ORIGINAL RESEARCH

Investigating the Impact of Total and Visceral Fat on Cardiovascular Sympathetic Functions: A Comprehensive Study

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ABSTRACT

Background:Obesity is marked by an excess accumulation and retention of fat in the body, leading to changes in cardiovascular autonomic functions. The autonomic nervous system, which consists of the Sympathetic and Parasympathetic divisions, plays a crucial role in regulating and modulating various internal functions of the body.**Methods**:This study adopted a cross-sectional design, focusing on primary data involving 400 healthy male volunteers aged 20 to 35 in the Shivpuri region. Anthropometric data for all participants were gathered using Karada scan, while cardiovascular sympathetic functions were evaluated through sphygmomanometry and electrocardiogram assessments.**Results**:The ANOVA analysis test conducted in this study indicates a correlation between the increase in visceral fat percentage and a simultaneous rise in sympathetic activity, coupled with a decrease in parasympathetic activity.**Conclusion**:The study draws a conclusion that a higher percentage of visceral fat is associated with an elevated risk of cardiovascular morbidity and mortality, compared to an increase in the overall percentage of body fat.

Keywords: Cardiovascular,SympatheticFunction

INTRODUCTION

Obesity, a pervasive health concern, emerges as a crucial and independent risk factor for cardiovascular morbidity and mortality, a challenge that is escalating at an alarming pace in underdeveloped nations.[1] This condition is characterized by the disproportionate deposition and storage of fat throughout the body, influencing various physiological processes.The traditional view of adipose tissue has undergone a paradigm shift. Once perceived merely as a passive reservoir for energy storage, it is now recognized as a highly dynamic and multifaceted organ with metabolic and endocrine functions. Adipose tissue actively produces and releases a variety of bioactive substances, collectively known as adipokines, which play pivotal roles in regulating metabolism, inflammation, and cardiovascular health.

The intricate regulation of adipose tissue functions involves a complex interplay of factors. External influences, such as autonomic nervous system activity, contribute to the delicate balance of adipokine secretion and metabolic processes. Additionally, the rate of blood flow and the delivery of a diverse mix of substrates and hormones in the bloodstream further modulate the functions of this dynamic organ.[2]As obesity continues to exert its influence on global health, understanding the intricate relationships between adipose tissue dynamics, external influences, and cardiovascular outcomes becomes imperative. Addressing the multifaceted nature of obesity requires a comprehensive approach that considers both the physiological intricacies of adipose tissue and the broader systemic impact on cardiovascular health.Body fat distribution is a multifaceted aspect that involves the consideration of both total body fat and visceral fat. Of particular concern is the heightened risk associated with visceral fat, which is recognized as more perilous than its total body fat counterpart. This heightened risk stems from the fact that visceral fat is not merely a passive storage depot but an active contributor to physiological processes, secreting specific cytokines and chemicals that can have profound effects on health.

Visceral fat has been identified as a significant source of cytokines, including interleukin-6 and tumor necrosis factor-alpha, which play pivotal roles in inflammation and are implicated in the development of atherosclerosis. Additionally, chemicals such as leptin, angiotensinogen, and non-esterified fatty acids released by visceral fat contribute to metabolic dysregulation and cardiovascular complications.The secretion of these bioactive molecules from visceral fat underscores its role in instigating and perpetuating various health issues. For instance, the inflammatory cascade initiated by cytokines can contribute to the progression of atherosclerosis, a condition characterized by the buildup of plaque in arterial walls, potentially leading to cardiovascular diseases.[3] Moreover, chemicals like leptin and angiotensinogen have been associated with alterations in blood pressure regulation, potentially contributing to the development of hypertension.The intricate relationship between visceral fat and these molecular factors emphasizes the systemic impact of adipose tissue on overall health. Notably, the autonomic nervous system (ANS) emerges as a central player in maintaining homeostasis. The balance between sympathetic and parasympathetic activities orchestrated by the ANS is essential for preserving the anabolic state of vital organs, including the cardiovascular and pulmonary systems. This delicate autonomic balance is crucial for optimal organ function and overall well-being.In unraveling the complex mechanisms linking visceral fat, cytokine release, and autonomic nervous system dynamics, a deeper understanding is gained regarding the nuanced implications of obesity on health. This knowledge underscores the importance of not only addressing total body fat but also specifically addressing the distribution and impact of visceral fat for a comprehensive approach to health management.

The autonomic nervous system (ANS) serves as a vital regulator of numerous involuntary physiological processes, orchestrating activities such as digestion, blood pressure regulation, hormonal balance, energy metabolism, and the modulation of the cardiovascular system. Recognized as a crucial controller, the ANS plays a pivotal role in maintaining the internal environment of the body in a state of dynamic equilibrium.In the realm of digestion, the ANS influences the intricate processes involved in breaking down and absorbing nutrients from ingested food. Its impact extends to the regulation of blood pressure, where the sympathetic and parasympathetic divisions work in tandem to finely adjust vascular tone and cardiac output, ensuring optimal circulation throughout the body.

Hormonal regulation is another domain where the ANS exerts its influence, participating in the intricate network that governs the release and balance of hormones essential for various bodily functions.[4] Energy metabolism, encompassing the utilization and storage of energy derived from nutrients, is intricately modulated by the ANS to meet the dynamic demands of the body's activities.Crucially, the cardiovascular system is under the continuous guidance of the ANS, with sympathetic and parasympathetic branches finely tuning heart rate, blood vessel constriction or dilation, and overall cardiac output. This orchestration is essential for adapting to the body's changing needs and maintaining cardiovascular homeostasis.In essence, the autonomic nervous system stands as a linchpin in the delicate balance of the body's internal environment. Its ability to regulate a wide array of physiological processes underscores its significance as a master controller, ensuring the seamless coordination of activities necessary for the body's overall health and well-being.

The autonomic nervous system (ANS) assumes a crucial role in governing energy expenditure and regulating body fat content. Its intricate control mechanisms, facilitated by the sympathetic and parasympathetic divisions, extend to the modulation of various visceral functions through a network of visceral reflexes.[5]In the realm of energy expenditure, the sympathetic division of the ANS plays a pivotal role. Activation of the sympathetic nervous system prompts the release of norepinephrine, which, among other effects, stimulates the breakdown of stored energy sources such as fat. This mobilization of energy reserves is integral to meeting the heightened energy demands during periods of increased activity or stress.Conversely, the parasympathetic division of the ANS, often associated with the "rest and digest" response, is instrumental in promoting energy conservation and storage. Activation of the parasympathetic system encourages processes like digestion and nutrient absorption, fostering the replenishment of energy stores.

The regulation of body fat content is intricately linked to these autonomic processes. Sympathetic activity can influence lipolysis (the breakdown of fat) and thermogenesis (heat production), both of which contribute to the management of body fat levels.[6] In contrast, parasympathetic activity supports anabolic processes, favoring the storage of energy and nutrients.Visceral functions, encompassing activities within internal organs, are finely tuned by the ANS through a series of visceral reflexes. These reflexes involve coordinated responses to stimuli, ensuring optimal functioning of vital organs such as the heart, lungs, and digestive system. The sympathetic and parasympathetic divisions work in concert to maintain a delicate balance in visceral activities, adapting to the body's changing needs and maintaining homeostasis.[7,8]In essence, the autonomic nervous system emerges as a master regulator, dynamically influencing energy metabolism, body fat regulation, and visceral functions. Its ability to modulate these processes underscores its significance in orchestrating the overall balance of the body's physiological activities.

MATERIALS AND METHODS

This cross-sectional study spanned a year and was conducted within the Department of Physiology. The inclusion criteria comprised 400 young and healthy adult male volunteers, aged between 20 to 35, residing in and around the Shivpuri district. Specifically, individuals with no major illnesses or chronic addictions were selected for the study.Conversely, exclusion criteria were established to refine the participant pool. Female subjects, children, male subjects exceeding 35 years of age, and those with major illnesses or addictions were excluded from the study.

To maintain consistency, all tests were conducted at the same time of day for each participant, creating a standardized environment. The anthropometric data collected included body weight (in kilograms), Body Mass Index (BMI), Body Age (in years), total body fat percentage, and visceral fat percentage. These measurements were obtained using Karada scan equipment (Omeron HBF 375 IN). Prior to participating in the study, all subjects provided written informed consent, ensuring ethical standards and the protection of participants' rights throughout the research process.

To evaluate cardiovascular sympathetic functions in all subjects, various physiological parameters were recorded. This included the Resting Heart Rate (RHR), Resting Systolic Blood Pressure (RSBP), Resting Diastolic Blood Pressure (RDBP), and Orthostatic Systolic Blood Pressure (Orthostatic-SBP). These measurements were obtained using essential medical equipment, including a stethoscope, sphygmomanometer, and electrocardiogram (ECG) in lead II configuration.

- **Resting Heart Rate (RHR):** This parameter reflects the number of heartbeats per minute while the subject is at rest. It serves as a baseline measure of the heart's activity.
- **Resting Systolic Blood Pressure (RSBP):** This denotes the pressure in the arteries when the heart is contracting. It is a key indicator of the force exerted on the arterial walls during each heartbeat.
- **Resting Diastolic Blood Pressure (RDBP):** This represents the pressure in the arteries when the heart is at rest between beats. It provides insight into the constant pressure in the arteries.
- **Orthostatic Systolic Blood Pressure (Orthostatic-SBP):** This measurement is taken when the subject moves from a lying or sitting position to a standing position, providing information on how blood pressure responds to changes in posture.

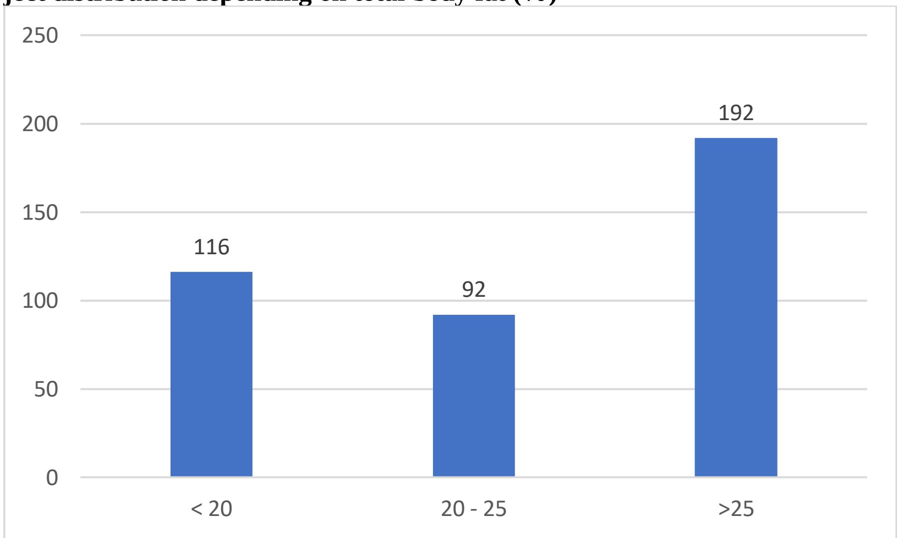
The data collected through these cardiovascular assessments contribute to the understanding of sympathetic nervous system activity and its impact on cardiovascular dynamics. The use of a stethoscope, sphygmomanometer, and electrocardiogram ensures accuracy and reliability in recording these essential cardiovascular parameters.

RESULTS

Table 1: Subject distribution depending on total body fat (%)

Total Body Fat %	No. of Subjects	Groups
< 20	116	Normal
20 - 25	92	Overweight
>25	192	Obese

Figure 1: Subject distribution depending on total body fat (%)



All subjects were grouped into categories based on their total body fat percentage. The classification criteria were as follows: normal (total body fat percentage less than 20%), overweight (total body fat percentage ranging from 20% to 25%), and obese (total body fat percentage exceeding 25%). This categorization system, presented in Table 1, facilitated the organization of individuals into different adiposity groups, enabling a systematic analysis and comparison of data across various levels of total body fat. Such classification was instrumental in identifying potential correlations between body fat composition and other physiological parameters, contributing valuable insights to the study's objectives.

Table 2: Subject distribution depending of visceral fat (%)

Visceral Fat %	No. of Subjects	Groups
<10	200	Normal
10- 15	172	Overweight
>15	28	Obese

All subjects were sorted into categories determined by their visceral fat percentage. The classification criteria were as follows: normal (visceral fat percentage less than 10%), overweight (visceral fat percentage ranging from 10% to 15%), and obese (visceral fat percentage exceeding 15%). This categorization, outlined in Table 2, enabled the organized grouping of individuals based on their visceral fat composition. Such classification facilitated the systematic analysis and comparison of data across different levels of visceral fat, offering a structured approach to investigate potential correlations between visceral fat content and other physiological parameters in the study.

DISCUSSION

In the course of our comprehensive investigation, subjects were meticulously categorized based on both their total body fat percentage and visceral fat percentage, as meticulously outlined in Tables 1 and 2. The profound insights gleaned from our study unearthed substantial variations in Resting Heart Rate (RHR) across the diverse adiposity categories, shedding light on the intricate interplay between body composition and cardiovascular parameters.[9]Delving into the percentage of Total Body Fat, our scrutiny revealed a statistically significant divergence in mean RHR among the groups. The subjects classified as obese exhibited a markedly higher mean RHR (89.4) compared to both the overweight (81.6) and normal counterparts (79.7) ($p < 0.000$). This discernible difference in RHR aligns closely with the outcomes reported in various seminal studies, including those conducted by Rajalakshmi R et al, Kanavi et al, Urs Scherrer et al, Stefanie Hillebrand et al, Camila Oliveira et al, Vishrutha K V et al, and Renata Claudino Rossia et al.Similarly, as we shifted our focus to the percentage of Visceral Fat, the data revealed a significant disparity in mean RHR among the groups. The obese subjects demonstrated a markedly elevated mean RHR (93.4) compared to the overweight (87.9) and normal individuals (80.9) ($p < 0.000$). These findings resonated with the observations in studies conducted by Rajalakshmi R et al, Kanavi et al, Urs Scherrer et al, Neeru Garge et al, Ram Lochan Yadav et al, and Mohamed F Lutfi et al, affirming the consistency of our results with existing scientific knowledge.[10]

Beyond heart rate, our meticulous analysis extended to blood pressure parameters, specifically Resting Systolic Blood Pressure (RSBP) and Resting Diastolic Blood Pressure (RDBP), in relation to Total Body Fat percentage. The results exposed a statistically significant difference in the mean RSBP among the groups, with obese subjects displaying a higher value (121.8) compared to overweight (117.9) and normal individuals (114.9) ($p = 0.019$). Moreover, with RDBP, the mean value in obese subjects (79.7) exceeded that in overweight (78.7) and normal individuals (75.1) ($p = 0.002$). These outcomes are consistent with findings from other investigations, underscoring the robustness of our study in contributing to the growing body of evidence regarding the impact of adiposity on cardiovascular parameters.[11,12]Expanding our examination to Visceral Fat percentage, the data unveiled a substantial difference in mean RSBP among the groups. Obese subjects demonstrated a significantly higher RSBP (131.7) compared to overweight (119.7) and normal individuals (116.4) ($p = 0.019$). Similarly, in the context of Resting Diastolic Blood Pressure, the mean value in obese subjects (87.1) surpassed that in overweight (77.6) and normal individuals (77.32) ($p = 0.002$). These findings echoed the results of studies conducted by Shahin Akhter et al, Talay Yar, and Kanavi et al, further strengthening the validity and generalizability of our findings.In summary, our meticulous study not only corroborates previous research but also unveils a consistent pattern of significantly higher Resting Heart Rate and blood pressure values in the obese group compared to both the overweight and normal groups.[13] These findings suggest a robust association between increased adiposity and sympathetic over-activity, coupled with reduced parasympathetic activity. The nuanced insights gained from this research contribute to a deeper understanding of the complex relationship between adiposity, autonomic function, and cardiovascular health. As we navigate the intricate landscape of obesity-related health implications, our study underscores the imperative of addressing adiposity as a crucial aspect of overall well-being.[14]

Our research findings are notably consistent with studies conducted by Simran Grewal et al, Shahin Akhter et al, Renata Claudino Rossia et al, and Paul Poirier et al, adding robustness and external validity to our observations. An integral facet of our study involved a detailed examination of orthostatic Systolic Blood Pressure (SBP) concerning visceral fat percentage.In our comprehensive analysis, the mean orthostatic SBP in obese subjects (124.8) exhibited a significant elevation compared to both the overweight (112.6) and normal individuals (109.68) ($p = 0.022$). These results mirror the findings reported by Simran Grewal et al and Shahin Akhter et al. The substantial increase in orthostatic SBP within the obese group, relative to the overweight and normal groups, implies a state of sympathetic over-activity and a concurrent reduction in parasympathetic activity.[15] This observation accentuates the intricate interplay between visceral fat content and the dynamics of the autonomic nervous system, reinforcing the critical role of adiposity in influencing cardiovascular regulation.The consistent alignment of our results with established research further emphasizes the broader implications of our findings. Elevated orthostatic SBP in individuals with higher visceral fat percentages underscores the potential cardiovascular impact of adiposity. This insight contributes to the growing body of knowledge linking obesity to autonomic function and cardiovascular health. As we navigate the complexities of understanding these relationships, our study adds valuable nuances to the discourse, emphasizing the importance of considering visceral fat content in the broader context of cardiovascular dynamics and sympathetic-parasympathetic balance.

CONCLUSION

The study's conclusive findings illuminate a significant association between high visceral fat percentage and elevated values in various sympathetic tests. This implies a clear correlation between increased deposition of visceral fat in the body and heightened sympathetic activity, particularly when contrasted with total body fat. The discerned pattern of heightened sympathetic activity suggests a prevailing dominance of sympathetic over parasympathetic activity.This dominance of sympathetic activity over activity holds substantial implications for cardiovascular health. The study's conclusion implies that a higher visceral fat percentage contributes to an augmented sympathetic response, potentially creating an imbalance in the intricate interplay between the sympathetic and parasympathetic branches of the autonomic nervous system. Such an imbalance, with sympathetic over-activity and reduced parasympathetic influence, may predispose individuals to an increased risk of cardiovascular morbidity and mortality.In essence, the study underscores the importance of considering the distribution of body fat, particularly visceral fat, in evaluating autonomic nervous system dynamics and its potential impact on cardiovascular health. The identified link between visceral fat and sympathetic over-activity emphasizes the need for comprehensive strategies in addressing obesity, particularly focusing on visceral fat reduction, to mitigate the associated cardiovascular risks.

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