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Serum Adiponectin and C-Peptide Levels in Relation to Body Mass Index and Age in Type 2 Diabetic Patients

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Abstract

Background: *Type 2 diabetes mellitus (T2DM) is a long-lasting metabolic condition that is strongly linked to obesity and the body's reduced ability to respond to insulin.*

Aim: *to investigate the relationships among serum adiponectin, c-peptide levels, body mass index (BMI), and age in patients with type 2 diabetes mellitus (T2DM).*

Settings and Design: *A cross-sectional study was conducted at the ESUTH diabetes clinic, Enugu, Nigeria, involving 120 type 2 diabetes patients aged 40–70 years. Participants were grouped by BMI (normal, overweight, obese) and further stratified by sex and age.*

Methods and Materials*: Fasting blood samples (3 mL) were collected, and serum adiponectin and c-peptide were measured using ELISA kits.*

Statistical analysis used*: Data analysis was done with SPSS.*

Results: *Serum adiponectin was highest in normal-weight individuals and declined in overweight and obese groups. Females exhibited significantly higher adiponectin than males (P = 0.015). Conversely, c-peptide was lowest in normal-weight individuals and increased with BMI, with males having elevated levels than females (P = 0.021). Older individuals had lower adiponectin and higher c-peptide. Adiponectin negatively correlated with BMI (r = -0.67, P = 0.004) and age (r = -0.45, P = 0.038), while c-peptide positively correlated with BMI (r = 0.72, P = 0.002) and age (r = 0.38, P = 0.049).*

Conclusions: *These findings highlight the potential of adiponectin and c-peptide as biomarkers for monitoring metabolic health, and the interplay between demographic factors and metabolic biomarkers in T2DM patients.*

Keywords: *Adiponectin, C-peptide, Body Mass Index, Type 2 Diabetes.*

INTRODUCTION

Type 2 diabetes mellitus (T2DM) is a long-term metabolic disorder characterized by hyperglycemia, insulin resistance, and defective pancreatic beta-cell function (1). It is of high clinical concern worldwide because of the increasing prevalence associated with the obesity epidemic, sedentary lifestyles, and aging population. Obesity or overweight is well known to be highly prevalent in subjects with type 2 diabetes in previous studies (1).

Adiponectin is a cytokine secreted by fat cells, which plays crucial role in regulating glucose metabolism and enhancing insulin sensitivity. Factors such as age, sex, and body mass index (BMI) are essential demographic and physiological

parameters that affect metabolic parameters, including adiponectin and C-peptide. Higher BMI has a deteriorating effect on insulin sensitivity and metabolic health (2), and is therefore an important factor in the progression of T2DM.

Knowledge of biochemical markers related to T2DM is important for timely diagnosis, risk stratification, and patient management. Reduced levels of adiponectin have been linked to a higher risk for T2DM, Cardiovascular disease, and metabolic syndrome.

In contrast, C-peptide, which is a product of insulin synthesis, is a vital marker of pancreatic endogenous secretion of insulin and beta-cell function (3). Although some of these markers have been studied respectively, the correlation between these markers and BMI, age, and sex of T2DM patients has not been well investigated.

This study examined the interaction between serum adiponectin, c-peptide levels and demographic features like BMI, age, and sex, in order to provide insight into the function of the three as a biomarker in T2DM.

SUBJECTS AND METHODS

Study Design and Population: This cross-sectional study recruited 120 individuals diagnosed with type 2 diabetes mellitus (T2DM), aged 40 to 70 years, who were receiving care at the diabetes clinic of ESUTH, Parklane, Enugu State, Nigeria. Participants were categorized based on their body mass index (BMI) into three groups: normal weight (BMI <25 kg/m²), overweight (BMI 25–29.9 kg/m²), and obese (BMI ≥30 kg/m²). BMI was determined by dividing each participant's weight in kilograms by the square of their height in meters (kg/m²). Further stratification was performed according to sex and age.

Inclusion and Exclusion Criteria: Eligible participants were those with a confirmed diagnosis of T2DM for at least one year, aged between 40 and 70 years, and who regularly attended the ESUTH diabetes clinic. Written informed consent was obtained from all participants prior to enrollment. Individuals were excluded if they had a history of malignancy, chronic illnesses known to affect metabolic health, or were currently undergoing insulin therapy.

Ethical Considerations: Ethical approval for this study was granted by the ESUTH Research Ethics Committee. All procedures were conducted in accordance with the principles outlined in the Declaration of Helsinki. Written informed consent was secured from all participants before enrollment.

Sample Collection and Laboratory Analyses: Fasting blood samples (3 millilitres) were collected from each participant. Serum levels of adiponectin and c-peptide were quantified using validated enzyme-linked immunosorbent assay (ELISA) kits, following the manufacturers' protocols.

Statistical Analysis: Data analysis was performed using SPSS version 26.0 (SPSS Inc., Chicago, IL, USA). Results are presented as mean ± standard deviation (SD). Differences between two groups were assessed using the independent Student's t-test, while comparisons across multiple groups were evaluated using analysis of variance (ANOVA) with post-hoc testing to identify specific group differences. Associations between serum biomarkers and demographic variables were examined using Pearson's correlation coefficient. A *P*-value of less than 0.05 was considered statistically significant.

RESULTS

As shown in Table 1, there were no statistically significant differences between males and females in terms of age ($P = 0.276$), weight ($P = 0.318$), height ($P = 0.293$), or BMI ($P = 0.301$). However, females exhibited notably higher serum adiponectin levels ($P = 0.015$) and lower c-peptide concentrations ($P = 0.021$) compared to their male counterparts.

Table 2 presents comparisons across BMI categories. Both age and weight were significantly greater in the obese group relative to the normal weight and overweight groups, and higher in the overweight group compared to the normal weight group ($P < 0.05$). Height did not differ significantly among the BMI categories ($P > 0.05$). Regarding serum markers, adiponectin levels were significantly reduced in obese participants compared to those with normal weight ($P = 0.002$) and overweight status ($P = 0.009$), and also lower in the overweight group compared to normal weight individuals ($P = 0.007$). In contrast, c-peptide levels were elevated in the obese group relative to both normal weight ($P = 0.004$) and overweight groups ($P = 0.015$), and higher in the overweight group compared to the normal weight group ($P = 0.011$).

Correlational analysis summarized in Table 3 revealed a significant inverse relationship between adiponectin levels and both age ($r = -0.45$, $P = 0.038$) and BMI ($r = -0.67$, $P = 0.004$). Conversely, c-peptide levels showed a positive correlation with age ($r = 0.38$, $P = 0.049$) and BMI ($r = 0.72$, $P = 0.002$).

Table 1: Age, BMI, Adiponectin, and C-Peptide Values with respect to Sex

Parameters	Male (n=65)	Female (n=55)	*P*-value
Age (Years)	55.3 ± 6.8	53.4 ± 7.2	0.276
Weight (kg)	81.5 ± 10.4	72.8 ± 8.6	0.318
Height (m)	1.74 ± 0.07	1.67 ± 0.06	0.293
BMI (kg/m²)	26.9 ± 3.2	26.1 ± 2.9	0.301
Adiponectin (µg/mL)	7.8 ± 2.4	13.5 ± 3.5	0.015*
C-Peptide (ng/mL)	5.4 ± 1.6	3.9 ± 1.4	0.021*

*Significant

Table 2: Age, Weight, Adiponectin, and C-Peptide Values with respect to Body Weight

Parameter	Normal Weight (n=25)	Overweight (n=45)	Obese (n=50)
Age (Years)	49.5 ± 5.7 [a, b]	54.2 ± 6.4 [b]	58.9 ± 7.1
Weight (kg)	62.3 ± 7.8 [a, b]	78.6 ± 9.5 [b]	95.7 ± 11.2
Height (m)	1.70 ± 0.08	1.72 ± 0.07	1.69 ± 0.06
Adiponectin (µg/mL)	14.2 ± 3.2 [a, b]	10.5 ± 3.0 [b]	6.8 ± 2.1
C-Peptide (ng/mL)	2.3 ± 1.1 [a, b]	3.8 ± 1.0 [b]	5.6 ± 1.3

a = Significant when compared to Overweight. b = Significant when compared to Obese.

Table 3: Correlation of Age and BMI with Adiponectin and C-Peptide

Variable	Adiponectin		C-Peptide	
	r	p-value	r	*P*-value
Age	-0.45	0.038*	0.38	0.049*
BMI	-0.67	0.004*	0.72	0.002*

*Significant

DISCUSSION

This investigation examined how serum adiponectin and c-peptide concentrations relate to age, sex, and body mass index among individuals living with type 2 diabetes mellitus (T2DM). The absence of significant differences in age, weight, height, and BMI between male and female participants suggests that the study sample was well balanced in terms of these demographic and anthropometric characteristics. This balance strengthens the validity of comparisons made between sexes regarding the biochemical markers assessed.

The gradual rise in age observed across the different BMI categories is consistent with the concept that extended exposure to detrimental lifestyle habits such as poor nutrition and physical inactivity contributes to both increased body weight and the worsening of metabolic health over time. Supporting this, Jura and Kozak reported that older adults with elevated BMI tend to have a higher likelihood of developing insulin resistance and related metabolic disturbances (4). The marked increase in body weight across the BMI groups corresponds with the natural progression of fat accumulation, which plays a central role in the development and advancement of type 2 diabetes mellitus.

Our findings reveal that female participants exhibited significantly higher serum adiponectin levels compared to males. This difference may be influenced by hormonal factors, particularly estrogen, which is known to stimulate adiponectin secretion and enhance insulin sensitivity.[7] These observations align with previous reports by Nishizawa et al. and Song et al., who also documented elevated adiponectin concentrations in females relative to males (5,6). Conversely, some studies have noted reduced adiponectin levels in women diagnosed with polycystic ovarian syndrome (PCOS), highlighting the complexity of hormonal regulation in different clinical contexts (7,8).

The elevated c-peptide levels observed in male participants could be attributed to variations in insulin resistance, patterns of fat distribution, and hormonal differences (9). The lack of estrogen's protective effects in males, which typically promote insulin sensitivity, may lead to increased pancreatic beta-cell activity and consequently higher c-peptide production. Estrogen's role in improving adipokine profiles (10) may partly explain the lower c-peptide levels seen among females in this study, consistent with findings from Basu et al., who reported a similar sex-related trend (11).

When considering body weight categories, serum adiponectin concentrations declined progressively with increasing BMI, with the lowest levels detected in the obese group. This reduction in adiponectin, often referred to as

hypoadiponectinemia, is likely a consequence of adipose tissue dysfunction commonly seen in obesity, where excessive fat accumulation, especially visceral fat, impairs adiponectin secretion and promotes insulin resistance (12). The significant differences observed between normal-weight and overweight/obese participants further emphasize the detrimental impact of excess adiposity on adiponectin levels. These results corroborate earlier research demonstrating an inverse relationship between adiponectin and obesity (13). Additionally, the negative correlations identified between adiponectin and BMI and age in our cohort suggest that adiponectin levels tend to decrease as body weight and age increase. This age-related decline may be driven by changes in adipocyte function, hormonal fluctuations, and increased oxidative stress associated with aging.

Interestingly, Cohen et al. and Obata et al. reported a positive association between adiponectin and age, attributing this to declining estrogen levels in older adults (14,15).

In contrast, c-peptide levels showed a significant positive correlation with BMI and age, reflecting an upregulated pancreatic beta-cell response to insulin resistance. This compensatory increase in insulin secretion is more evident in overweight and obese individuals, whose higher insulin resistance demands greater insulin output. These findings are in agreement with Thunander et al., who observed similar positive correlations between c-peptide, age, and BMI in adults newly diagnosed with diabetes (16). Gilsa et al. also demonstrated a significant relationship between c-peptide levels and BMI in healthy adults (17). The elevated c-peptide concentrations in obese participants may indicate increased pancreatic workload, which, if sustained, could lead to beta-cell exhaustion and deteriorating glycemic control.

CONCLUSION

This study highlights significant associations between serum adiponectin and c-peptide concentrations and key demographic factors in individuals with type 2 diabetes mellitus. The results emphasize the value of monitoring these biomarkers as indicators of metabolic status in this patient population. Therapeutic approaches that elevate adiponectin levels may enhance insulin sensitivity, slow disease progression, and reduce the likelihood of diabetes-related complications. Furthermore, interventions aimed at reducing pancreatic beta-cell stress, particularly in obese patients, could help preserve beta-cell function and maintain effective glycemic control over time.

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Conflict of Interests: None.

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