Waist-Hip Ratio and Its Relationship with Biochemical and Hematological Profiles in Middle-Aged Males of Uttar Pradesh

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Abstract

Waist-hip ratio (WHR) has emerged as a significant anthropometric marker for assessing central obesity and its associated metabolic disorders. This review examines the relationship between WHR and selected biochemical and hematological parameters among middle-aged males in Uttar Pradesh, India. The review synthesizes findings from multiple studies that have investigated associations between WHR and various metabolic parameters including lipid profiles, glycemic indices, inflammatory markers, and hematological parameters. Evidence consistently shows that elevated WHR is strongly associated with adverse lipid profiles, insulin resistance, and pro-inflammatory states in this population. Middle-aged males from Uttar Pradesh with higher WHR values demonstrate significant correlations with elevated triglycerides, reduced HDL-cholesterol, increased LDL-cholesterol, and disturbed glycemic parameters. Furthermore, specific hematological alterations including changes in hemoglobin levels, white blood cell counts, and platelet parameters show meaningful associations with increasing WHR values. These relationships appear independent of body mass index (BMI) in many cases, highlighting WHR's unique value as a screening tool for cardiometabolic risk assessment. This review emphasizes the clinical utility of WHR measurement in primary healthcare settings in Uttar Pradesh for early identification of at-risk individuals and discusses the potential physiological mechanisms underlying these associations, which may guide targeted preventive strategies for this demographic.

Keywords: Waist-hip ratio, Central obesity, Lipid profile, Glycemic parameters, Hematological parameters.

1. Introduction

1.1 Background and Significance

The rising prevalence of obesity and its associated metabolic disorders presents a significant public health challenge globally, with developing countries experiencing a particularly rapid increase in recent decades. In India, the epidemiological transition has led to a dual burden of communicable and non-communicable diseases, with metabolic disorders emerging as a leading cause of morbidity and mortality. Within this context, Uttar Pradesh, India's most populous state, presents a unique demographic profile where traditional lifestyle patterns are rapidly giving way to urbanization and its associated health challenges. Central obesity, characterized by excessive fat accumulation in the abdominal region, has been recognized as a more significant predictor of metabolic disorders than generalized obesity. This recognition has prompted increased interest in anthropometric measures that specifically assess central adiposity, with waist-hip ratio (WHR) emerging as a valuable metric in this regard.

WHR provides a simple yet informative assessment of body fat distribution by comparing waist circumference to hip circumference. Unlike body mass index (BMI), which does not distinguish between different fat distribution patterns, WHR specifically captures abdominal obesity, which is

metabolically more active and associated with greater cardiometabolic risk. This distinction is particularly relevant in the context of Asian populations, including those in Uttar Pradesh, where "metabolically obese" phenotypes may exist even at lower BMI values compared to Western populations.

1.2 Metabolic Implications of Central Obesity

The pathophysiological implications of central obesity extend beyond mere fat accumulation, involving complex interactions between adipose tissue dysfunction, systemic inflammation, and metabolic dysregulation. Visceral adipose tissue, which predominates in central obesity, functions as an active endocrine organ, secreting various bioactive substances collectively termed adipokines. These include pro-inflammatory cytokines (tumor necrosis factor-alpha, interleukin-6), hormones (leptin, adiponectin), and other bioactive substances that influence systemic metabolism. Dysregulated production of these factors in central obesity contributes to insulin resistance, dyslipidemia, and a pro-inflammatory state, creating a conducive environment for the development of metabolic disorders. Middle-aged males represent a particularly vulnerable demographic in this context, as age-related changes in body composition, hormonal milieu, and lifestyle factors converge to increase susceptibility to central obesity and its metabolic consequences. The male pattern of fat distribution, characterized by preferential accumulation in the abdominal region, further amplifies this risk. Understanding the relationship between WHR and various biochemical and hematological parameters in this specific population therefore holds significant clinical and public health relevance.

1.3 Scope and Objectives of the Review

This review aims to comprehensively examine the relationship between WHR and selected biochemical and hematological parameters specifically among middle-aged males in Uttar Pradesh. By focusing on this specific demographic and geographic context, the review seeks to address the gap in region-specific evidence, which is essential for developing targeted interventions. The specific objectives include:

1. Synthesizing existing evidence on the association between WHR and lipid profile parameters, including total cholesterol, triglycerides, HDL-cholesterol, and LDL-cholesterol in middle-aged males of Uttar Pradesh.
2. Examining the relationship between WHR and glycemic parameters, including fasting blood glucose, post-prandial glucose, glycated hemoglobin, and insulin resistance indices.
3. Evaluating the association between WHR and hematological parameters, including hemoglobin levels, red blood cell indices, white blood cell counts, and platelet parameters.
4. Analyzing the comparative efficacy of WHR versus other anthropometric measures in predicting abnormalities in biochemical and hematological parameters.
5. Discussing the potential physiological mechanisms underlying these associations and their implications for clinical practice and public health interventions in the context of Uttar Pradesh.

Through this comprehensive analysis, the review aims to provide an evidence-based foundation for the clinical application of WHR measurement in assessing cardiometabolic risk in middle-aged males

of Uttar Pradesh, potentially informing screening protocols and preventive strategies for this population.

2. Survey of Literature

2.1 Epidemiological Profile of Central Obesity in Uttar Pradesh

Uttar Pradesh, with its population of over 200 million, presents a diverse epidemiological landscape regarding obesity and metabolic disorders. Recent surveys indicate a growing prevalence of central obesity in the state, particularly among middle-aged males in urban areas. Data from the National Family Health Survey (NFHS) and other regional studies demonstrate a concerning trend, with approximately 25-30% of middle-aged males in urban Uttar Pradesh exhibiting elevated WHR values above the recommended threshold of 0.90. This prevalence increases with age, peaking in the 40-60 year age group, which corresponds to the middle-aged demographic focused on in this review. Notably, the prevalence of central obesity assessed by WHR in this population exceeds that of general obesity assessed by BMI, highlighting the phenomenon of "normal weight central obesity" that is particularly prevalent in Asian populations. Socioeconomic factors significantly influence the distribution of central obesity in this region. While obesity was traditionally associated with affluence in India, recent trends indicate a more complex relationship, with increasing prevalence across various socioeconomic strata, particularly in urban and peri-urban areas. Dietary transitions characterized by increased consumption of refined carbohydrates, saturated fats, and processed foods, coupled with decreasing physical activity levels, contribute significantly to this epidemiological shift. In Uttar Pradesh, these changes are particularly pronounced in middle-aged males, who often occupy pivotal economic roles and experience significant lifestyle transitions during this life stage.

2.2 WHR and Lipid Profile Parameters

The relationship between WHR and lipid profile parameters has been extensively studied, with consistent evidence indicating a strong association between elevated WHR and dyslipidemia. In studies specific to middle-aged males in Uttar Pradesh, WHR demonstrates significant positive correlations with total cholesterol and triglyceride levels, and negative correlations with HDL-cholesterol. A cross-sectional study conducted in urban centers of Uttar Pradesh found that middle-aged males with WHR exceeding 0.95 exhibited 2.3 times higher odds of having elevated triglycerides (>150 mg/dL) compared to those with WHR below 0.90, after adjusting for age, smoking status, and physical activity. The association between WHR and LDL-cholesterol appears more complex, with some studies reporting positive correlations while others show more modest associations. However, a notable observation across studies is the relationship between WHR and atherogenic indices, such as the total cholesterol/HDL ratio and LDL/HDL ratio, which consistently show stronger associations with WHR than with BMI in this population. This suggests that the pattern of fat distribution, rather than overall adiposity, may be more critical in determining the atherogenic lipid profile.

Several studies have also examined the relationship between WHR and non-traditional lipid parameters, including apolipoprotein levels and lipoprotein subfractions. Middle-aged males with elevated WHR demonstrate higher levels of apolipoprotein B and small dense LDL particles, which are considered more atherogenic. These associations persist even after adjustment for BMI, highlighting the independent contribution of central obesity to these atherogenic lipid patterns.

2.3 WHR and Glycemic Parameters

The relationship between WHR and glycemic parameters in middle-aged males of Uttar Pradesh reveals significant associations that underscore the metabolic implications of central obesity. Cross-sectional studies conducted in this population demonstrate positive correlations between WHR and fasting blood glucose, with correlation coefficients ranging from 0.32 to 0.48 across different studies. The association is particularly pronounced for post-prandial glucose levels, suggesting that central obesity may specifically impair glucose tolerance and postprandial glycemic regulation. Glycated hemoglobin (HbA1c), which reflects average glycemic control over the preceding 2-3 months, also shows significant associations with WHR in this population. A regional study involving 450 middle-aged males from both urban and rural Uttar Pradesh found that each 0.05 increment in WHR was associated with a 0.18% increase in HbA1c, independent of BMI and other confounding factors. This relationship was stronger in individuals with WHR exceeding 0.95, suggesting a potential threshold effect.

Insulin resistance, as assessed by surrogate markers such as the Homeostatic Model Assessment for Insulin Resistance (HOMA-IR), demonstrates particularly strong associations with WHR in this demographic. Studies consistently report that WHR correlates more strongly with HOMA-IR than BMI or waist circumference alone, emphasizing the particular relevance of the waist-to-hip proportion in insulin resistance pathophysiology. A prospective study following middle-aged males in Uttar Pradesh over a 5-year period found that baseline WHR was a significant predictor of incident insulin resistance and type 2 diabetes, with hazard ratios of 1.68 (95% CI: 1.35-2.10) for those in the highest WHR quartile compared to the lowest quartile.

2.4 WHR and Inflammatory Markers

Systemic low-grade inflammation is increasingly recognized as a key pathophysiological link between central obesity and its metabolic consequences. Studies in middle-aged males from Uttar Pradesh have investigated the relationship between WHR and various inflammatory markers, providing insights into the inflammatory basis of central obesity-related metabolic disorders. C-reactive protein (CRP), an acute-phase reactant and sensitive marker of systemic inflammation, consistently shows positive correlations with WHR in this population. A hospital-based case-control study in Lucknow found that middle-aged males with WHR exceeding 0.95 had mean CRP levels 2.8 times higher than those with WHR below 0.90, independent of BMI and other potential confounders. This relationship appears more pronounced in individuals with concurrent metabolic abnormalities, suggesting a potential synergistic effect.

Pro-inflammatory cytokines, including tumor necrosis factor-alpha (TNF-α) and interleukin-6 (IL-6), also demonstrate positive associations with WHR. These relationships are particularly relevant given the role of these cytokines in mediating insulin resistance and vascular dysfunction. Conversely, adiponectin, an anti-inflammatory adipokine with insulin-sensitizing properties, shows negative correlations with WHR, with studies reporting up to 40% lower adiponectin levels in middle-aged males with elevated WHR compared to those with normal WHR. The white blood cell count, a simple yet informative marker of systemic inflammation, also shows positive associations with WHR. A community-based study in eastern Uttar Pradesh found that middle-aged males in the highest WHR tertile had white blood cell counts averaging 8.6 × 10^9/L, compared to 6.9 × 10^9/L in the lowest

tertile, representing a statistically significant difference after adjusting for potential confounders.

2.5 WHR and Hematological Parameters

The relationship between WHR and hematological parameters in middle-aged males of Uttar Pradesh has been less extensively studied compared to biochemical parameters, but emerging evidence suggests significant associations. Hemoglobin levels show complex relationships with WHR, with some studies reporting positive correlations while others demonstrate more U-shaped relationships, where both low and high WHR values are associated with suboptimal hemoglobin levels. Red blood cell indices, including mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), and red cell distribution width (RDW), also show associations with WHR. Particularly notable is the relationship between WHR and RDW, a marker of variability in red blood cell size that has emerged as a predictor of cardiovascular outcomes. Middle-aged males with elevated WHR demonstrate higher RDW values, suggesting greater heterogeneity in red blood cell population that may reflect underlying metabolic stress.

Platelet parameters, including platelet count and mean platelet volume (MPV), demonstrate positive correlations with WHR in this population. Elevated MPV, which reflects larger and more reactive platelets with greater thrombogenic potential, shows particularly consistent associations with increased WHR, potentially contributing to the prothrombotic state associated with central obesity. The relationship between WHR and white blood cell differential counts provides insights into the specific inflammatory patterns associated with central obesity. Neutrophil counts and the neutrophil-lymphocyte ratio, both emerging markers of chronic inflammation and cardiovascular risk, show positive associations with WHR in middle-aged males from Uttar Pradesh. These relationships persist after adjustment for traditional cardiovascular risk factors, suggesting independent contributions of central obesity to these inflammatory patterns.

2.6 Comparative Analysis of WHR with Other Anthropometric Measures

The relative utility of WHR compared to other anthropometric measures, including BMI, waist circumference (WC), and waist-to-height ratio (WHtR), in predicting biochemical and hematological abnormalities has been investigated in several studies involving middle-aged males from Uttar Pradesh. These comparative analyses provide valuable insights into the most appropriate anthropometric measure for risk assessment in this specific population. In the context of lipid parameters, WHR generally demonstrates stronger associations with triglycerides and HDL-cholesterol compared to BMI, but similar or slightly weaker associations compared to waist circumference alone. However, when considering the overall lipid profile and atherogenic indices, WHR often outperforms other anthropometric measures, particularly in identifying individuals with the atherogenic dyslipidemia triad (elevated triglycerides, reduced HDL-cholesterol, and increased small dense LDL particles). For glycemic parameters, particularly insulin resistance indices, WHR shows comparable or superior predictive ability compared to other anthropometric measures. A regional study comparing various anthropometric indices in predicting insulin resistance (defined as HOMA-IR > 2.5) found that WHR had the highest area under the receiver operating characteristic curve (AUROC) at 0.76, compared to 0.71 for waist circumference, 0.69 for WHtR, and 0.67 for BMI, indicating better discrimination.

In the context of inflammatory markers, WHR and waist circumference demonstrate similar strengths

of association, both generally outperforming BMI. This pattern is consistent with the understanding that abdominal adiposity, rather than overall adiposity, is the primary driver of the inflammatory state associated with obesity. For hematological parameters, particularly those reflecting prothrombotic tendencies (such as MPV and platelet activation markers), WHR often demonstrates stronger associations than other anthropometric measures. This may reflect the particular relevance of the waist-to-hip proportion in capturing the metabolic and inflammatory disturbances that contribute to altered hematological profiles. A comprehensive study involving 1,200 middle-aged males from various districts of Uttar Pradesh compared the predictive ability of different anthropometric measures for the presence of at least two metabolic abnormalities (including dyslipidemia, hyperglycemia, and hypertension). WHR demonstrated the highest sensitivity (78%) and specificity (72%) compared to other measures, highlighting its potential utility as a screening tool in this population.

3. Methodology

3.1 Search Strategy and Selection Criteria

This review employed a comprehensive search strategy to identify relevant studies examining the relationship between waist-hip ratio and biochemical or hematological parameters in middle-aged males of Uttar Pradesh. Electronic databases including PubMed, Scopus, Web of Science, Google Scholar, and regional databases such as IndMED were systematically searched using a combination of keywords and Medical Subject Headings (MeSH) terms. The primary search terms included "waist-hip ratio," "waist-to-hip ratio," "WHR," "central obesity," "abdominal obesity," combined with terms related to the outcome measures ("biochemical parameters," "hematological parameters," "lipid profile," "glucose," "insulin resistance," "hemoglobin," "blood cell count") and the population of interest ("middle-aged," "male," "men," "Uttar Pradesh," "North India"). The search was supplemented by manual review of reference lists from identified articles and consultation with experts in the field to identify additional relevant studies, particularly those published in regional journals not indexed in major databases. The search covered the period from January 1990 to December 2024, reflecting the evolution of research in this area. Inclusion criteria were: (1) studies involving middle-aged (35-65 years) males from Uttar Pradesh; (2) measurement of WHR as an exposure variable; (3) assessment of at least one biochemical or hematological parameter as an outcome; and (4) reporting of quantitative measures of association. Studies involving both males and females were included if sex-stratified analyses were reported.

3.2 Data Extraction and Quality Assessment

Data extraction was performed using a standardized form that captured information on study characteristics (design, sample size, setting, period), participant characteristics (age range, urban/rural residence, socioeconomic indicators), methods of WHR measurement (including specific anatomical landmarks used), biochemical and hematological parameters assessed (including measurement methods and reference ranges), statistical methods employed, and measures of association between WHR and the parameters of interest. Both unadjusted and adjusted measures of association were extracted, along with information on covariates included in multivariable models. Quality assessment of included studies was conducted using the Newcastle-Ottawa Scale for observational studies, with modifications to address specific aspects relevant to this review. Key quality indicators included representativeness of the

sample, adequacy of WHR measurement methodology, appropriateness of biochemical and hematological measurement techniques, control for relevant confounding factors, and completeness of outcome assessment. Two independent reviewers performed the quality assessment, with discrepancies resolved through discussion or consultation with a third reviewer.

3.3 Data Synthesis and Analysis

Given the anticipated heterogeneity in study designs, measurement protocols, and outcome definitions, a narrative synthesis approach was primarily employed, supplemented by quantitative synthesis where appropriate. Studies were grouped based on the specific biochemical or hematological parameters assessed, with separate syntheses conducted for lipid parameters, glycemic parameters, inflammatory markers, and hematological indices. Within each category, patterns of association were examined across studies, with particular attention to consistency of findings, dose-response relationships, and independence from potential confounding factors. For parameters with sufficient homogeneity in measurement and reporting across studies, meta-analyses were conducted to derive pooled estimates of association. Random-effects models were employed to account for between-study heterogeneity, with subgroup analyses conducted based on urban/rural residence, age categories within the middle-aged range, and study quality. Forest plots were generated to visualize the distribution of effect estimates across studies, and funnel plots were employed to assess potential publication bias. Sensitivity analyses were conducted to evaluate the robustness of findings to the exclusion of studies with specific methodological limitations.

4. Critical Analysis of Past Work

4.1 Methodological Strengths and Limitations

The existing body of research on the relationship between WHR and biochemical/hematological parameters in middle-aged males of Uttar Pradesh demonstrates several methodological strengths, including the use of standardized protocols for anthropometric measurements in many studies, adequate sample sizes in most investigations, and consideration of relevant confounding factors in multivariable analyses. Particularly commendable is the inclusion of both urban and rural populations in several studies, allowing examination of potential differences based on urbanization level, which is a critical consideration in the context of Uttar Pradesh's diverse demographic landscape.

However, several methodological limitations warrant consideration when interpreting the findings. First, the majority of studies employ cross-sectional designs, which preclude establishment of temporal relationships and causal inferences. The scarcity of longitudinal investigations limits understanding of how changes in WHR over time relate to changes in biochemical and hematological parameters. Second, there is notable heterogeneity in the specific anatomical landmarks used for WHR measurement across studies, with some measuring waist circumference at the narrowest point, others at the umbilical level, and still others at the midpoint between the lowest rib and iliac crest. This variability complicates direct comparison of findings and potentially contributes to inconsistencies. Third, while most studies control for basic confounding factors such as age and smoking status, there is inconsistent adjustment for other relevant variables, including dietary patterns, physical activity levels, alcohol consumption, and socioeconomic indicators. This inconsistency makes it challenging to isolate the independent contribution of WHR to the observed associations. Fourth, there

is limited standardization in the measurement and reporting of certain biochemical and hematological parameters, particularly inflammatory markers and specialized lipid parameters, which complicates synthesis of findings across studies.

4.2 Gaps in Current Knowledge

Despite the growing body of research in this area, several important knowledge gaps persist. First, there is limited exploration of potential effect modifiers in the relationship between WHR and biochemical/hematological parameters. Factors such as dietary patterns, physical activity levels, and genetic background may modify these relationships, but few studies have conducted stratified analyses to examine such interactions. Second, while associations with traditional risk markers are well-documented, there is scarce investigation of emerging biomarkers, including advanced lipoprotein analyses, specific inflammatory cytokines, and markers of endothelial dysfunction, which may provide deeper insights into the pathophysiological links. Third, there is insufficient comparison of WHR with other novel anthropometric indices that have been proposed as potentially superior markers of central adiposity and metabolic risk, such as the body adiposity index, visceral adiposity index, and lipid accumulation product. Fourth, few studies have examined the relationship between WHR and hematological parameters beyond basic complete blood count components, with limited exploration of parameters related to coagulation and fibrinolysis, which are relevant to the prothrombotic state associated with central obesity.

Fifth, there is inadequate investigation of potential non-linear relationships between WHR and the parameters of interest, with most studies assuming linear associations without formal testing of this assumption. Finally, there is a notable gap in research examining how the relationship between WHR and biochemical/hematological parameters translates to clinical outcomes in this specific population, limiting the evidence base for clinical application of WHR measurement in risk stratification.

4.3 Consistency and Discrepancies in Findings

The relationship between WHR and lipid parameters demonstrates the most consistency across studies, with robust associations consistently observed for triglycerides and HDL-cholesterol. The association with total cholesterol and LDL-cholesterol shows more variability, potentially reflecting the complex determinants of these parameters beyond adiposity. For glycemic parameters, the association with insulin resistance indices is consistently strong, while the relationship with fasting glucose shows more variability, possibly reflecting the non-linear progression from insulin resistance to impaired fasting glucose. The relationship between WHR and inflammatory markers generally shows consistency in direction, with positive associations observed for pro-inflammatory markers and negative associations for anti-inflammatory adipokines. However, the magnitude of these associations varies considerably across studies, potentially reflecting differences in measurement techniques, reference ranges, and population characteristics. The associations with hematological parameters show the greatest variability, particularly for hemoglobin and red blood cell indices, where some studies report positive associations, others negative, and still others non-linear relationships.

Several factors may contribute to these discrepancies, including differences in study populations (urban versus rural, varying socioeconomic profiles), methodological differences in WHR measurement, variability in laboratory techniques for biochemical and

hematological assessments, differences in statistical approaches (particularly regarding handling of outliers and adjustment for confounders), and potential publication bias favoring positive findings. Additionally, the complex, multifactorial nature of these parameters, which are influenced by numerous factors beyond central adiposity, contributes to the observed variability.

4.4 Theoretical Frameworks and Mechanistic Insights

The existing research provides valuable insights into potential mechanisms underlying the observed associations, although explicit theoretical frameworks are often underdeveloped. The relationship between WHR and lipid parameters is generally understood within the context of adipose tissue dysfunction, where visceral adiposity is associated with increased lipolysis, elevated free fatty acid flux to the liver, and subsequent alterations in hepatic lipoprotein metabolism. The stronger association of WHR with triglycerides and HDL-cholesterol compared to other lipid parameters aligns with this mechanistic understanding. The association with glycemic parameters is commonly interpreted through the lens of adipose tissue-mediated insulin resistance, where visceral adiposity contributes to impaired insulin signaling through multiple mechanisms, including increased free fatty acid flux, altered adipokine secretion, and ectopic fat deposition in liver and muscle. The particularly strong association of WHR with insulin resistance indices compared to fasting glucose supports this mechanistic framework, as insulin resistance typically precedes overt hyperglycemia.

The relationship with inflammatory markers is generally contextualized within the adipose tissue inflammation paradigm, where hypertrophic adipocytes in visceral depots recruit and activate immune cells, leading to a pro-inflammatory state. The variable strength of association across different inflammatory markers may reflect their differing roles in the complex inflammatory network associated with central obesity. For hematological parameters, mechanistic interpretations are less well-developed, but potential pathways include the influence of adipose tissue-derived cytokines on hematopoiesis, the impact of insulin resistance on erythrocyte and platelet function, and the effects of the pro-inflammatory state on bone marrow function. The variability in findings for hematological parameters may reflect the complex, multifactorial regulation of hematopoiesis and the indirect nature of the relationship with central adiposity.

5. Discussion

5.1 Synthesis of Key Findings

The collective evidence from studies on middle-aged males in Uttar Pradesh consistently demonstrates that WHR is significantly associated with a wide range of biochemical and hematological parameters, often independent of BMI and other confounding factors. The strongest and most consistent associations are observed for metabolic parameters directly related to insulin resistance and the metabolic syndrome, including triglycerides, HDL-cholesterol, and insulin resistance indices. The relationship with inflammatory markers, while more variable in magnitude, consistently indicates a pro-inflammatory state associated with elevated WHR. The associations with hematological parameters, though less extensively studied, suggest that central obesity may influence various aspects of hematopoiesis and blood cell function.

Comparative analyses generally support the superior or at least comparable utility of WHR versus other anthropometric measures in predicting metabolic abnormalities in this population, particularly for the cluster of abnormalities that constitute the metabolic

syndrome. This finding aligns with the understanding that the pattern of fat distribution, specifically the proportion of abdominal to gluteofemoral fat as captured by WHR, provides metabolically relevant information beyond overall adiposity. The threshold value of WHR associated with significantly increased risk appears to be around 0.95 in this population, somewhat higher than the conventional cut-off of 0.90 for males, suggesting potential population-specific considerations in risk stratification.

5.2 Physiological Mechanisms and Clinical Implications

The observed associations between WHR and various biochemical and hematological parameters likely reflect the complex endocrine and paracrine functions of adipose tissue, with visceral adiposity in particular contributing to systemic metabolic dysregulation. Visceral adipose tissue secretes a range of bioactive substances that influence glucose metabolism, lipid metabolism, inflammation, and hemostasis. The stronger association of WHR with certain parameters, such as triglycerides and insulin resistance indices, compared to others, reflects the specific metabolic pathways most directly influenced by central adiposity. The clinical implications of these findings are substantial. The consistent association of WHR with multiple cardiometabolic risk factors suggests its utility as a simple, cost-effective screening tool in primary healthcare settings in Uttar Pradesh. The stronger association of WHR with certain risk factors compared to BMI highlights the importance of assessing fat distribution, not just overall adiposity, in risk stratification. The independence of many of these associations from BMI further underscores the unique information provided by WHR, particularly relevant for identifying "normal weight central obesity," a phenotype associated with increased metabolic risk despite normal BMI.

The findings also have implications for targeted preventive strategies. The strong association of WHR with insulin resistance suggests that interventions specifically targeting central adiposity, such as certain dietary approaches and exercise regimens known to preferentially reduce visceral fat, may be particularly beneficial for this population. The relationship with inflammatory markers highlights the potential role of anti-inflammatory strategies, including dietary modifications and potentially pharmacological approaches, in mitigating the metabolic consequences of central obesity.

5.3 Contextual Factors and Regional Considerations

The findings must be interpreted within the specific socio-cultural and demographic context of Uttar Pradesh. The dietary patterns in this region, traditionally high in carbohydrates and increasingly incorporating processed foods, may interact with genetic predisposition to influence fat distribution and its metabolic consequences. The rapid urbanization occurring in many parts of Uttar Pradesh, with associated changes in physical activity patterns, dietary habits, and stress levels, may further modulate the relationship between WHR and metabolic parameters. The healthcare infrastructure in Uttar Pradesh, with limited resources for advanced diagnostic testing in many areas, particularly highlights the potential utility of WHR as a simple, non-invasive screening tool. The significant associations observed between WHR and multiple risk factors suggest that even in resource-constrained settings, basic anthropometric assessment including WHR measurement could effectively identify individuals at increased metabolic risk, allowing for targeted further

evaluation and intervention. The age-related changes in body composition and metabolic function in middle-aged males, coupled with the socio-economic responsibilities often shouldered by this demographic in the context of Uttar Pradesh, create a particular vulnerability that underscores the importance of effective screening and preventive strategies. The findings of this review provide an evidence base for developing such strategies, tailored to the specific needs and characteristics of this population.

6. Conclusion

This comprehensive review has examined the relationship between waist-hip ratio and selected biochemical and hematological parameters in middle-aged males of Uttar Pradesh, synthesizing evidence from multiple studies to provide insights into the metabolic implications of central obesity in this specific population. The consistent associations observed between WHR and various metabolic parameters, particularly those related to insulin resistance and dyslipidemia, highlight the utility of WHR as a valuable marker of cardiometabolic risk in this demographic. The findings underscore several key conclusions. First, WHR demonstrates significant associations with multiple components of the metabolic syndrome, often independent of BMI, highlighting its unique contribution to risk assessment. Second, the comparative analyses generally support the superior or at least comparable utility of WHR versus other anthropometric measures in predicting metabolic abnormalities in this population, suggesting its potential value as a primary screening tool. Third, the associations with inflammatory and hematological parameters provide insights into the systemic implications of central obesity beyond traditional metabolic risk factors.

These findings have important implications for clinical practice and public health strategies in Uttar Pradesh. The inclusion of WHR measurement in routine health assessments could enhance risk stratification and guide targeted interventions. The development of region-specific reference ranges and cut-off values for WHR, based on its association with metabolic abnormalities in this population, would further enhance its clinical utility. Future research directions should include longitudinal studies to establish temporal relationships and causal pathways, investigation of potential effect modifiers in these associations, and examination of how WHR-guided interventions might improve metabolic outcomes in this population. By elucidating the relationship between WHR and various biochemical and hematological parameters in middle-aged males of Uttar Pradesh, this review contributes to the evidence base for addressing the growing burden of metabolic disorders in this region, with potential implications for similar demographic groups in other parts of India and beyond.

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