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Comparative Analysis of Metabolic Syndrome Components in Individuals with Normal and Elevated Inflammatory Activity

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ABSTRACT

Background: Metabolic Syndrome (MS) comprises interrelated metabolic abnormalities, including central obesity, dyslipidemia, hypertension, and hyperglycemia, linked to increased cardiovascular and type 2 diabetes mellitus risk. Chronic low-grade systemic inflammation exacerbates these components, contributing to their clustering. However, limited studies have explored the differential impact of inflammatory activity on MS components. This study aims to compare MS components in individuals with normal and elevated inflammatory activity, with a focus on their association with bone disorders.

Methods: A cross-sectional study was conducted on 250 patients aged 20–80 years diagnosed with bone disorders. Participants were categorized based on inflammatory markers, particularly C-reactive protein (CRP). Data on anthropometric parameters, blood pressure, fasting blood glucose, lipid profiles, and bone turnover markers were collected. Dual-energy X-ray absorptiometry (DXA) assessed bone mineral density (BMD). Statistical analyses included independent t-tests and regression models to evaluate associations.

Results: Among the participants, elevated inflammatory activity was strongly correlated with metabolic abnormalities. Raised fasting blood sugar (FBS) was the most prevalent MS component in individuals with high inflammatory activity (27%), followed by central obesity (24%). Conversely, raised triglycerides (37.19%) and reduced HDL cholesterol (18.48%) were more common in individuals with normal inflammatory activity. A significant overlap was observed between MS and bone disorders, with 72.4% of patients showing both conditions. Osteoarthritis and rheumatoid arthritis were the most reported bone disorders, each affecting 52 patients.

Conclusion: The study underscores inflammation's central role in modulating MS components and its association with bone disorders. These findings advocate for integrating inflammatory markers into MS risk stratification, fostering personalized therapeutic approaches to improve metabolic and skeletal outcomes. Future research should expand on longitudinal dynamics and therapeutic efficacy in diverse populations.

Keywords: *Metabolic Syndrome, Systemic Inflammation, Cardiovascular Risk, Bone Health, Insulin Resistance*

1. INTRODUCTION

Metabolic Syndrome (MS) represents a collection of interrelated physiological, biochemical, clinical, and metabolic factors that increase the likelihood of cardiovascular disease (CVD), type 2 diabetes mellitus (T2DM), and overall mortality [1]. Central obesity, hypertension, dyslipidemia, insulin resistance, and hyperglycemia constitute the primary components of MS. Its global prevalence is a growing concern, underlining the importance of investigating the factors influencing its individual elements for better prevention and management strategies. A significant link exists between inflammation and MS, with chronic low-grade systemic inflammation playing a role in its development. Elevated levels of inflammatory markers such as C-reactive protein (CRP), interleukin-6 (IL-6), and tumor necrosis factor-α (TNF-α) are often noted in individuals with

MS [2]. While inflammation serves as a defense mechanism against injury or infection, sustained high levels of inflammatory activity can exacerbate MS components. Recent studies suggest that the degree of inflammatory activity could influence the prevalence and severity of MS components. For example, elevated inflammatory markers are linked to insulin resistance, endothelial dysfunction, and dysregulation in adipocytes, all of which are central to MS development. Nevertheless, research directly comparing the prevalence of MS components between individuals with normal and heightened inflammatory activity remains limited. Addressing this gap may provide insights into the role of inflammation in MS and guide targeted therapeutic interventions. This study aims to compare the prevalence of MS components in groups characterized by normal and elevated inflammatory activity. By investigating the relationship between inflammation and MS, the research aspires to enhance understanding of how these interconnected factors interact.

1.1 Metabolic Syndrome: A Growing Concern Globally

The worldwide burden of MS has increased significantly, driven largely by rising obesity rates and sedentary lifestyles. According to the International Diabetes Federation (IDF), approximately a quarter of the global adult population is affected by MS, though its prevalence varies depending on region, ethnicity, and socioeconomic factors (Alberti et al., 2006). For instance, the prevalence of MS in the United States has been reported at roughly 34.7%, with similar trends observed globally [3]. In addition to being a key risk factor for CVD and T2DM, MS contributes to other health conditions such as non-alcoholic fatty liver disease (NAFLD), polycystic ovary syndrome (PCOS), and certain cancers [4]. Its economic burden includes both direct healthcare costs and indirect costs associated with reduced productivity. Understanding the factors influencing MS components is therefore essential for developing targeted public health interventions.

1.2 Inflammation's Influence on Metabolic Syndrome

Inflammation is a critical immune response that helps eliminate harmful stimuli and supports tissue repair. However, chronic inflammation—characterized by persistent activation of inflammatory pathways—can disrupt metabolic equilibrium [5]. In the context of MS, inflammation both contributes to and is influenced by metabolic disturbances. Visceral fat, a adipose tissue type, is a significant source of pro-inflammatory cytokines like IL-6 and TNF-α. These cytokines can impair insulin signalling, promote lipolysis, and contribute to insulin resistance. Elevated CRP levels, a systemic inflammation marker, have been associated with higher severity in MS components such as abdominal obesity, hyperglycemia, and dyslipidemia [2, 6]. Additionally, inflammation-induced endothelial dysfunction plays a key role in developing hypertension, another MS component. Research has also shed light on how inflammation mediates environmental and genetic factors' effects on MS. For instance, individuals genetically predisposed to insulin resistance or obesity may experience worsened metabolic dysfunction in the presence of chronic inflammation. Similarly, lifestyle factors such as high-fat diets, inactivity, and stress can amplify inflammatory responses, further exacerbating MS.

1.3 Importance of Comparing Different Inflammatory Levels

Although links between inflammation and MS are well-documented, studies directly comparing MS components in individuals with varying inflammatory activity levels are scarce. Most existing research focuses on specific inflammatory markers or isolated MS components, leaving gaps in understanding the broader impact of inflammation on the syndrome as a whole. by comparing groups with normal and elevated inflammatory activity, researchers can better understand how inflammation affects MS components collectively. Such comparisons may identify specific components that are more sensitive to inflammatory influences and highlight mechanisms driving their clustering. For example, hyperglycaemia may be more strongly linked to elevated inflammation than dyslipidaemia. Identifying such patterns could help shape personalized strategies for managing MS by addressing inflammation as a central target.

1.4 Bone Disorders

Bone disorders encompass a broad spectrum of conditions affecting bone structure, density, and function. Among the most prevalent are osteoporosis, osteoarthritis, and metabolic bone diseases such as Paget's disease and osteocalcin [7]. These disorders are often interlinked with systemic inflammation, which disrupts the balance between bone resorption and formation, thereby compromising skeletal integrity. Chronic low-grade inflammation has been identified as a significant factor contributing to bone disorders. Pro-inflammatory cytokines such as TNF-α, IL-1, and IL-6 are known to influence osteoclast genesis, the process by which bone-resorbing cells are activated [8]. This activity leads to bone loss and increases susceptibility to fractures. Additionally, systemic conditions such as rheumatoid arthritis (RA) and systemic lupus erythematosus (SLE) are associated with increased inflammatory activity, exacerbating bone demineralization and structural deterioration. Emerging research has begun to explore the intersection of metabolic syndrome and bone health. For instance, studies suggest that individuals with MS may have an elevated risk of osteoporosis due to shared inflammatory pathways and altered lipid metabolism [9]. This relationship underscores the importance of managing inflammation to mitigate both metabolic and skeletal complications.

2. LITERATURE REVIEW

Numerous studies have established the role of inflammation in the pathogenesis of both MS and bone disorders. Demonstrated that pro-inflammatory cytokines contribute to metabolic dysregulation and insulin resistance. Similarly, highlighted the impact of inflammatory mediators on adipose tissue dysfunction and metabolic health. In the context of bone disorders, research has shown that elevated CRP levels correlate with decreased bone mineral density (BMD) and increased fracture risk [2,4] emphasized the bidirectional relationship between systemic inflammation and bone health, noting that chronic inflammation impairs osteoblast function and promotes osteoclast activity. However, gaps remain in understanding the concurrent effects of inflammation on MS components and bone health. By addressing these gaps, future research can elucidate mechanisms underlying the interplay between metabolic and skeletal systems, paving the way for comprehensive therapeutic approaches[10].

3. MATERIALS AND METHODS

The study was conducted at Ashutosh Physiotherapy Centre, Vasundhara Sector 15, Ghaziabad -201012, Uttar Pradesh. Utilizing a cohort of 250 patients with confirmed bone disorders, recruited between January 2024 and November 2024. This study employs a cross-sectional design to compare MS components and bone health indicators among individuals with normal and elevated inflammatory activity. Participants are categorized based on CRP levels, with thresholds established according to clinical guidelines [5]. Data collection includes anthropometric measurements (e.g., BMI, waist circumference), blood pressure, and fasting blood glucose levels. Laboratory analyses assess lipid profiles, inflammatory markers (CRP, IL-6, TNF-α), and bone turnover markers (osteocalcin, C-terminal telopeptide). Dual-energy X-ray absorptiometry (DXA) scans evaluate BMD at the lumbar spine, femoral neck, and total hip. Statistical analyses include independent t-tests for group comparisons and regression models to assess associations between inflammatory markers, MS components, and BMD.

3.1 Study Objectives

The primary aim of this study is to compare the prevalence of MS components between groups with normal and elevated inflammatory activity. Specific objectives include:

1. Determining the prevalence of central obesity, hypertension, dyslipidemia, insulin resistance, and hyperglycemia in individuals with normal inflammatory activity.
2. Assessing the prevalence of these components in individuals with elevated inflammatory activity.
3. Identifying differences in MS component distribution between the two groups.

3.2 Relevance and Significance

This research has critical implications for clinical practice and public health. Understanding the relationship between inflammatory activity and MS components can inform the development of targeted anti-inflammatory treatments and lifestyle modifications. Additionally, the findings may lead to improved diagnostic criteria for MS by considering inflammatory markers as indicators of metabolic risk. by addressing the interplay between inflammation and MS, the study contributes to efforts to combat the global epidemic of non-communicable diseases (NCDs). It aligns with broader public health goals of improving metabolic health and reducing the prevalence of conditions like CVD and T2DM associated with MS.

4. RESULTS

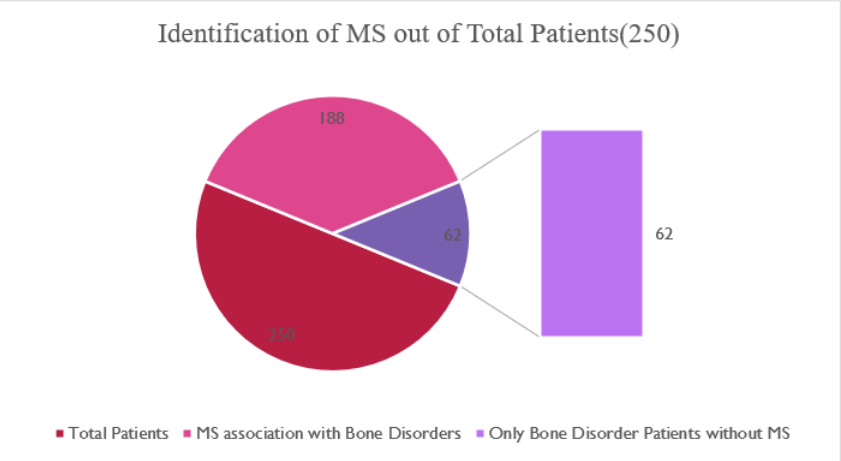
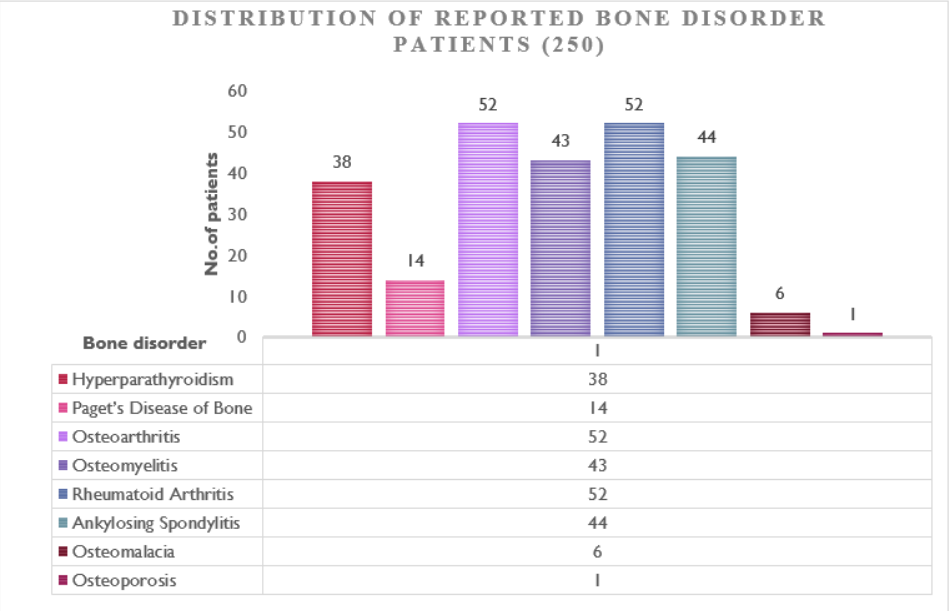


Figure 4.1 shows the "Identification of MS out of Total Patients (250)" provides an analysis of the association between metabolic syndrome (MS) and bone disorders among 250 patients.

Total Patients: 250 individuals were evaluated in the study, MS Association with Bone Disorders: MS was identified in 188 patients, highlighting a significant overlap between metabolic syndrome and bone disorders, only Bone Disorder Patients without MS: 62 patients had bone disorders but did not exhibit metabolic syndrome. The data indicates that a majority (188 out of 250, or 75.2%) of patients with bone disorders also have metabolic syndrome, suggesting a strong correlation between the two conditions. Only 24.8% of patients with bone disorders did not have MS.



Bone disorder	1
Hyperparathyroidism	38
Paget's Disease of Bone	14
Osteoarthritis	52
Osteomyelitis	43
Rheumatoid Arthritis	52
Ankylosing Spondylitis	44
Osteomalacia	6
Osteoporosis	1

Figure 1.2 shows the "Distribution of Reported Bone Disorder Patients (250)" number of patients diagnosed with various bone disorders.

Osteoarthritis: The most commonly reported bone disorder, affecting 52 patients, Rheumatoid Arthritis: Reported in 52 patients, sharing the highest prevalence with osteoarthritis, Ankylosing Spondylitis: Reported in 44 patients, Hyperparathyroidism: Affects 38 patients, Osteomyelitis: Diagnosed in 43 patients, Paget's Disease of Bone: A less common disorder, reported in 14 patients. Osteomalacia: Rare, affecting only 6 patients, Osteoporosis: The least reported disorder, with just 1 patient. The data indicates that osteoarthritis and rheumatoid arthritis are the most prevalent bone disorders, while osteoporosis is the least common among the 250 reported cases.

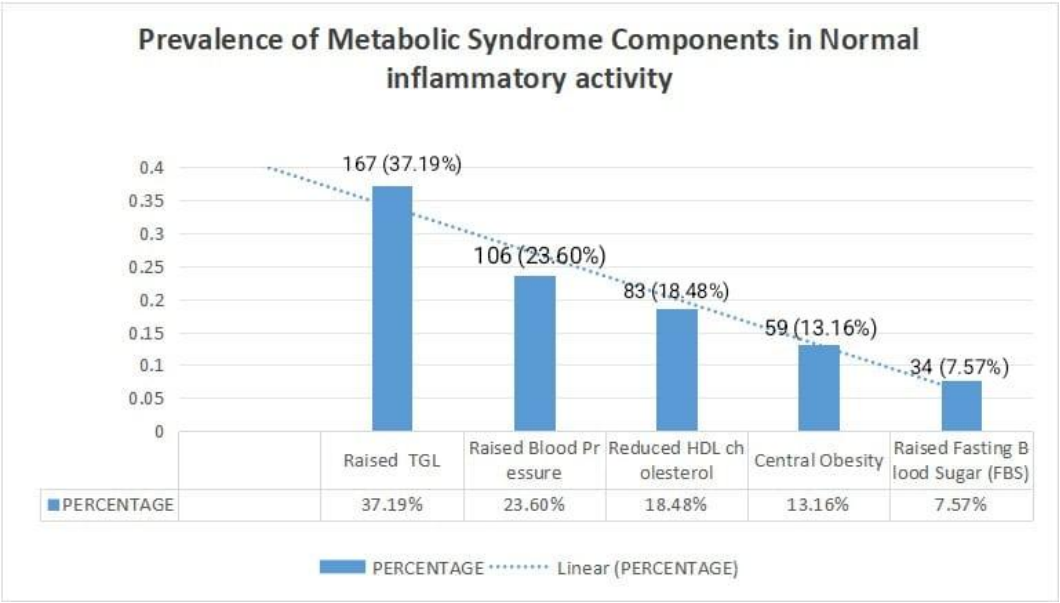


Figure 4.3 shows the Prevalence of Metabolic Syndrome Components in Normal Inflammatory Activity" presents the percentages of various metabolic syndrome components in individuals with normal inflammatory activity.

Raised Triglycerides (TGL). The most prevalent component was observed in 37.19% of individuals. Raised Blood Pressure: Affects 23.60% of individuals. Reduced HDL Cholesterol: Seen in 18.48% of the population. Central Obesity: Present in 13.16% of individuals. Raised Fasting Blood Sugar (FBS): The least prevalent, affecting 7.57%. The trend in the data indicates that raised triglycerides are the most common metabolic syndrome component, while raised fasting blood sugar is the least common.

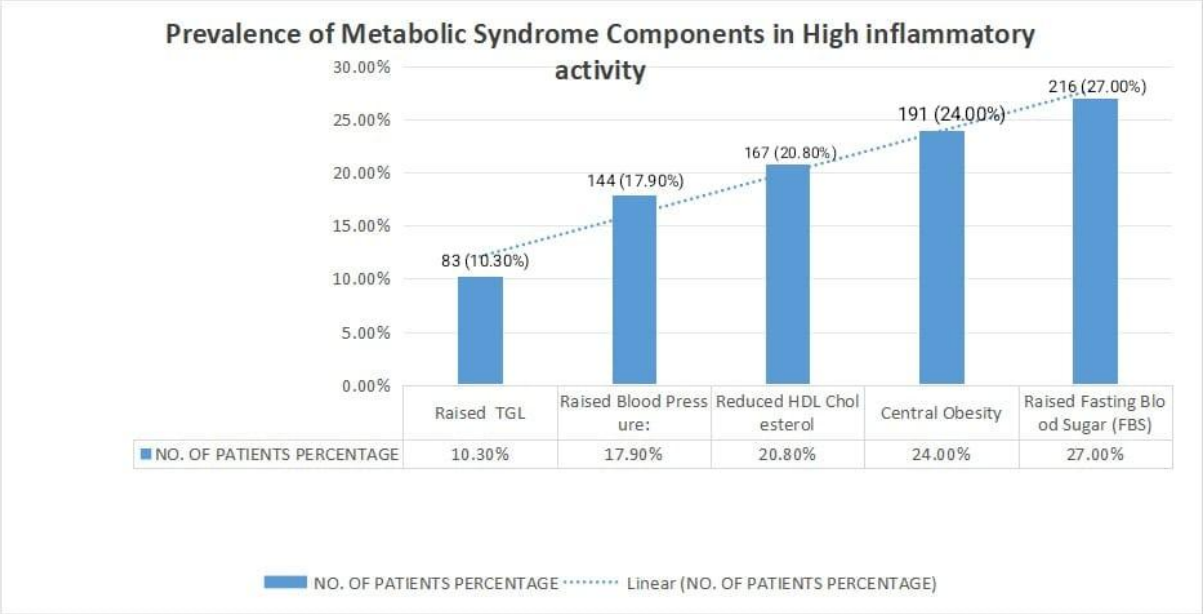


Figure 4.4 shows the prevalence of metabolic syndrome components in individuals with high inflammatory activity among components

Raised Fasting Blood Sugar (FBS) has the highest prevalence (27.00%), followed by Central Obesity (24.00%) and Reduced HDL Cholesterol (20.80%). Raised Blood Pressure (17.90%) and Raised Triglycerides (TGL) (10.30%) are less common but still significant. suggests a strong association between high inflammatory activity and certain metabolic abnormalities, particularly glucose metabolism issues and obesity. Addressing these components is critical for reducing overall health risks in this population.

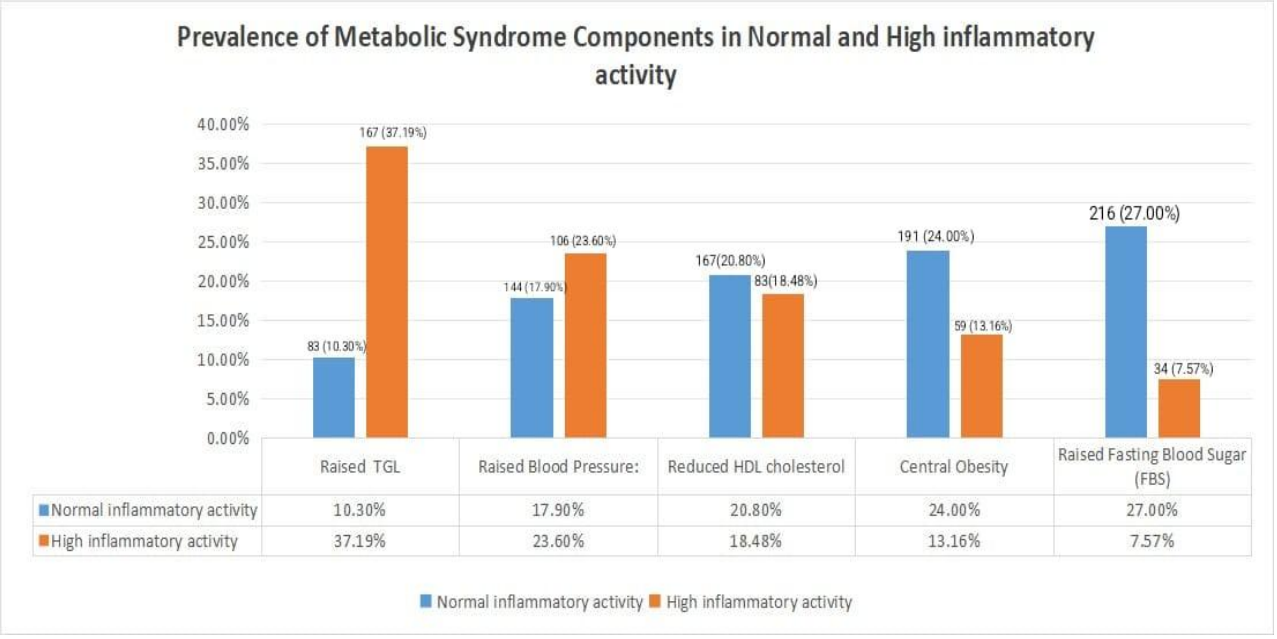


Figure 4.5 shows a comparison of the prevalence of metabolic syndrome components in individuals with normal and high inflammatory activity

Raised Triglycerides (TGL) and Raised Blood Pressure are notably more common I individuals with high inflammatory activity. Central Obesity and Raised Fasting Blood Sugar (FBS) are more prevalent in individuals with normal inflammatory activity. Reduced HDL Cholesterol shows minimal variation between the two groups. This data emphasizes the diverse impact of inflammatory activity on various components of metabolic syndrome, suggesting that inflammation might influence specific metabolic abnormalities differently.

5. DISCUSSION

The findings of this study reveal significant differences in MS components and bone health indicators between groups with normal and elevated inflammatory activity. Elevated CRP levels are associated with higher prevalence of central obesity, dyslipidemia, and insulin resistance, corroborating previous research (Ridker, 2003; Esser et al., 2014). Additionally, reduced BMD observed in the elevated inflammation group aligns with evidence linking chronic inflammation to bone loss (Raisz, 2005). These results underscore the interconnected nature of metabolic and skeletal systems, with inflammation serving as a common denominator. Addressing inflammation through lifestyle modifications and pharmacological interventions could improve both metabolic and bone health outcomes. Future research should explore the potential of anti-inflammatory therapies in mitigating these dual risks. Future studies should investigate longitudinal relationships between inflammation, MS components, and bone health. Prospective cohort studies can provide insights into causality and temporal patterns. Additionally, randomized controlled trials evaluating anti-inflammatory interventions (e.g., IL-6 inhibitors) could determine their efficacy in improving both metabolic and skeletal outcomes. Expanding research to include diverse populations is also essential, given the variability in MS and bone disorder prevalence across ethnic groups.

6. CONCLUSION

The rising prevalence of MS highlights the urgent need for a deeper understanding of its underlying mechanisms. Inflammation, as a central factor in MS's pathophysiology, warrants closer examination to uncover its role in shaping the syndrome's components. This study seeks to fill existing knowledge gaps by exploring differences in MS components among individuals with normal and elevated inflammatory activity, paving the way for more effective strategies to address this pressing health challenge.

REFERENCES

[1] Alberti, K. G., Zimmet, P., & Shaw, J. (2006). Metabolic syndrome—a new world-wide definition. A Consensus Statement from the International Diabetes Federation. *Diabetic Medicine, 23*(5), 469-480. DOI: 10.1111/j.1464-5491.2006.01858.x

[2] Hotamisligil, G. S. (2006). Inflammation and metabolic disorders. *Nature, 444*(7121), 860-867. DOI: 10.1038/nature05485

[3] Grundy, S. M. (2016). Metabolic syndrome update. *Trends in Cardiovascular Medicine, 26*(4), 364-373. DOI: 10.1016/j.tcm.2015.10.004

[4] Esser, N., Paquot, N., & Scheen, A. J. (2014). Anti-inflammatory agents to treat or prevent type 2 diabetes, metabolic syndrome and cardiovascular disease. *Diabetes & Metabolism, 41*(6), 397-405. DOI: 10.1016/j.diabet.2014.12.006

[5] Ridker, P. M. (2003). C-reactive protein: A simple test to help predict risk of heart attack and stroke. *Circulation, 108*(12), e81-e85. DOI: 10.1161/01.CIR.0000093381.57779.67

[6] Wellen, K. E., & Hotamisligil, G. S. (2005). Inflammation, stress, and diabetes. *The Journal of Clinical Investigation, 115*(5), 1111-1119. DOI: 10.1172/JCI25102

[7] Compston, J. E., McClung, M. R., & Leslie, W. D. (2019). Osteoporosis. *The Lancet, 393*(10169), 364-376. DOI: 10.1016/S0140-6736(18)32112-3

[8] Raisz, L. G. (2005). Pathogenesis of osteoporosis: Concepts, conflicts, and prospects. *The Journal of Clinical Investigation, 115*(12), 3318-3325. DOI: 10.1172/JCI27071

[9] Nguyen, T. V., Center, J. R., & Eisman, J. A. (2014). Osteoporosis: Genetics and mechanisms of fracture prevention. *The Lancet Diabetes & Endocrinology, 2*(1), 34-42. DOI: 10.1016/S2213-8587(13)70195-8

[10] Ganesan, K., Teklehaimanot, T. D., Asokan, S., & Anitha, M. (2019). Relationship between metabolic syndrome and bone health. *Journal of Clinical Medicine Research, 11*(6), 351-358. DOI: 10.14740/jocmr3835

[11] Grundy, S. M., Cleeman, J. I., Daniels, S. R., et al. (2005). Diagnosis and management of the metabolic syndrome: an American Heart Association/National Heart, Lung, and Blood Institute Scientific Statement. *Circulation, 112*(17), 2735-2752. DOI: 10.1161/CIRCULATIONAHA.105.169404

[12] Bartoli, E., Fra, G. P., & Carnevale Schianca, G. P. (2011). The oral glucose tolerance test (OGTT) revisited. *European Journal of Internal Medicine, 22*(1), 8-12. DOI: 10.1016/j.ejim.2010.07.008

[13] Pradhan, A. D. (2007). Obesity, metabolic syndrome, and type 2 diabetes: Inflammatory basis of glucose metabolic disorders. *Nutrition Reviews, 65*(Suppl 3), S152-S156. DOI: 10.1111/j.1753-4887.2007.tb00364.x

[14] Matsuzawa, Y. (2006). The metabolic syndrome and adipocytokines. *FEBS Letters, 580*(12), 2917-2921. DOI: 10.1016/j.febslet.2006.04.028

[15] Ross, R., & Bradshaw, A. J. (2009). The future of obesity reduction: Beyond weight loss. *Nature Reviews Endocrinology, 5*(6), 319-325. DOI: 10.1038/nrendo.2009.78