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Multivariable Statistical Analysis of Anthropometric, Clinical, and Lifestyle Factors Associated with Glycemic Control Among Adults with Diabetes in Kirkuk, Iraq

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ABSTRACT

Despite its prominence, glycemic control is an important part of diabetes care. Worldwide, diabetic mellitus is a serious health issue and accounts for considerable morbidity and mortality. In a hospital-based retrospective cross-sectional analysis of records of 920 patients with diabetes registered at the Diabetes and Endocrinology Center of Kirkuk Teaching Hospital, HbA1c was used as an indicator of glycemic control. Appropriate statistical analyses was applied for compare glycemic control between diabetes subtypes, and the relationship between lifestyle/anthropometric parameters and glycemic control was applied by multivariable linear, logistic, and ordinal regression analyses, respectively.

Most of the ninety-two subjects were Type 2 diabetes patients (89.3%) and women (61.4%). The percentage of patients with HbA1c <7.0% was not over 12.6%, and that of patients who had poor glycemic control was 59.1%. Prevalences of both obesity and central obesity were also high. Neither of being current smoking nor a sedentary lifestyle had a relationship with glycemic control in statistical tests, but BMI was negatively correlated with glycemic control at logistic regression model. Poor glycemic control and high BMI, in particular waist circumference, are prevalent in adult diabetic patients. The only anthropometrics significantly associated with glycemic control were waist circumference, suggesting that it seems to offer additional clinical usefulness over traditional anthropometry in the routine tests of diabetes.

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1. Introduction

According to the Diabetes Atlas by the International Diabetes Federation (IDF), there were 589 million people with diabetes in the world in 2024, with an estimated 853 million by 2050, aged between 20 and 79. Amongst these, the prevalence of diabetes is expected to increase the most in low- and middle-income countries as a result of population ageing, rapid urbanization, and changing lifestyles [1]. Chronic hyperglycemia is associated with increased risk of diabetes-related complications and increased health care utilization, so it remains a key treatment target for diabetes.

Recognizing HbA1c is recognized as a validated test for measuring glycemic control and tracking diabetes response to therapy [2, 3]. These tests are commonly performed during clinical evaluations, are non-invasive, and moderately priced. BMI is commonly used to determine total body fatness, although it makes no distinction between different forms of fat.

In the diabetes group, comparing different anthropometric measures may offer a more thorough assessment of diabetics' body composition. Diabetes management includes a frequent assessment of lifestyle behaviors, such as exercise, smoking, and other behavioral factors, as well as anthropometric measures [5]. By characterizing these features in patients with diabetes, valuable clinical data may be collected, as well as patient profiles across various healthcare settings [6].

While the association between BMI as well as HbA1c has been fewer constant across groups, some studies have revealed that higher waist circumference or central obesity were linked to worse glycemic control. Likewise, the findings on lifestyle factors, particularly smoking and physical inactivity, have varied between different studies, study populations, and health care settings [7, 8].

Higher waist circumference and central obesity have been correlated with worse glycemic control, though the association among BMI and HbA1c has been differing across typical people. Similarly, the results regarding lifestyle variables, including smoking along with lack of physical activity, have varied [7, 8].

Diabetes was a serious public health issue in Iraq, and information about the anthropometric characteristics, lifestyle, and

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glycemic management of discharged diabetics is insufficient. Data from local individuals is valuable in explaining the medical history of people receiving diabetes treatment and comparing outcomes with those reported from other locations. Thus, describing the anthropometric, clinical, lifestyle, and demographic traits of people with diabetes is important.

2. Methods

Study Design and Setting

This cross-sectional study was carried out using the medical records of all adult diabetic patients who were seen at the Diabetes and Endocrinology Center of Kirkuk Teaching Hospital, located in Kirkuk, Iraq. It serves as a significant referral center and provides specialized treatment to diabetes patients from Kirkuk as well as from other governorates.

Study Population

Included were data from adults with a confirmed diagnosis of diabetes mellitus whose medical records contained demographic, clinical, anthropometric, and laboratory information, including glycated hemoglobin (HbA1C). Records of women with gestational diabetes were excluded, as were records lacking the variables of interest and those with no HbA1c reading.

Sample Size

Ultimately, 920 records of eligible patients were analyzed.

Data Collection

Medical information was collected from patients' charts and was collected in a "standardized form" in a retrospective fashion. Retrieved characteristics were age, gender, diabetes subtype, duration, smoking habits, diabetes family history, sedentary lifestyle, weight, height, hip circumference, waist circumference, HbA1c, and other pertinent clinical factors. Anthropometric factors included body weight, body height, hip circumference, and waist circumference. Body mass index (BMI) was defined as weight (kg) over height (m2). Waist-to-hip ratio is the waist circumference divided by the hip circumference. BMI was categorized in four groups: underweight score, normal score, overworld score, and over apply score, following the World Health Organization. We used a WHR greater than 0.85 for women and a WHR greater than 0.90 for men as a definition of central obesity.

Diabetes Glycemic Control Assessment

Glycemic control was assessed using routine laboratory investigations documented in the patients' medical records, specifically glycated hemoglobin (HbA1C).↻ HbA1c reflects long-term glycaemic control and is typically used to monitor glycaemic control over the preceding 2-3 months.

According to the American Diabetes Association (ADA), glycemic control was classified as follows:

- Controlled: HbA1c <7.0%
- Suboptimal control: HbA1c 7.0–8.9%
- Poor control: HbA1c ≥9.0%

These categories were used for descriptive analysis and the ordinal logistic regression model. In the binary comparison, glycemic control was classified as better (HbA1c <9.0%) or poor (HbA1c ≥9.0%).

Statistical Analysis

Comparisons of continuous variables between diabetes subtypes were performed using one-way ANOVA, and categorical variables were compared using the chi-square test. The independent-samples t-test was used to evaluate discrepancies for glycemic control [HbA1C ≥9.0% versus HbA1C <9.0%]. The bad/better classification of HbA1c was modeled with binary logistic regression, and glycemic control categories was modeled with ordinal logistic regression. Regression coefficients, odds ratios, as well as confidence 95% intervals were shown. For multicollinearity, VIFs were assessed, and for model fit, Omnibus and Hosmer-Lemeshow tests were used; $P < 0.05$ was considered significant.

3. Results

A total of 920 diabetes adult patients was enrolled in the study. The findings of the multivariable linear and binary logistic analyses are described and compared between the poor and good metabolized groups of the study population for each diabetes type and additionally in terms of characteristics of the diabetes population.

Of the study population, 38.6% were males while 61.4% of them were female. The mean age was 53.7 ± 13.5 years, and the mean diabetes duration was 9.3 ± 7.6 years. Type 2 diabetes was the most common type (89.3%), followed by Type 1a (7.0%) and Type 1b (3.6%).

The average WHR (waist-to-hip ratio) was 1.02 ± 0.13. Central obesity was present in 322 of 355 males (90.7%) and 523 of 565 women (92.6%). The average HbA1c was 9.28 ± 1.90%. The mean ages of all these family members were between 40 and 49 years; 53.6% of them were sedentary, and 48.5% of them had hypertension, and 10.0% of them were current smokers.

Table 1. Enrollment and the demographic features of participants (n = 920).

Characteristic	n	%
Gender		
Female	565	61.4%
Male	355	38.6%
Age (years) Mean ± SD	53.7 ± 13.5	
Diabetes Type 2	822	89.3%
Diabetes Type 1a	64	7.0%
Diabetes Type 1b	33	3.6%
Diabetes Duration (years) Mean ± SD	9.3 ± 7.6	
BMI (kg/m²) Mean ± SD	30.1 ± 6.4	
Normal weight	183	19.9%
Overweight	290	31.5%
Obese	430	46.7%
Underweight	17	1.8%
Waist-to-Hip Ratio (WHR) Mean ± SD	1.02 ± 0.13	
Central obesity — women (WHR>0.85)	523/565	92.6%
Central obesity — men (WHR>0.90)	322/355	90.7%
HbA1c (%) Mean ± SD	9.28 ± 1.90	
Sedentary Lifestyle — Yes	613	66.6%
Hypertension — Yes	446	48.5%
Current Smoker — Yes	92	10.0%
Family History of Diabetes —		
1st degree	467	50.8%
2nd degree	128	13.9%
None	325	35.3%
Frequency (n) and percentage (%)		

Table 2. Distribution of the clinical outcome of glycemic control based on HbA1c categories.

Glycemic Control Category	HbA1c Range	n	%
Controlled	< 7.0%	116	12.6 %
Suboptimal	7.0 – 8.9%	260	28.3 %
Poor Control	≥ 9.0%	544	59.1 %
Frequency (n) and percentage (%), Note: HbA1c thresholds based on American Diabetes Association guidelines.			

In total, 544 (59.1%) had poor glycemic control (HbA1c ≥9.0%), 260 (28.3%) had inadequate glycemic control (HbA1c 7.0–8.9%), and 116 (12.6%) had managed glycemic status (HbA1c <7.0%). Table 3 below presents the anthropometric, clinical, lifestyle, and demographic characteristics of the diabetes subgroups. There were significant differences among the 3 diabetes subgroups with respect to sex, age, BMI, WHC, WHR, hypertension, sedentary lifestyle, and family history of diabetes.

In comparison with those who had Type 1a and Type 1b diabetes, individuals with Type 2 diabetes were considerably older (55.27 ± 12.22 vs. 43.03 ± 15.97 and 34.21 ± 13.39 years, respectively). The mean BMI, hip circumference, waist circumference, and WHR were also greater in these than in any of the Type 1 diabetes groups.

Those with Type 1b predominately had a prevalence of sedentary lifestyle as well, and this was significant (81.8%, P = 0.032). The duration of diabetes, HbA1c level, and current smoking status were not found to be statistically significantly different between the diabetes subtypes (all P=0.602-0.883). There was no difference in statistically significant difference in the duration of diabetes, HbA1C level between the three disease subtypes, or in current smoking status (all P=0.280-0.883.(

Of these two categorical variables, significantly more cases of hypertension were seen in the Type 2 diabetes group compared with Type 1a and 1b diabetics. There was a significant difference between Type 2 versus sedentary life of Type 1a diabetes and Type 2 versus Type 1b diabetes, but not between Type 1a and Type 1b diabetes. The families with type 2 diabetes experienced a history of diabetes different than those with type 1a.

Table 3. Anthropometric outcomes of diabetes subtypes.

Parameter	Type 2 (n=822)	Type 1a (n=64)	Type 1b (n=33)	Test Statistic	p-value
Age (years)	55.27 ± 12.22	43.03 ± 15.97	34.21 ± 13.39	F = 69.24	<0.001
Gender Female n (%) Male n (%)	 509 (61.9%) 313 (38.1%)	 36 (56.3%) 28 (43.8%)	 19 (57.6%) 14 (42.4%)	χ^2 = 1.01	0.602
Diabetes Duration (years)	9.29 ± 7.62	9.44 ± 6.89	9.06 ± 7.66	F = 0.03	0.973
HbA1c (%)	9.29 ± 1.90	9.18 ± 1.92	9.21 ± 1.84	F = 0.12	0.883
BMI (kg/m²)	30.72 ± 6.25	25.04 ± 5.49	25.80 ± 5.47	F = 33.64	<0.001
Waist Circumference (cm)	106.50 ± 14.66	88.41 ± 16.38	89.09 ± 14.59	F = 63.38	<0.001
Hip Circumference (cm)	104.59 ± 14.29	93.59 ± 14.82	94.88 ± 12.10	F = 23.88	<0.001
Waist-to-Hip Ratio (WHR)	1.03 ± 0.13	0.95 ± 0.14	0.94 ± 0.10	F = 17.25	<0.001
Comorbid Hypertension — Yes, n (%)	431 (52.4%)	8 (12.5%)	6 (18.2%)	χ^2 = 50.45	<0.001
Sedentary Lifestyle — Yes n (%)	553 (67.3%)	33 (51.6%)	27 (81.8%)	χ^2 = 10.12	0.006
Current Smoker — Yes (%)	80 (9.7%)	6 (9.4%)	6 (18.2%)	χ^2 = 2.55	0.280
Family History of Diabetes 1st degree n (%) 2nd degree n (%) None n (%)	 420 (51.1%) 123 (15.0%) 279 (33.9%)	 32 (50.0%) 2 (3.1%) 30 (46.9%)	 15 (45.5%) 3 (9.1%) 15 (45.5%)	χ^2 = 10.58	0.032

Waist circumference was the only variable for which the difference was significant. The mean WC of the poor glycemic control group was significantly higher than that of the superior glycemic control group (105.59 ± 13.66 cm vs. 103.16 ± 18.29 cm, P = 0.021).

No significant difference was observed between participants with poor and better glycemic control with regard to age, gender, duration of diabetes, body mass index (BMI), hip circumference, waist-to-hip ratio (WHR), hypertension, sedentary lifestyle, current smoking status, or family history of diabetes.

Table 4. A comparison outline into glycemic control status.

Variable	Poor Control (n=544)	Better Control (n=376)	Test Statistic	p-value
Age (years)	54.28 ± 13.38	52.75 ± 13.53	t = 1.69	0.091
Gender — (Female vs. Male) n (%)	334 (61.4%)	231 (61.4%)	Fisher	1.000
Diabetes Duration (years)	9.67 ± 7.87	8.78 ± 7.08	t = 1.75	0.080
BMI (kg/m²)	30.15 ± 6.09	30.13 ± 6.81	t = 0.04	0.972
Waist Circumference (cm)	105.59 ± 13.66	103.16 ± 18.29	t = 2.31	0.021
Hip Circumference (cm)	103.93 ± 13.67	102.81 ± 15.85	t = 1.15	0.250
Waist-to-Hip Ratio (WHR)	1.02 ± 0.12	1.01 ± 0.14	t = 1.62	0.106
Comorbid Hypertension — Yes n (%)	273 (50.2%)	173 (46.0%)	Fisher	0.227
Sedentary Lifestyle — Yes (%)	362 (66.5%)	251 (66.8%)	Fisher	1.000
Current Smoker — Yes n (%)	48 (8.8%)	44 (11.7%)	Fisher	0.180
Family History of Diabetes— (1st degree vs. Others) n (%)	265 (48.7%)	202 (53.7%)	χ^2 = 3.95	0.139

In every three regression analyzes, there was a positive correlation among poor glycemic control and waist circumference.

Greater waist circumference was related to higher HbA1c levels in the model of linear regression (β = a value of 95% confidence interval (CI): 0.004–0.025, P = 0.008). Waist circumference was also linked to increased odds of uncontrolled diabetes in the ordinal logistic regression model (Odds ratio = 1.016, 95% CI: 1.005–1.027, P = 0.003) and binary logistic regression. However, a greater BMI was linked to somewhat lower chances of low glycemic control within the ordinal & binary logistical regression models (odds ratio = 0.968, 95% confidence interval: 0.941–0.997).

Overall, the binary logistic regression model was statistically significant, indicating that it was a better model than the intercept-only model. Multicollinearity among the predictor variables was not serious (variance inflation factor: 1.02–1.80); good model calibration was demonstrated by the Hosmer–Lemeshow goodness-of-fit test (P = 0.617).

Table 5. Analysis each of anthropometric and lifestyle characteristics who related to glycemic control according to multivariable linear regression.

Predictor / Determinant	Linear β (95% CI)	p-value	Logistic OR (95% CI)	p-value	Ordinal OR (95% CI)	p-value
Anthropometric Determinants						
Body Mass Index (per kg/m²)	-0.021(-0.046, 0.006)	0.128	0.968 (0.941, 0.997)	0.029	0.972 (0.946, 0.998)	0.037
Waist Circumference (per cm)	0.014 (0.004, 0.025)	0.008	1.019 (1.007, 1.031)	0.002	1.016 (1.005, 1.027)	0.003
Lifestyle Determinants						
Sedentary Lifestyle (Yes vs. No)	-0.106 (-0.367, 0.154)	0.424	1.021 (0.770, 1.355)	0.883	1.005 (0.765, 1.320)	0.971
Current Smoking (Yes vs. No)	-0.351 (-0.762, 0.061)	0.095	0.711 (0.459, 1.102)	0.127	0.771 (0.510, 1.167)	0.219

4. Discussion

The present study is a retrospective cross-sectional study that aims to determine anthropometric, clinical, and lifestyle characteristics of adult diabetic patients treated in Kirkuk Teaching Hospital. The relationship between anthropometric and lifestyle parameters with glycemic control was evaluated in MVRAs. The study revealed that obesity, central obesity, and glycemic control issues were very common among the study group. The most common diabetes type observed was Type 2, and there was significant variation in anthropometric features among diabetes types. However, of the anthropometric values measured, only waist circumference was found to be significantly different between the poor and good glycemic-controlled patients.

In addition, it was observed that 59.1% of the investigated people had poor glycemic control (HbA1c ≥ 9.0%) while 12.6% achieved the recommended HbA1c target (< 7.0%). The results of this study revealed that poor glycemic control was still a significant problem for people undergoing treatment for diabetes at the study center. This has been reported in another recent literature review and meta-analysis of LMCB data that showed that approximately 69% of those with T2DM were not properly managed [9, 10]. There was a high prevalence of overweight in the participants of the study. One third of the respondents were overweight, almost half were obese, and over 90% of both the male and the female participants fulfilled the criterion for central obesity. The results were consistent with those of the American Diabetes Association (ADA), which recommended using body fat distribution data—that is, waist circumference and waist-to-hip ratio—in addition to BMI to measure obesity in adults with diabetes [7, 8, 9].

Significant differences were seen when comparing the diabetes subtypes by age or anthropometric measurements. People with Type 2 diabetes were older and had higher BMIs, hip circumferences, waist circumferences, and waist-to-hip ratios than those with Type 1 diabetes [10, 11, 12, 13]. There were significant differences in waist circumference between those without good glycemic control and those with good glycemic control, and for all three multivariable models (linear, binary logistic, and ordinal logistic regression), there was a significant positive association between waist circumference and poorer glycemic control. The logistic regression models had slightly lower odds of poor glycemic control for every degree of BMI increase after adjusting for other variables; however, none of the models for linear regression suggested that HbA1c was related to BMI [14, 15]. Previous studies also have confirmed that central fat levels present a greater clinical value than BMI [16-19].

In the linear regression model, WC was still a significant determinant of increased HbA1C levels, while in the binary and ordinal logistic regression models, this was associated with increased odds of poor glycemic control. The results support the importance of measures of central adiposity in relation to the glycemic status in patients with diabetes, and provide some clinical information beyond BMI that has not been found in other studies [5, 6, 16]. After adjusting for other variables, however, there was some inverse association evident in the logistic regression analyses, but BMI was not significantly associated with HbA1c in the linear regression analysis. Association with glycemic control was found after adjusting for other risk factors, independent of which was current smoking. Systematic recent evaluations have demonstrated similar variability, indicative of population-specific and analytical-model-specific lifestyle factors related to glycemic control [9, 10].

About two-thirds of the individuals were noted to have a sedentary lifestyle. Multivariable regression analyses, however, revealed no relationship between smoking at the study time or sedentary lifestyle with glycemic control. Comparable results have been reported from other investigations [9, 20,21,22,23], so associations between these lifestyle characteristics and glycemic control depend upon the study subjects, assessment of behavior, and context.

Strengths and Limitations

This study has a number of strengths, such as the large sample size and the detailed reporting of demographic, anthropometric, clinical, and lifestyle parameters, obtained from routinely collected clinical data. To complement this evaluative process of body composition in adults with diabetes, several anthropometric measures were performed, such as BMI, WC, and WHR. The other benefit was the combination of multiple linear, binary logistic, and ordinal logistic regression analyses; the analyses were used to explore the relationship between anthropometric or lifestyle factors on glycemic control in different ways.

Certain restrictions can be outlined. First, it is a retrospective cross-sectional design, limiting any interpretation of associations during the study period from being interpreted as representing temporal relations. Secondly, this is a single tertiary care centre and may not be representative for other healthcare settings or all diabetics. Third, analyses used available data from medical records, and some important variables that could be relevant were missing, such as objective indications of treatment regimen, physical activity, and intake of food and drinks. Last, due to the nature of the data used (routinely collected clinical data), unmeasured confounding cannot be ruled out.

5. Conclusion

A retrospective cross-sectional study which describes the anthropometric and lifestyle factors of adult diabetic patients at Kirkuk Teaching Hospital. In this study population, glycemic control was poor, with almost half (48%) having an HbA1c level ≥ 9.0%. The most common disease type was type 2 diabetes, and obesity and central obesity were quite common.

The anthropometric parameter most strongly related with glycemic control was waist circumference. In the multivariable linear regression model, waist circumference was significantly higher among those with poor glycemic control compared with those with better glycemic control in all of the regression models. In all multivariable regression models, waist circumference was significantly greater among persons with poor glycemic control compared with persons with better glycemic control. Following adjustment, BMI and WHR were not independently related to glycemic control, while age, diabetes duration, sedentary lifestyle, or smoking were unrelated.

As a result of this study, the anthropometric and clinical data of this population with diabetes and under treatment with an Iraqi tertiary diabetes hospital can be added to the current body of knowledge. Further large-scale multi-center studies are recommended to confirm these findings and expand the knowledge of anthropometric traits and glycemic control among the Iraqi patients suffering with diabetes mellitus and other clinical and behavioral factors.

Author contributions

All the authors were involved in the design and conceptualization of the study. Some members of the research team participated in both data collection and laboratory analysis, whereas the others participated in statistical analysis. Interpretation of data, draft and revision of the manuscript was done by all authors, and they approved the final version for publication.

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Author Contributions:

Waleed Mohammed Ali; Basher Kareem Mohammed; Rabab Jumaa Asghar— Clinical oversight, medical interpretation, manuscript review

Conflicts of Interest:

The authors declare no conflicts of interest.

Ethics Approval:

This study was approved with approval No. 331 and issued on April 6, 2026, by the National Center of Training as well as Human Development under the direction of the Health Directorate in Kirkuk, Al-Qadriyah, and the Iraqi Ministry of Health. De-identified, publicly available NHANES data are used in the study. All individuals gave written informed permission at the time of data collection, and the NCHS Institutional Review Board approved the initial NHANES procedure.

Use of generative AI: Claude (Anthropic, Claude Opus 4, 2026) was used for manuscript language polishing, formatting assistance, and generation of the DOCX document from structured notes. The ML pipeline, all statistical analyses, data interpretation, and scientific conclusions were produced by the first author (SN) and reviewed by the co-author (WMA). Both authors verified all content and

take full responsibility for the work.

Data Availability

NHANES data are publicly available at https://www.cdc.gov/nchs/nhanes/. NDI-linked mortality files are at https://www.cdc.gov/nchs/data-linkage/mortality.htm. Analysis scripts and frozen model files are available from the corresponding author upon reasonable request.

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