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Serum Adiponectin Levels and Their Association with Age, Gender and Waist Circumference: Insights from a Cross-Sectional Study

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ABSTRACT

Adipose tissue secretes the adipokine adiponectin, which is essential for insulin sensitivity, cardiovascular health, and metabolic control. Although prior studies suggest that age and waist circumference (WC) influence adiponectin levels, contradictory results indicate the need for further research. **Objectives:** To evaluate and compare serum adiponectin levels among individuals of different age groups and waist circumference categories. **Methods:** A cross-sectional study was conducted with 50 individuals. Age, WC, body mass index (BMI), and gender were among the anthropometric information gathered. Spearman's correlation was used to test serum adiponectin levels and their relationships with these factors. The threshold for statistical significance was $p<0.050$. **Results:** The average amount of adiponectin in the blood was 5.59 ± 1.94 ng/mL. Adiponectin did not significantly correlate with either WC ($r=+0.17$, $p=0.160$) or age ($r=-0.06$, $p=0.600$). Furthermore, although somewhat higher in females, adiponectin levels did not significantly correlate with either gender ($p=0.470$) or BMI ($r=+0.10$, $p=0.370$). **Conclusion:** It was concluded that results show no significant relationships of adiponectin with WC, in contrast to previous research that found an inverse link with WC or an age-related increase in adiponectin. This could be the result of unmeasured confounding variables, including food and lifestyle, sample size restrictions, or demographic characteristics. More extensive research is needed to elucidate these connections and investigate adiponectin's potential as a biomarker for metabolic diseases.

INTRODUCTION

Obesity is a serious health issue in both industrialized and developing nations, and one-third to half of adults suffer from it. Obesity is more common in women than in male in developing nations, and it is predicted to affect 70% of the population in the coming years. Although the exact processes behind the association between obesity and an elevated risk of metabolic disease remain unclear, strong evidence suggests that adipose tissue secretions play a role in this relationship [1]. Some of the most significant biological substances, known as adipokines, are produced by adipose tissue, an endocrine organ that has a unique function in controlling immunological responses and

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metabolism. Adiponectin, one of the adipokines of adipose tissue, has positive effects on the lipid profile, enhances tissue sensitivity to insulin, and functions as an anti-diabetic hormone. It is essential for controlling inflammation, lipid homeostasis, and glucose metabolism. It is an important biomarker in metabolic and cardiovascular disorders and has been extensively researched for its insulin-sensitizing, anti-inflammatory, and cardioprotective qualities [2]. Adiponectin is the only adipokine that doesn't encourage metabolic dysfunction since, although being released by adipose tissue, its levels strangely drop in people with obesity and metabolic syndrome (MS), demonstrating its inverse association with adiposity. Two main receptors, AdipoR1 and AdipoR2, which are expressed in skeletal muscle, the liver, and endothelial cells, regulate its biological activities [3]. Adiponectin is a topic of interest in both clinical and research contexts because of its inverse association with obesity, which makes it a possible biomarker for metabolic diseases. Serum adiponectin levels are influenced by several factors, including lifestyle, hormones, and genetic factors [4]. Age and waist circumference are two of these that have been extensively researched because of their substantial effects on adiponectin levels. Metabolic indicators are measurable biological markers that reflect the state of metabolic processes in the body, often used to assess an individual's risk for metabolic disorders such as obesity, type 2 diabetes, and cardiovascular diseases. Key metabolic indicators include anthropometric measurements like body mass index (BMI) and waist circumference (WC), which provide insights into overall and central adiposity. Biochemical markers, such as serum adiponectin levels, play crucial roles in metabolic regulation by influencing insulin sensitivity, inflammation, and lipid metabolism [5]. Elevated or reduced levels of these indicators can signal disruptions in metabolic homeostasis, thereby serving as valuable tools in the early detection, monitoring, and management of metabolic health and disease risk. Adiponectin levels are affected by metabolic function, inflammatory processes, and body composition changes that occur with ageing. Despite the typical decrease in insulin sensitivity seen in older persons, research has revealed that serum adiponectin levels tend to rise with age [6]. Changes in the distribution of adipose tissue, hormonal fluctuations, and persistent low-grade inflammation in the aged population are some of the causes of this contradictory tendency. Furthermore, there are sex-specific variations in the dynamics of adiponectin with age. Due in part to variations in fat distribution and the impact of sex hormones, women often have higher levels of adiponectin than men [7]. These results demonstrate the intricate relationship between adiponectin regulation, age, and gender [8]. Waist circumference (WC) is a key indicator of metabolic health and a recognized indicator of central obesity. WC precisely measures visceral adiposity, which is more strongly linked to metabolic dysfunction than body mass index (BMI), which does not distinguish between lean and fat mass. Although previous research has highlighted an inverse relationship between adiponectin levels and obesity, particularly central adiposity, findings regarding its association with age and gender remain inconsistent. Some studies suggest adiponectin levels increase with age, potentially reflecting compensatory mechanisms or altered adipose tissue function, while others report contradictory trends. Given the growing prevalence of obesity and metabolic syndrome, particularly in diverse populations, it is essential to clarify how physiological factors like age and anthropometric measures such as waist circumference independently and jointly influence serum adiponectin levels. This study aims to fill this knowledge gap by systematically analyzing the relationships between adiponectin, age, waist circumference and BMI in a sample of healthy adults of both genders, thereby contributing to improved metabolic risk assessment and potential therapeutic targeting. A thorough investigation is necessary to elucidate the combined influence of these parameters on adiponectin regulation, given the contradictory results on their interplay. To clarify the separate and combined impacts of age and weight, gender and BMI, this study was designed to compare serum adiponectin levels by these variables. Adiponectin's function in metabolic health and disease risk can be better understood by taking into account how its levels change with physiological and anthropometric variables like age and waist circumference.

Adiponectin is widely recognized as a protective adipokine with significant roles in insulin sensitivity and metabolic regulation; however, evidence regarding its relationship with age, gender, and waist circumference remains inconsistent. While several studies report inverse associations with central obesity and age-related variations, findings differ across populations and ethnic groups. Moreover, limited local data exist evaluating these associations in healthy Pakistani adults. This gap necessitates further investigation to clarify the independent and combined effects of anthropometric and demographic variables on serum adiponectin levels. This study aimed to bridge the knowledge gap regarding adiponectin regulation by systematically analyzing its relationship with age, waist circumference and BMI. The findings could help improve metabolic risk assessment and possibly guide future endocrinology and metabolic health research.

METHODS

It was a cross-sectional analytical study. For sampling, a non-probability convenience sampling method was used. It

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was conducted at Multan Medical and Dental College and its attached clinical hospital from June 2024 to December 2024. Ethical approval was obtained from the relevant institutional review board (IRB No. C-92-1046), and written informed consent was obtained from all participants before data collection. Participant confidentiality was maintained by assigning unique identification codes and securely storing data in password-protected files accessible only to the research team. The outcome variable used for sample size calculation was serum adiponectin level. As the study aimed to estimate the mean serum adiponectin level in the population, the sample size was calculated using the formula for estimating a single mean: $n = (Z_{1-\alpha/2} \cdot \sigma/d)^2$. Where: $Z_{1-\alpha/2}$=1.96 (corresponding to 95% confidence level), σ=9ng/mL (assumed standard deviation based on international literature) and d=2.5ng/mL (acceptable margin of error). The standard deviation reported serum adiponectin variability between 7 to 10 ng/mL in healthy adults. Based on this, a conservative SD of 9 ng/mL was selected for the present calculation. This yielded a sample size of approximately 50 individuals, which was deemed adequate for estimating the mean serum adiponectin levels with acceptable precision. A total of 50 healthy individuals, 27 males (54 %) and 23 females (46%), were enrolled in the study. There were males and females above the age of 18. Pregnant females, individuals with a BMI less than 18 and patients currently or recently diagnosed with COVID-19 and any other chronic disease were excluded from the study. For anthropometric measurements, waist circumference (WC) was measured at the midpoint between the lower margin of the last palpable rib and the top of the iliac crest using a non-stretchable measuring tape. Participants were asked to stand upright with feet close together, arms at the sides, and abdomen relaxed. The tape was applied snugly without compressing the skin, and two measurements were taken and averaged to ensure accuracy. In the same way, height was measured in centimeters in standing posture, and weight was measured by standardized weighing scale in Kilograms. To calculate body mass index (BMI), height and weight measurements were used by taking weight in kilograms and height in meters squared with the following formula. BMI = kg/m2. Where Kg=person's weight in kilograms and m2 = height in meters square. A person is said to be overweight if their BMI is 25 or above; a healthy range is between 18.5 and 24.9. About 5 cc of blood was taken using aseptic technique, and serum was separated and centrifuged to determine the outcome variable, serum adiponectin level by ELISA. Serum adiponectin levels were determined using a commercially available ELISA kit (Crystal Chem). All assays were performed according to the manufacturer's instructions, with appropriate standards and controls included to ensure data quality and reproducibility. Data for this study were analysed using P.A.S.W 18.0 (formerly SPSS). Quantitative data, including age, BMI, waist circumference, and serum adiponectin levels, were expressed as mean ± standard deviation (SD) to summarize central tendency along with variability. Spearman's rank correlation coefficients were calculated to evaluate the associations between serum adiponectin levels and key anthropometric variables, including age, gender, body mass index (BMI), and waist circumference. This method was selected to isolate the independent influence of variables such as age and waist circumference on adiponectin. The assumptions for correlation analysis, including linearity and normal distribution, were evaluated before implementation. For statistically significant results, the p-value was set at p-value≤0.050.

RESULTS

Study presents the descriptive statistics for the demographic and clinical parameters of the study participants. For continuous variables, mean, standard deviation, median, and interquartile range (IQR) were reported. The p-values presented in Table 1 correspond to the results of normality testing (Shapiro-Wilk test) for continuous variables, which inform the choice between parametric and non-parametric tests in subsequent analyses. The mean serum adiponectin level for the overall cohort was 5.53 ± 1.94 ng/mL, with males showing a mean level of 5.42 ± 1.35 ng/mL and females 5.74 ± 2.58 ng/mL; however, the difference was not statistically significant (p=0.470), as determined using independent samples t-test. Mean values were also compared across groups of waist circumference and age, and although variations were observed, no statistically significant differences were found (p>0.050), as determined using one-way ANOVA. Correlation analysis indicated weak and statistically non-significant relationships between adiponectin and age, BMI, waist circumference and gender.

Table 1: Participants' Demographics and Fundamental Characteristics(n=50)

Sr.No	Characteristics	Frequency (%)		'p'* for normality
1	**Gender**	Male	27(54%)	–
		Female	23(46%)	
-	–	**Mean ± SD**	**Median ± IQR**	–
2	Age (Years)*	34.65 ± 11.39	33.00 ± 21.00	<0.001
3	BMI (kg/m^2)*	27.74 ±7.63	26.90 ± 15.00	<0.001
4	Waist Circumference Inches*	38.73 ±12.55	36.00 ± 19.00	<0.001
5	Serum Adiponectin in ng/mL	5.53 ± 1.94	5.34 ± 2.64	0.050

p-value indicates the results of the Shapiro-Wilk normality test for continuous variables.

Findings demonstrate no statistically significant variation amongst levels of mean serum adiponectin across waist circumference groups (p>0.050)(Figure 1).

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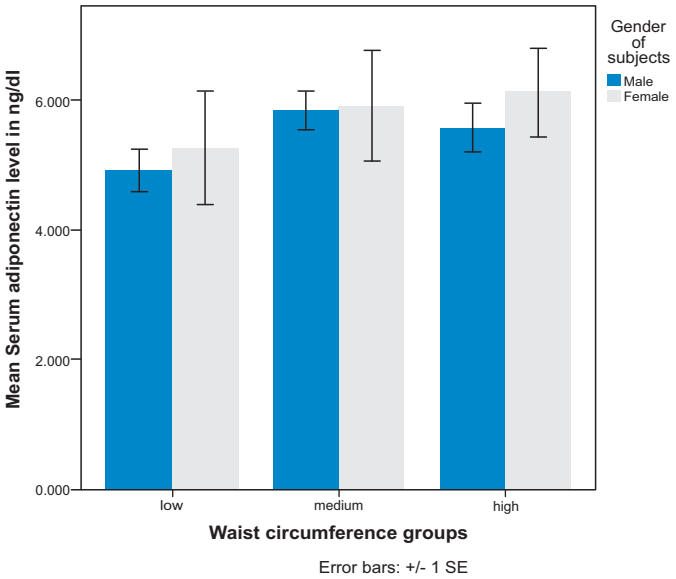

Figure 1: Mean Serum Adiponectin Levels Distribution According to Waist Circumference Groups (p>0.050)

Findings demonstrate no statistically significant variation amongst levels of mean serum adiponectin across waist circumference age groups (Figure 2).

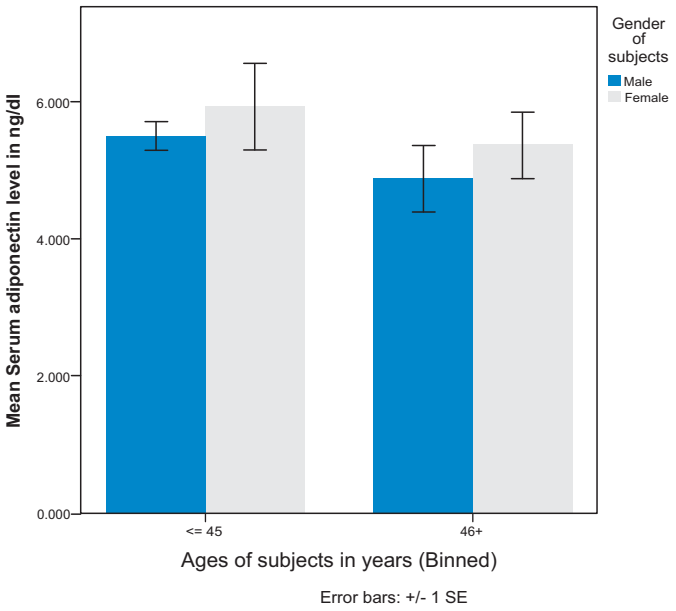

Figure 2: Mean Serum Adiponectin Levels Distribution According to Age Groups (p>0.050)

The results indicate no statistically significant correlations between adiponectin and any of these variables. Specifically, the correlation coefficients were as follows: age (r= -0.06, p=0.600), gender (r = +0.001, p=0.960), BMI (r = +0.10, p=0.370), and waist circumference (r = +0.17, p=0.160). These findings suggest that within this sample, serum adiponectin levels are not significantly associated with variations in age, sex, general obesity (BMI), or central obesity (waist circumference). Our findings do not demonstrate a significant correlation between adiponectin and age; this discrepancy may be attributed to several factors, including differences in sample size, population characteristics, or underlying metabolic conditions. These findings are presented and align with the study's aim to evaluate the independent and combined influence of age and waist circumference on serum adiponectin levels (Table 2).

Table 2: Spearman Correlation Showing Relationship Between Serum Adiponectin and Anthropometric Variables

Sr. No	Variables	Correlation Coefficient (r)	p-value
1	Age	- 0.06	0.600
2	Gender	+ 0.001	0.960
3	Body Mass Index	+ 0.10	0.370
4	Waist Circumference	+ 0.17	0.160

DISCUSSION

The present study aimed to examine the relationship between serum adiponectin levels, age, waist circumference (WC) and BMI in a cohort of adults. Given adiponectin's well-documented role in metabolic regulation and its inverse association with obesity and metabolic syndrome (MS), it's crucial to understand how its levels vary with age and WC. It is critical for assessing metabolic health risks. However, our findings indicate no statistically significant associations between serum adiponectin and the examined anthropometric parameters, including age, gender, BMI, and WC. Our results show no significant relationship between adiponectin and age, which is in contrast to several previous studies that claim a rise in serum adiponectin levels with ageing [9, 10]. According to another study, ageing is typically connected to higher adiponectin levels because of changes in the composition of adipose tissue and hormonal fluctuations [11]. The observed changes in adiponectin regulation with age may also be influenced by genetic, dietary, and lifestyle variations. According to research, adiponectin levels in healthy people tend to rise with age, perhaps as a result of hormonal changes or a decrease in body fat [12]. A large cohort study by Li et al. observed significantly higher adiponectin levels in older adults and postulated that this rise may reflect adipose tissue remodeling or altered hormonal signals associated with ageing [13]. One important factor influencing adiponectin levels is waist circumference, which is a gauge of central obesity. Adiponectin and waist circumference are inversely correlated, with lesser adiponectin secretion resulting from an increase in visceral fat. WC and adiponectin levels are inversely correlated in numerous studies; those with higher levels of abdominal obesity also have lower levels of circulating adiponectin [14]. Current findings, however, did not show a statistically significant correlation between WC and serum adiponectin. This may be attributed to the use of WC as a general proxy for central

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obesity, which does not distinguish between subcutaneous and visceral adipose compartments. Imaging techniques such as CT or MRI could provide a more precise estimation of visceral fat, which may better explain variations in adiponectin levels. Our results do not indicate a significant correlation between WC and serum adiponectin levels, even though WC is a commonly used indicator of central obesity and metabolic risk. Because adipose tissue development, especially visceral fat, is associated with reduced adiponectin secretion, prior studies have consistently shown an adverse connection between adiponectin and abdominal obesity [15]. The sample size may limit the statistical ability to detect tiny alterations, which could be one reason for our study's lack of significance. Individual differences in fat distribution should also be taken into account. Although WC is a general predictor of abdominal obesity, it is unable to distinguish between visceral and subcutaneous adipose tissue, both of which may have distinct effects on adiponectin secretion [16]. Furthermore, dyslipidemia and elevated insulin resistance are linked to excessive visceral fat storage, and these conditions also lead to the downregulation of adiponectin [17]. In comparison to males, females had somewhat higher mean adiponectin levels; however, this difference was not statistically significant (p=0.47). This pattern is in line with earlier studies that show that adiponectin levels vary by gender, with women typically having greater levels than men [18]. In a recent study, adiponectin levels were significantly higher in women across all age groups [19]. Interestingly, although adiponectin is often inversely associated with BMI [20], our study did not find this relationship to be significant. Recent evidence confirmed adiponectin's negative correlation with BMI and fat mass, independent of insulin resistance and other metabolic parameters. The absence of this pattern in our study might be due to BMI's limited ability to distinguish between fat and lean mass or due to unaccounted factors such as physical activity, dietary intake, and inflammatory markers. In our study, no significant relationships between serum adiponectin and other anthropometric measurements, such as BMI, were found by the correlation analysis (r=+0.10, p=0.370). Because obesity suppresses adiponectin secretion, prior research has found an inverse link between adiponectin and BMI [21]. Our lack of significance could be related to the relatively small sample size or the absence of stratification by menopausal status, which is known to influence adiponectin expression. The current study's lack of statistical significance, however, raises the possibility that these disparities are influenced by other variables such as genetic predisposition, dietary practices, and lifestyle choices.

The current study's lack of statistical significance, however, raises the possibility that these disparities are influenced by other variables such as genetic predisposition, dietary practices, and lifestyle choices.This study was limited by its relatively small sample size and single-center design, which may reduce statistical power and limit generalizability. The use of convenience sampling and absence of advanced measures of visceral adiposity, such as imaging techniques, may have restricted the precision of obesity assessment. Additionally, potential confounders including dietary habits, physical activity, hormonal status, and inflammatory markers were not evaluated. Future large-scale, multicenter studies incorporating longitudinal follow-up and comprehensive metabolic profiling are recommended to better elucidate adiponectin's role as a biomarker of metabolic health.

CONCLUSIONS

It was concluded that there were no discernible correlations between serum adiponectin levels and age, gender, waist circumference, or BMI. Although prior studies indicate that adiponectin is essential for metabolic health, its levels are probably influenced by the intricate interactions of numerous physiological and environmental variables. To elucidate these connections and investigate the possible application of adiponectin as a biomarker for metabolic and cardiovascular disorders, more extensive research is required. It is still crucial to comprehend the factors that influence adiponectin variance to create focused therapies that enhance metabolic health outcomes. Preventive medicine, clinical practice, and public health are all significantly impacted by the study's conclusions.

Authors' Contribution

Conceptualization: ZH
Methodology: ZH, HF, AA, ZC, TM[2]
Formal analysis: HF, SR, TM[1],
Writing and Drafting: MZ, SS, ZC, FH
Review and Editing: MZ, SS, ZC, FH, ZH, HF, AA, SR, TM[1], TM[2]

All authors approved the final manuscript and take responsibility for the integrity of the work

Conflicts of Interest

All the authors declare no conflict of interest.

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