight central obesity (NWCO) and hypertension among females across six cross-sectional studies (7) (8) (9) (10) (11) (12). The pooled analysis indicates a significant positive association, with a combined odds ratio of 1.45 (95% CI: 1.26–1.67), suggesting that women with NWCO are 45% more likely to develop hypertension compared to their non-NWCO counterparts. Individual studies reported varying effect sizes. For instance, Ahmed showed the strongest association with an OR of 3.29 (1.13–9.60) (7), while Yogesh reported a weaker and statistically non-significant association OR = 1.60 (0.55–4.64) (12). Despite the variability in individual estimates, the overall effect was statistically significant ($p < 0.00001$).

The heterogeneity analysis indicated substantial between-study variability (**$I^2 = 92\%$**), suggesting that differences in study design, population characteristics, or measurement methods

may have influenced the results. Nonetheless, the consistent direction of the association across studies reinforces the potential link between NWCO and elevated hypertension risk in females.

Association Between Norwal Weight Central Obesity and Hypertension in Males

Figure 3 displays the forest plot summarizing the association between normal weight central obesity (NWCO) and hypertension among males across six cross-sectional studies (7) (8) (9) (10) (11) (12). The pooled odds ratio (OR) is 9.18 (95% CI: 4.74–17.80), indicating that men with NWCO are over nine times more likely to develop hypertension compared to those without central obesity despite having a normal BMI. This association is statistically significant ($p < 0.00001$).

Several individual studies reported notably high odds ratios. Gao reported the highest estimate (OR = 62.18; 95% CI: 18.37–210.42), followed by Yogesh (OR = 33.12; 95% CI: 12.43–88.23) (10) (12). Other studies, including Ahmed, Das, Das Gupta, and Gupta, also demonstrated significantly increased risks, with ORs ranging from 4.71 to 5.42 (7) (9).

However, substantial heterogeneity was observed across studies ($I^2 = 85\%$), indicating considerable variability in effect sizes. This heterogeneity may be attributed to differences in population characteristics, sample sizes, and measurement criteria.

Exploration of Heterogeneity

Although formal subgroup meta-analysis was not performed due to the limited number of studies, a qualitative exploration suggests several potential sources of heterogeneity. First, variations in population characteristics, including age distribution and ethnic background, may influence the association between NWCO and hypertension. Second, differences in sample sizes may contribute to variability, as studies with smaller samples (e.g., Ahmed and Yogesh) tend to report more extreme effect estimates. Third, inconsistencies in the measurement of central obesity, such as the use of different waist circumference cut-off points or alternative indices, may affect comparability across studies.

Despite the observed heterogeneity, the direction of the association was consistent across all included studies, with NWCO showing a positive relationship with hypertension. Therefore, while the pooled estimate indicates a strong association, it should be interpreted with caution. Further studies using standardized measurement criteria and larger sample sizes are needed to better understand the sources of heterogeneity and to strengthen the robustness of the findings.

Publication Bias

Figure 4 illustrates the risk of bias assessment across the included studies. The graph indicates a high risk of bias in several domains, particularly in allocation concealment (selection bias) and blinding of participants and personnel (performance bias), where 100% of studies were rated as high risk. Additionally, blinding of outcome assessment (detection bias) also showed a predominantly high risk, suggesting that outcome assessors may have been aware of participant status, potentially influencing results.

In contrast, random sequence generation and incomplete outcome data (attrition bias) were predominantly rated as low risk, reflecting adequate methodological handling in these areas. Likewise, selective reporting (reporting bias) appears to be well-controlled in most studies.

The overall pattern suggests a considerable performance and detection bias, likely due to the cross-sectional nature of most included studies and the inherent difficulty in blinding participants and outcome assessors in observational designs. These sources of bias may influence the internal validity of the findings and should be considered when interpreting the associations between normal weight central obesity and hypertension.

Figure 5 presents the risk of bias summary for the included studies. The assessment reveals that the majority of studies exhibit a high risk of selection bias, particularly in random sequence generation and allocation concealment, as all studies received high-risk ratings in these domains. This suggests that participant selection procedures may not have been adequately randomized or concealed, potentially affecting the internal validity of the findings.
In terms of performance bias, most studies were also rated as high risk due to the lack of blinding of participants and personnel, which is a common limitation in observational research. Similarly, detection bias related to the blinding of outcome assessment was found to be high in nearly all studies.

On a more positive note, all studies were rated as low risk for incomplete outcome data (attrition bias) and selective reporting (reporting bias), indicating that data handling and reporting practices were generally transparent and complete.
These findings highlight notable methodological weaknesses, particularly in blinding and randomization processes, which could introduce bias into the estimation of the association between normal weight central obesity and hypertension. As a result, the conclusions drawn from the included studies should be interpreted with caution.

DISCUSSIONS

This study demonstrates a significant association between normal weight central obesity (NWCO) and hypertension, with a notably stronger effect observed in men compared to women. The pooled estimates indicate that men with NWCO have a substantially higher risk of hypertension, whereas the association in women, although significant, is relatively weaker. These findings suggest that central fat accumulation, even in individuals with normal BMI, plays a critical role in increasing blood pressure, particularly among males.

The observed sex differences may be explained by biological mechanisms, including differences in fat distribution and hormonal profiles. Men tend to accumulate more visceral fat, which is metabolically active and strongly linked to increased blood pressure through mechanisms such as insulin resistance, inflammation, and activation of the renin angiotensin system. In contrast, women generally have higher subcutaneous fat distribution, which may confer a relatively lower cardiometabolic risk.

However, substantial heterogeneity across studies indicates that the strength of the association varies depending on study characteristics. Differences in population demographics, sample sizes, and measurement criteria for central obesity likely contributed to this variability. Despite this, the direction of the association remained consistent across studies, supporting the robustness of the overall findings.

Several limitations should be acknowledged. Most included studies were cross-sectional, limiting causal inference. In addition, variations in the definition of central obesity and the lack of direct statistical comparison between sexes may affect the interpretation of gender differences.Overall, these findings highlight the importance of assessing central obesity in individuals with normal BMI, particularly among men, and emphasize the need for longitudinal studies with standardized measurement approaches to better understand causal relationships.

Alignment with Previous Literature

Traditionally, BMI has been the standard index for assessing obesity-related health risk. However, it is now widely accepted that BMI alone does not adequately account for fat distribution, particularly visceral adiposity, which has a much stronger correlation with cardiovascular and metabolic disorders. Central obesity, typically measured by waist circumference or waist-to-height ratio, is therefore a more precise predictor of hypertension and cardiovascular risk, especially among individuals who would otherwise be considered healthy based on BMI standards.

A cross-sectional study utilizing data from the Longitudinal Aging Study in India (LASI), involving over 54,000 adults, found that NWCO was significantly associated with an increased risk of hypertension in both sexes, with adjusted odds ratios of 1.57 for men and 1.53 for women (8). Although NWCO was more prevalent among women (33.9%) than men (17.8%), men exhibited a slightly higher risk of hypertension, suggesting potential differences in physiological response or fat distribution. Similarly, a large-scale study conducted in Japan involving over 117,000 middle-aged adults reported that NWCO was associated with significantly higher odds of hypertension in both sexes, with adjusted odds ratios of 1.22 for men and 1.23 for women (13). While the magnitude of association was comparable, the overall cardiovascular risk burden may be higher in men due to additional risk factors such as smoking and alcohol use.

Moreover, evidence from the China H-type Hypertension Registry substantiated these sex-based disparities in arterial stiffness. NWCO was significantly associated with increased brachial-ankle pulse wave velocity (baPWV), with a more pronounced effect in men ($\beta = 39.87$) than in women ($\beta = 29.65$). The corresponding odds ratio for arterial stiffness was also higher in men (OR = 1.29) compared to women (OR = 1.18) (14). These findings suggest that the adverse vascular effects of central obesity may manifest more strongly in men despite similar BMI values, possibly due to differences in visceral fat volume and hormonal influences.Interestingly, although men with NWCO appear to have a higher relative risk of hypertension, the physiological consequences in women may be more severe once hypertension is established. Supriya et al. reported that hypertensive women with central obesity exhibited a pro-inflammatory adipokine profile, characterized by elevated levels of TNF-α and leptin and reduced adiponectin levels, indicating a greater inflammatory burden (15).

Further supporting these findings, a study among Sunni Muslims in North India reported that individuals with NWCO had higher systolic and diastolic blood pressure compared to those

without central obesity. Although this pattern was observed in both sexes, mean blood pressure levels were consistently higher among men with NWCO (16).

Despite the consistency of these findings, it is important to note that the current evidence is largely derived from observational studies, particularly cross-sectional designs, which limit the ability to establish causal relationships. Therefore, the observed associations should be interpreted with caution. Future research incorporating longitudinal, interventional, or experimental study designs is needed to better elucidate causal pathways and strengthen the evidence base.Overall, this body of evidence challenges the conventional reliance on BMI and underscores the importance of incorporating waist-based measurements into hypertension screening and prevention protocols. The observed sex differences likely reflect a combination of hormonal influences, lifestyle factors, and differences in fat distribution. Visceral fat, more commonly found in men, is metabolically active and strongly associated with endothelial dysfunction, insulin resistance, and inflammation, all of which are central to the pathogenesis of hypertension.

Potential Biological Mechanisms

Numerous studies have confirmed that normal weight central obesity (NWCO) is associated with an increased risk of hypertension in both sexes, but several lines of evidence suggest that men may be more adversely affected. For instance, Das et al. reported that although the prevalence of NWCO was higher among women in India, men exhibited a greater overall prevalence of hypertension (8). Furthermore, the adjusted odds ratio for hypertension associated with NWCO was slightly higher in men than in women, highlighting a potential sex-based vulnerability (8).

A plausible explanation for this disparity lies in the differential biological behaviour of visceral adipose tissue (VAT), which is the primary fat depot involved in central obesity. VAT is more metabolically active in men and secretes higher levels of pro-inflammatory cytokines, such as interleukin-6 (IL-6) and tumor necrosis factor-alpha (TNF-α), which contribute to endothelial dysfunction and activation of the sympathetic nervous system (14). These pathways can lead to vasoconstriction, increased arterial stiffness, and ultimately elevated blood pressure. Notably, the adverse vascular consequences of VAT appear to be more pronounced in men, potentially explaining their heightened hypertension risk in the context of NWCO (14).

Sex hormones further modulate these biological differences. Estrogen, which is predominant in premenopausal women, exerts protective cardiovascular effects through vasodilation, improvement of endothelial function, and favorable modulation of lipid metabolism (17). This hormonal milieu may offer a degree of resilience against the hypertensive effects of central adiposity in women. In contrast, testosterone in men has been implicated in promoting visceral fat deposition and enhancing sympathetic nervous activity, both of which can aggravate blood pressure regulation and cardiovascular strain (13).

In addition to hormonal influences, differences in fat distribution patterns between sexes contribute to the disparity. Men tend to accumulate fat viscerally (intra-abdominally), which is strongly associated with metabolic and cardiovascular dysfunction, whereas women especially before menopause accumulate more subcutaneous fat, particularly in gluteofemoral regions, which is considered metabolically benign or even protective (18). This anatomical distinction

in adipose tissue distribution may result in a greater hypertensive burden for men with NWCO, even at similar BMI levels.

Moreover, studies on vascular function have revealed that arterial compliance and pulse wave velocity both key indicators of arterial stiffness and independent predictors of hypertension are more adversely affected in men with NWCO compared to women (14). These findings suggest that vascular aging processes or early endothelial impairment may be more accelerated in men under conditions of central adiposity, further amplifying their risk of hypertension.

Beyond biological and physiological mechanisms, socio behavioral factors also play a contributory role. Men are generally more likely to engage in risk-enhancing behaviors such as tobacco use, excessive alcohol consumption, and poor dietary habits, which can interact synergistically with NWCO to compound cardiovascular risk (19). Additionally, lower health-seeking behavior among men may delay early detection and management of hypertension, thereby exacerbating the condition's progression.

Taken together, the intersection of biological vulnerability, hormonal regulation, adipose tissue distribution, vascular health, and behavioral patterns may underlie the disproportionately higher risk of hypertension observed in men with NWCO. These findings highlight the importance of sex-specific prevention strategies and the need for clinical awareness of NWCO as a distinct phenotype with varying implications across genders.

Limitation and Strength

This systematic review and meta-analysis present several notable strengths. First, the study employed a rigorous and comprehensive search strategy across multiple databases (PubMed and Scopus) using standardized keywords and MeSH terms, ensuring the inclusion of relevant literature from diverse populations and settings. The methodological quality of included studies was assessed using the Newcastle-Ottawa Scale, and sensitivity analyses were conducted to examine the robustness of the findings. Additionally, the application of a random-effects model and subgroup analyses enhanced the ability to account for heterogeneity across studies, while the use of the GRADE approach provided a transparent evaluation of the overall strength of evidence. The study also incorporated gender-specific analysis, which allowed for nuanced insights into the differential risk of hypertension among men and women with normal weight central obesity (NWCO).

Nevertheless, several limitations should be acknowledged. All included studies were cross-sectional in nature, precluding causal inference between NWCO and hypertension. The reliance on self-reported data in some studies may have introduced recall bias or misclassification. Significant heterogeneity was observed ($I^2 > 85\%$ in both gender-specific analyses), likely due to differences in central obesity definitions, measurement methods (waist circumference vs. waist-to-hip ratio), cut-off points, and population characteristics. Moreover, the predominance of studies from South and East Asia limits the generalizability of findings to other regions. High risk of performance and detection bias was identified in most studies due to lack of blinding, a common challenge in observational research. Finally, while sex-specific odds ratios were reported, the absence of formal interaction testing between sexes restricts

definitive conclusions about gender differences. Future longitudinal and interventional studies using standardized definitions and stratified analyses are needed to further elucidate these associations.

Conclusions

This systematic review and meta-analysis demonstrate that individuals with normal weight central obesity (NWCO) are at significantly increased risk of developing hypertension, with a stronger association observed in males. These findings underscore the inadequacy of BMI as a sole diagnostic criterion and support the incorporation of waist-based measurements into routine clinical assessments. However, the predominance of cross-sectional studies and considerable heterogeneity limit causal inferences. Future longitudinal research with standardized definitions and sex-stratified analyses is essential to strengthen the evidence base and guide targeted prevention strategies.

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