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Article

Anthropometric and Laboratory Markers Associated with Glycemic Imbalance in Adults on Insulin Therapy

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Abstract

Objectives: To analyze the anthropometric and laboratory levels associated in adults with diabetes on insulin therapy, monitored by Brazilian Primary Health Care. **Methods:** Cross-sectional study conducted from August 2024 to January 2025 in 17 Basic Health Units. The final sample included 60 adults (≥ 18 years) with confirmed type 1 or type 2 diabetes, responsible for insulin preparation and self-administration for at least 6 months. Sociodemographic, clinical, anthropometric, and laboratory data (HbA1c, fasting blood glucose, and blood pressure) were collected by trained undergraduate researchers. Normality was tested using the Shapiro-Wilk test, and variables were described using means, SD, 95% CI, and absolute/relative frequencies. One-sample t-tests compared observed means to international clinical targets ($p < 0.05$). **Results:** Most of participants had type 2 diabetes (71.7%), diagnosed >10 years ago (54.9%), and 50% did not perform daily self-monitoring of blood glucose. Insulin therapy was long-established with 90% with >1 year of continuous use. Clinical means were significantly higher than recommended targets for HbA1c (mean = 9.08%; 86.7% altered; $p < 0.001$) and fasting blood glucose (mean = 198.7 mg/dL; 81.7% altered; $p < 0.001$). Overweight/excess adiposity were frequent (BMI mean = 26.5 ± 4.85 ; 58.3% altered), and 63.3% had increased waist circumference. Calf and neck circumferences suggested emerging body-composition risk in part of the sample. **Conclusions:** Adults on established insulin therapy showed persistent glycemic imbalance and a high frequency of clinically anthropometric risk markers. The findings reinforce the need for individualized metabolic monitoring structured PHC interventions to support safe insulin self-administration.

Keywords: diabetes mellitus; insulin therapy; primary health care; glycemic control; anthropometric markers; social vulnerability; self-administration

1. Introduction

Diabetes Mellitus (DM) is a chronic, non-communicable disease characterized by persistent hyperglycemia resulting from impaired insulin production and/or action. When left untreated or uncontrolled, DM contributes to the development of cardiovascular, renal, and metabolic complications, ranking among the ten leading causes of mortality in adults worldwide [1,2].

Across the globe, an estimated 589 million adults between the ages of 20 and 79 have diabetes (11.1% of all adults in this age group), a figure that could reach 852.5 million by 2050 [3]. Brazil follows this trend, with over 16 million adults living with the disease, making it the sixth-largest country in the world with the highest number of people living with diabetes [4]. It is estimated that 12% of the Brazilian population has a confirmed diagnosis of the disease, with a growing trend driven by population aging and lifestyle changes [5].

Glycemic control in DM involves both behavioral changes that require an adequate diet and regular exercise, as well as the use of oral or injectable medications [6]. Insulin therapy stands out as a fundamental step in treatment, especially in individuals with type 1 DM (T1DM) and those with type 2 DM (T2DM) who do not achieve control goals with other strategies [7].

Despite therapeutic advances, insulin use still faces significant challenges. Strict care is required in the preparation, storage, and administration of the medication, in addition to technical expertise for correct dose adjustment [8]. Factors such as individual differences in insulin sensitivity, abdominal obesity, and the risk of hypoglycemia require constant monitoring and qualified guidance [9].

Another common obstacle is so-called therapeutic inertia, characterized by delayed initiation of insulin therapy, often associated with patient resistance, lack of access, or lack of preparedness on the part of health services [8,10]. Furthermore, users' lack of technical knowledge and the lack of training of health professionals, combined with limited access, contribute to glycemic imbalance and worsening diabetes complications. This situation highlights the need for continued improvement in Primary Health Care (PHC) and the expansion of health education initiatives focused on self-care and safe insulin use. The PHC, as the preferred gateway to the Brazilian healthcare system, the Unified Health System, occupies a strategic position in the monitoring of people with diabetes, especially those using insulin therapy. Through consultations, home visits, and educational initiatives, PHC professionals must assess treatment conditions, guide the preparation and proper use of insulin, and promote self-care tailored to individual needs [12,13].

Strengthening PHC initiatives focused on clinical monitoring and self-management support is essential to reduce DM-related complications, including cardiovascular disease, kidney failure, and amputations, as well as to prevent avoidable hospitalizations [12]. However, reaching this potential requires structural investments in infrastructure, professional training, and public policies tailored to mitigate persistent barriers in access and social vulnerabilities, particularly in high-burden, lower-resource regions such as Northeast Brazil [13]. Within this context, and considering the complexity of insulin preparation, storage, dose adjustment, and self-administration, understanding both the clinical condition and the sociodemographic determinants that shape metabolic outcomes in adults on long-term insulin therapy becomes crucial for informing individualized PHC-based interventions with greater prognostic relevance. Thus, this study aims to analyze the anthropometric and laboratory levels associated in adults with diabetes on insulin therapy, monitored by Brazilian Primary Health Care.

2. Materials and Methods

This is a cross-sectional study conducted with individuals with diabetes undergoing insulin therapy, monitored by the Brazilian Primary Health Care system. The research was carried out between August 2024 and January 2025 in 17 Basic Health Units (BHUs) located in the city of Floriano, in the state of Piauí, northeastern Brazil.

The sample size was calculated based on a total of 2,674 individuals with diabetes registered and followed by Primary Health Care. Among them, only 13.6% were using insulin. The sample size was calculated using the formula for finite populations: $n = (Z^2 \times p \times (1-p) \times N) / [(e^2 \times (N-1)) + (Z^2 \times p \times (1-p))]$, where $N=2,674$, $p=0.5$, $e=0.05$, and $Z=1.96$ (95% confidence). The minimum required sample size was 46 individuals. However, to account for potential losses, a 20% increase was applied, resulting in a final sample of 60 participants.

The eligibility criteria for this study were: a confirmed diagnosis of type 1 or type 2 diabetes recorded in medical and/or electronic health records; current use of insulin, with or without the association of oral antidiabetic drugs, for at least six months—considering dosage stabilization; being responsible for the pre-preparation, preparation, and administration of insulin doses; and being ≥ 18 years of age. Conversely, individuals using insulin pumps, pregnant women, and those who used insulin only as a supplemental dose at non-predefined times were excluded from the study.

For data collection, authorization was requested from the Municipal Health Department. After approval, visits were made to each of the 17 Basic Health Units located in the urban area of the city. The researchers explained the objectives of the study to nurses and community health agents, who then assisted in recruiting participants by delivering invitations. Data collection took place in the mornings at the health units, on scheduled dates and times. Participants were instructed to arrive fasting and wear light clothing for blood collection and anthropometric assessments.

Data were collected using a structured instrument developed by the authors, which was previously piloted before the start of data collection. A team composed of three nursing students was trained to collect sociodemographic data (age, sex, educational level, marital status, skin color, income, and religion) and diabetes-related variables (type of diabetes, time since diabetes diagnosis, daily capillary blood glucose monitoring, episodes of hypoglycemia, hyperglycemia, hospitalization in the 30 days prior to data collection, alcohol and tobacco use, physical activity, type of insulin used, and duration of insulin use).

The team also collected anthropometric data (body weight, arm circumference considered low if < 22 cm) [14], waist circumference (high if ≥ 88 cm for women and ≥ 102 cm for men) [15], calf circumference (indicative of muscle depletion if < 31 cm) [16], thigh circumference (low if < 45 cm, with variations according to sex and age), neck circumference (increased if ≥ 37 cm for men and ≥ 34 cm for women), body adiposity index – BAI (obesity defined as $\text{BAI} \geq 35\%$ for women and $\geq 25\%$ for men), and body mass index – BMI (normal range: $18.5\text{--}24.9$ kg/m²; overweight: $25.0\text{--}29.9$ kg/m²; obesity: ≥ 30.0 kg/m²) [17], and systolic and diastolic blood pressure (normal $< 120/80$ mmHg; hypertension if $\geq 140/90$ mmHg, according to the VI Brazilian Guidelines on Hypertension). Anthropometric measurements followed WHO standards. Weight was measured using a calibrated digital scale (Seca®), and circumferences were assessed using a non-elastic anthropometric measuring tape.

Regarding laboratory variables (glycated hemoglobin – HbA1c, considered adequate if $< 7.0\%$ according to the American Diabetes Association; and fasting blood glucose, normal if < 100 mg/dL), blood samples were collected by trained phlebotomists and analyzed at the municipal laboratory using high-performance liquid chromatography (HPLC) with a Bio-Rad® Variant II analyzer.

Statistical analysis was performed using JAMOVI software. All data were double-checked by two independent researchers. Outliers and inconsistencies were verified against the original records. The normality of continuous variables was assessed using the Shapiro-Wilk test.

Categorical variables were described using absolute and relative frequencies (%), including sex, marital status, skin color, religion, education level, type of diabetes, time since diagnosis, daily capillary blood glucose monitoring, occurrence of hypoglycemia and hyperglycemia in the last 30 days, hospitalization due to diabetes-related complications in the last 30 days, alcohol and tobacco use, physical activity, type of insulin used, and duration of insulin therapy. Continuous variables were presented as means, standard deviations (SD), and 95% confidence intervals (95% CI), including monthly income, age, body weight, arm, waist, calf, thigh, and neck circumferences, body adiposity index (BAI), body mass index (BMI), glycated hemoglobin (HbA1c), fasting blood glucose, and systolic and diastolic blood pressure.

For continuous clinical and anthropometric variables, one-sample t-tests were performed to compare the observed means with established clinical reference values. A significance level of 5% ($p < 0.05$) was adopted. Categorization of variables (normal vs. altered) was based on internationally recognized clinical cut-off points.

The study was approved by the Human Research Ethics Committee of the Federal University of Piauí under protocol number 6,746,565/2024.

3. Results

The participants ($n = 60$) had a mean age of 58.5 years ($SD = 18.3$), indicating a predominantly middle-aged to older adult population. The average monthly income was 2.76 minimum wages

(USD= 737.00; SD= 2.2), suggesting socioeconomic vulnerability in part of the sample. The sample was composed mostly of female participants (56.7%) and individuals who were married (58.3%).

A significant proportion self-identified as Black (71.7%), and the vast majority declared Christianity as their religion (83.3%). In terms of educational level, 36.7% had between 1 and 9 years of schooling, while 21.7% were illiterate, reinforcing educational inequalities. Most individuals had type 2 diabetes (71.7%), with 54.9% having been diagnosed for more than 10 years, reflecting a population with a long-term condition. Only half of the participants performed daily blood glucose monitoring (50%). In the 30 days prior to data collection, 45% experienced hypoglycemia, 50% reported hyperglycemia episodes, and 8.3% were hospitalized due to diabetes-related complications. Regarding lifestyle, 15% reported alcohol use, and 3.3% used tobacco products.

Only 31.7% engaged in regular physical activity, indicating a low prevalence of healthy behavior among participants. Concerning insulin therapy, 56.7% used NPH insulin alone, followed by 31.7% using other insulin types, while only 1.7% used regular insulin alone. Half of the participants had been using insulin for 1 to 5 years (50%), and 40% for 6 to 10 years, indicating an established pattern of insulin dependence (Table 1).

Table 1. Sociodemographic and clinical characteristics of the individuals with diabetes undergoing insulin therapy monitored by the Primary Health Care. Florianópolis, Piauí, Brazil, 2025. (n = 60).

Variables	n (%)
Sex	
Female	34 (56.7)
Male	26 (43.3)
Marital status	
Married	35 (58.3)
Single	25 (41.7)
Skin color	
White	12 (20)
Black	43 (71.7)
Mixed	5 (8.3)
Religion	
Christian	50 (83.3)
Others	10 (16.7)
Education	
Illiterate	13 (21.7)
1-9 years	22 (36.7)
10-12 years	14 (23.3)
Over 13 years	11 (18.3)
Type of diabetes	
Type 1 diabetes	17 (28.3)
Type 2 diabetes	43 (71.7)
Time since diagnosis	
< 1 year	1 (1.7)
1-5 years	7 (11.7)
6-10 years	19 (31.7)
> 10 years	32 (54.9)
Daily blood glucose monitoring	

Yes	30 (50)
No	30 (50)
Hypoglycemia in the last 30 days	
Yes	27 (45)
No	33 (55)
Hyperglycemia in the last 30 days	
Yes	30 (50)
No	30 (50)
Hospitalization due to diabetes in the last 30 days	
Yes	5 (8.3)
No	55 (91.7)
Uses alcohol	
Yes	9 (15)
No	51 (85)
Uses tobacco	
Yes	2 (3.3)
No	58 (96.7)
Does physical exercise	
Yes	19 (31.7)
No	41 (68.3)
Type of insulin used	
NPH	34 (56.7)
Regular	1 (1.7)
NPH + Regular	6 (10)
Other insulins	19 (31.7)
Time using insulin	
< 1 year	6 (10)
1-5 years	30 (50)
6-10 years	24 (40)

Participants had a mean body weight of 66.5 kg (95% CI: 63.2–69.9), with an average body mass index (BMI) of 26.5 kg/m² (95% CI: 25.2–27.8), indicating a general trend toward overweight in the sample. The waist circumference averaged 91.5 cm (95% CI: 87.8–95.3), a value considered elevated for women and approaching the cutoff point for men, suggesting increased cardiometabolic risk. Regarding limb measurements, the arm circumference averaged 29.6 cm (95% CI: 28.2–30.9), while the calf circumference was 33.0 cm (95% CI: 31.8–34.2), above the threshold for muscle mass depletion. The thigh circumference was 45.4 cm (95% CI: 43.2–47.6), and neck circumference reached 37.6 cm (95% CI: 36.3–38.8), bordering the threshold associated with cardiovascular risk in men. The body adiposity index (BAI) averaged 28.3% (95% CI: 26.0–30.5), indicating excess adiposity, particularly for male participants. Mean glycated hemoglobin (HbA1c) was 9.08% (95% CI: 8.55–9.62), well above the recommended target of <7.0%, reflecting poor glycemic control. Similarly, fasting blood glucose averaged 199.0 mg/dL (95% CI: 178.0–220.0), also indicating significant hyperglycemia. Regarding hemodynamic parameters, systolic blood pressure averaged 125.0 mmHg (95% CI: 121.0–129.0), and diastolic pressure was 77.5 mmHg (95% CI: 74.9–80.0), with values close to the thresholds for hypertension, particularly for systolic pressure (Table 2).

Table 2. Descriptive statistics of anthropometric and laboratory variables among individuals with diabetes undergoing insulin therapy. Floriano, Piauí, Brazil, 2025. (n = 60).

Variables	Mean	CI 95%	SD
Weight	66.5	63.2-69.9	13.0
Arm Circumference	29.6	28.2-30.9	5.29
Waist Circumference	91.5	87.8-95.3	14.4
Calf Circumference	33.0	31.8-34.2	4.61
Thigh Circumference	45.4	43.2-47.6	8.58
Neck Circumference	37.6	36.3-38.8	4.81
BAI	28.3	26.0-30.5	8.67
BMI	26.5	25.2-27.8	4.85
HbA1c	9.08	8.55-9.62	2.08
Fasting blood glucose	199.0	178.0-220.0	80.7
Systolic Blood Pressure	125.0	121.0-129.0	14.0
Diastolic Blood Pressure	77.5	74.9-80.0	9.91

Most of participants presented altered clinical and anthropometric parameters. The mean HbA1c was 9.08% (SD = 2.08), significantly higher than the clinical target of 7.0% ($p < 0.001$), with 86.7% of participants classified as having inadequate glycemic control. Similarly, the mean fasting blood glucose was 198.7 mg/dL (SD = 80.7), with 81.7% classified as altered ($p < 0.001$). In terms of body composition, 85% of participants had abnormal BMI (overweight or obesity), and 63.3% showed increased waist circumference. Calf circumference was reduced in 20% of the sample, suggesting potential muscle mass depletion. Neck circumference was above the clinical threshold in over half of the participants, and 86.7% showed altered BAI. Most of the clinical parameters assessed were significantly different from recommended cut-off points (Table 3).

Table 3. Classification of normal and altered values among individuals with diabetes undergoing insulin therapy, according to anthropometric and laboratory variables and clinical cut-off points. Floriano, Piauí, Brazil, 2025 (n = 60).

Variables	n	%	Mean	SD	CI95%	p value*
HbA1c (%)			9.08	2.08	8.55-9.61	<0.001
Normal	8	13.33%				
Altered	52	86.67%				
Fasting Glucose (mg/dL)			198.68	80.73	178.25-219.11	<0.001
Normal	11	18.33%				
Altered	49	81.67%				
Systolic BP (mmHg)			125.0	13.96	121.47-128.53	<0.001
Normal	49	81.67%				
Altered	11	18.33%				
Diastolic BP (mmHg)			77.47	9.91	74.96-79.98	<0.001
Normal	47	78.33%				

Altered	13	21.67%				
BAI			28.25	8.67	26.06-30.44	0.0051
Normal	19	31.67%				
Altered	41	68.33%				
BMI			26.5	4.85	25.27-27.73	0.0197
Normal	25	41.67%				
Altered	35	58.33%				
Waist Circumference (cm)			91.52	14.43	87.87-95.17	0.0633
Normal	26	43.33%				
Altered	34	56.67%				
Calf Circumference (cm)			33.02	4.61	31.85-34.19	0.0012
Normal	48	80.0%				
Altered	12	20.0%				
Neck Circumference (cm)			37.57	4.81	36.35-38.79	0.3625
Normal	29	48.33%				
Altered	31	51.67%				
Thigh Circumference (cm)			45.38	8.58	43.21-47.55	0.7316
Normal	33	55.0%				
Altered	27	45.0%				
Arm Circumference (cm)			29.57	5.29	28.23-30.91	<0.001
Normal	58	96.67%				
Altered	2	3.33%				

*One-sample t-test.

4. Discussion

Evidence shows that sex, age, skin color, time since diagnosis, and smoking are some of the demographic and lifestyle factors that contribute to the development of complications in people with diabetes. Furthermore, parameters related to obesity, hyperglycemia, hypertension, and dyslipidemia are also clinical predictors that should be considered for better prognostic accuracy when approaching people with the disease [18].

This study observed that the profile of patients using insulin therapy was mostly women with T2DM, with a mean age of 58 years, black skin color, married, with less than 13 years of education, with more than 10 years of diagnosis of the disease, and having been using NPH insulin for more than a year. It was also observed that the mean weight of the participants was 66.5 kg, with a waist circumference of 91.5 cm, BMI of 26.5 kg/m2, and BAI of 28.3%. Regarding blood glucose levels, the mean HbA1c was 9.08% and fasting glucose of 199 mg/dL. These elevated glycemic markers, alongside the high prevalence of overweight and obesity (83.9%) within similar patient cohorts,

underscore the critical need for intensified therapeutic interventions beyond current insulin regimens [19].

Our study findings are like others conducted in Indonesia and Switzerland, where the average age of people with diabetes was between 59 and 64 years [20,21]. This may be related to the fact that T2DM is more prevalent in people over 40, particularly due to sedentary lifestyles, excess weight, and a family history of DM [22]. Among those using insulin, aging may be a limiting factor for the development of skills and the autonomy of self-administration. The literature shows that people over 60 years of age were more likely to have poor glycemic control compared to younger individuals. This may be because older individuals have impaired cognitive abilities, and as they age, their executive functioning begins to decline, which is necessary for achieving glycemic control [23]. Furthermore, diminished visual acuity and fine motor skills in elderly patients can significantly impede proper insulin administration techniques, contributing to suboptimal glycemic management. Moreover, the complexity of insulin regimens, often involving multiple daily injections and dose adjustments, can further exacerbate these challenges in older adults [24].

Black skin color, low education level, and low income were common factors among the patients studied. According to Ref. [25], Black people with diabetes are more likely to be undertreated and to be treated by lower-quality physicians and health services or those with fewer resources available for quality care. Furthermore, people from lower socioeconomic backgrounds may have reduced DM control rates, as well as limited access to preventive care, and, therefore, have high rates of complications and morbidity, as well as greater need for medical care and lower rates of hospital and specialized care [26]. These results can lead to weaknesses in disease control. Related to this, low education level is related to difficulty understanding care for disease control and prevention of complications [27,28]. In those who use insulin, it is worth noting that low levels of education can be a weakness for the correct administration of this drug [27]. Moreover, individuals with lower educational attainment often demonstrate reduced eHealth literacy, impacting their ability to effectively utilize digital tools for diabetes management and potentially contributing to suboptimal glycemic control [21].

The most common time since diagnosis among patients using insulin therapy was more than 10 years, which corroborates the findings of a study conducted in another city in northeastern Brazil [22], in which the most prevalent time since DM diagnosis was 10 to 19 years. A Brazilian study of elderly individuals highlights that the time since diabetes diagnosis significantly influences quality of life. In this context, the time since the disease has been developing is considered an important variable, since the longer the time since diagnosis, the lower the adherence to treatment tends to be, which consequently increases the risk of complications related to inadequate metabolic control [29]. This extended duration of diabetes often correlates with a decreased health-related quality of life, particularly in older patients with Type 2 Diabetes, further complicating adherence and overall management [24]. Additionally, the cumulative effect of chronic hyperglycemia over prolonged periods significantly increases the risk of microvascular and macrovascular complications, thereby intensifying the need for rigorous and sustained glycemic management [30].

The participants in this study were mostly sedentary, with only 31.7% engaging in physical exercise. These findings corroborate those of Ref. [28], who observed a low prevalence of regular physical exercise among people with diabetes. A systematic review with meta-analysis indicates that physical exercise is crucial for promoting a decrease in HbA1c levels in people with T2DM, thus reducing complications associated with the disease [31]. This is because regular physical activity improves insulin sensitivity and glucose utilization, both of which are critical for maintaining euglycemia and mitigating the progression of diabetic complications [32]. Conversely, a high frequency of individuals with type 2 diabetes not engaging in physical activity is consistently observed, underscoring a significant barrier to effective non-pharmacological glycemic control [33].

Recent insulin use was also reported by the participants. In this regard, a study conducted in Spain, which aimed to identify barriers to initiating insulin therapy, showed that fear of hypoglycemia, the need for blood glucose monitoring, the injection method of insulin administration,

social rejection associated with the stigma of injections, weight gain, and the feeling of initial treatment failure are factors that contribute to therapeutic inertia at the beginning of treatment [34]. In turn, an integrative review on the topic showed that one of the limiting factors for good diabetes management is the lack of knowledge about insulin handling and administration techniques [35]. This highlights the need for and importance of establishing assertive clinical protocols and introducing practices to identify and manage these sociodemographic determinants in the care of people with diabetes using insulin.

Also in the present study, the BAI, BMI and WC were investigated, which are predictors that contribute to diabetes [36]. Participants had a BMI indicating a general tendency toward overweight, a WC value considered high for women and close to the cutoff point for men, suggesting increased cardiometabolic risk, and a BAI indicating excess adiposity, particularly for male participants. Regarding BAI, it is known that fat distribution is generally associated with an increased risk of cardiovascular disease, dyslipidemia, and insulin resistance [37]. These anthropometric indicators collectively signify a heightened risk for metabolic syndrome and its associated complications in the study population [38]. The prevalence of overweight and obesity, often indicated by elevated BMI and WC measurements, is a significant determinant of glycemic control challenges, necessitating targeted interventions [19].

Still on this subject, a study carried out with more than 70 thousand elderly Chinese people with T2DM showed that anthropometric indicators were strongly associated with diabetes, with WC being more predictive among men, and BMI better adjusted for women [39]. Another study, this time carried out in Colombia, showed that in addition to WC, BMI and BAI are also good anthropometric predictors for identifying T2DM among men, and WC and conicity index are more assertive for women [40]. Meta-analysis showed a linear association between anthropometric markers and metabolic changes that lead to diabetes and its complications [41]. That is, changes in these markers are good indicators for identifying glycemic dysregulation and are essential for assessment in Primary Health Care, especially among those using insulin, who generally have more complex care needs. Furthermore, these indicators also signal a higher risk of multimorbidity, and negative outcomes that prevent patients from performing their activities of daily living, such as lower extremity arterial disease [42].

Glycemic parameters such as HbA1c and fasting glucose were also elevated in most study participants, reflecting inadequate glycemic control. These findings corroborate another study, in which most patients had HbA1c levels greater than 7% [43]. In addition, evidence indicates that poor management of insulin application by patients can generate higher levels of this biomarker, as well as being more associated with lipohypertrophy [44]. This is no different in people with fasting glucose dysregulation. The prevalence of comorbidities, such as hypertension and dyslipidemia, further exacerbates the complexity of diabetes management, increasing the risk of diabetes-related complications [45]. This aligns with broader observations in Type 2 Diabetes populations, where a substantial proportion of individuals exhibit suboptimal glycemic control, often complicated by coexisting conditions like hypertension and hypercholesterolemia [45,46].

A meta-analysis on the topic showed that the estimated overall prevalence of glycemic control among patients with T2DM using insulin was only 26% [47], demonstrating low effectiveness of glycemic management through this practice, potentially increasing the risk of preventable complications. This highlights the need for supportive strategies among researchers, specialists, clinicians, patients, and caregivers, including closer monitoring, improved functional health literacy, and even the use of technologies such as continuous sensors to prevent adverse outcomes. The literature also shows that diabetes self-management, attitude toward insulin treatment, insulin injection technique, and self-monitoring of blood glucose are significantly associated with good glycemic control [48]. Furthermore, the results of this study also challenge policymakers to consider more assertive decisions for the target audience.

This study's limitations include a small, non-probabilistic sample, which compromises generalizability, and its cross-sectional design, which impedes causality. However, the findings of

this research represent important determinants and potential predictors of mandatory investigation and clinical management when caring for people with diabetes on insulin therapy.

5. Conclusions

The main sociodemographic characteristics of people with diabetes receiving insulin therapy in Primary Health Care were linked to long-term disease occurrence, low education level, and vulnerable socioeconomic conditions. Anthropometric and clinical analysis revealed a predominance of overweight, excess adiposity, especially in BAI and BMI, and significant glycemic alterations in HbA1c and fasting glucose, reflecting inadequate glycemic control. These findings reinforce the importance of individualized monitoring strategies, health education, and encouragement of diabetes self-management, including correct insulin administration techniques and glycemic monitoring, especially in contexts of social vulnerability and long-term disease.

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Informed Consent Statement: Informed consent was obtained from all subjects involved in the study. Written informed consent has been obtained from the patient(s) to publish this paper.

Data Availability Statement: Data supporting the results of this study are not publicly archived due to ethical and privacy considerations involving patient information. The underlying dataset was generated by the research team and can be made available upon reasonable request directly to the corresponding author, who takes full responsibility for data stewardship and integrity at the MDPI journal network. Requests for data access should be sent directly to the corresponding author, who will evaluate and securely share the dataset in compliance with ethical approvals and applicable data protection standards.

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Conflicts of Interest: The authors declare no conflicts of interest.

Abbreviations

The following abbreviations are used in this manuscript:

BAI	Body Adiposity Index
BHUs	Basic Health Units
BMI	Body Mass Index
DM	Diabetes Mellitus
HbA1c	Glycated Hemoglobin
PHC	Primary Health Care
WC	Waist Circumference

References

1. Vieira, JT; Mota, FGA; Mota, JVF; Paz, SV; Queiroz, DT; Diogenes, LMMB; Gonçalves, VF; Esmeraldo, GROV. Caracterização clínica e epidemiológica dos usuários com diabetes mellitus: revisão integrativa. *Conjecturas*. **2022**, 24, 1025–1045, <https://doi.org/10.53660/CONJ-1908-2W85>.
2. Cabascango, KEC; Anrango, JPA; Grijalva, MCF. Incertidumbre y afrontamiento en pacientes con diagnóstico de diabetes mellitus. *Revista Eugenio Espejo*. **2025**, 19, 44-59, <https://doi.org/10.37135/ee.04.22.04>.
3. International Diabetes Federation. *The Diabetes Atlas*. 11th ed.; IDF: Brussels, **2023**. Available online: <https://diabetesatlas.org> (accessed on 26 June 2025).
4. Deina, C; Fogliatto, FS; Reis, MAD; Schaan, BD. Machine learning for high-risk hospitalization prediction in outpatient individuals with diabetes at a tertiary hospital. *Arch Endocrinol Metab*. **2025**, 69, e230348, <https://doi.org/10.20945/2359-4292-2024-0317>.
5. Brasil, Ministério da Saúde. *Vigitel Brasil 2023: vigilância de fatores de risco e proteção para doenças crônicas por inquérito telefônico: estimativas sobre frequência e distribuição sociodemográfica de fatores de risco e proteção para doenças crônicas nas capitais dos 26 estados brasileiros e no Distrito Federal em 2023*. Ministério da Saúde: Brasília, **2023**. Available online: http://bvsmis.saude.gov.br/bvs/publicacoes/vigitel_brasil_2023.pdf (accessed on 26 June 2025).
6. Moraes, HAB; Mengue, SS; Molina, MCB; Cade, NV. Fatores associados ao controle glicêmico em amostra de indivíduos com diabetes mellitus do Estudo Longitudinal de Saúde do Adulto, Brasil, 2008 a 2010. *Epidemiol Serv Saúde*. **2020**, 29, e2018500, <https://doi.org/10.5123/S1679-49742020000300017>.
7. Silva Júnior, WS; Gabbay, MAL; Lamounier, RN. Insulinoterapia no diabetes mellitus tipo 1 (DM1). *Diretriz Oficial da Sociedade Brasileira de Diabetes*. **2021**, <https://doi.org/10.29327/557753.2022-5>.
8. Yang, A; Yu, J; Cheung, JTK; Chan, JCN; Chow, E. Real world evidence of insulin and biosimilar insulin therapy—Opportunities to improve adherence, outcomes and cost effectiveness. *Diabetes Obes Metab*. **2025**, 27, 45–62, <https://doi.org/10.1111/dom.16386>.
9. Apostolopoulou, M; Lambadiari, V; Roden, M; Dimitriadis, GD. Insulin Resistance in Type 1 Diabetes: Pathophysiological, Clinical, and Therapeutic Relevance. *Endocr Rev*. **2025**, 46, 317-348, <https://doi.org/10.1210/endrev/bnae032>.
10. Home, PD. An overview of insulin therapy for the non-specialist. *Diabetes Obes Metab*. **2025**, 27, 3–15, <https://doi.org/10.1111/dom.16280>.
11. Reis, P; Marcon, SS; Teston, EF; Nass, EMA; Ruiz, AGB; Francisqueti, V; Silva, ES; Otero, LM. Educational intervention on insulin knowledge and management at home. *Acta Paul Enferm*. **2020**, 33, eAPE20190241, <https://doi.org/10.37689/acta-ape/2020AO0241>.
12. Tomasi, E; Silveira, DS; Neves, RG; Thumé, E; Cesar, MADC; Barros, NR; Facchini, LA. Indicadores de qualidade da atenção a usuários com diabetes na Atenção Primária à Saúde do Brasil: 2012 e 2018. *Rev Bras Med Fam Comunidade*. **2024**, 19, 3678-3678, [https://doi.org/10.5712/rbmfc19\(46\)3678](https://doi.org/10.5712/rbmfc19(46)3678).
13. Almeida, MM; Santana, BFL; Requião, BH; Oliveira, KAS; Feres, ABS. Diabetes mellitus: manejo e prevenção das suas complicações na atenção primária à saúde. *Revista Eletrônica Acervo Saúde*. **2024**, 24, e16805-e16805, <https://doi.org/10.25248/reas.e16805.2024>.
14. World Health Organization (WHO). Physical status: the use and interpretation of anthropometry. Report of a WHO Expert Committee. *World Health Organ Tech Rep Ser*. **1995**, 854, 1-452. Available online: <https://pubmed.ncbi.nlm.nih.gov/8594834/> (accessed on 26 June 2025).
15. World Health Organization. Waist circumference and waist-hip ratio: report of a WHO expert consultation. *World Health Organization*. **2008**, 8-11. Available online: <https://iris.who.int/handle/10665/44583> (accessed on 26 June 2025).
16. Rolland, Y; Lauwers-Cances, V; Cristini, C; Abellan van Kan, G; Janssen, I; Morley, JE; Vellas, B. Difficulties with physical function associated with obesity, sarcopenia, and sarcopenic-obesity in community-dwelling elderly women: the EPIDOS (EPIDemiologie de l'OSteoporose) Study. *Am J Clin Nutr*. **2009**, 89, 1895–1900, <https://doi.org/10.3945/ajcn.2008.26950>.
17. Vasques, AC; Rosado, L; Rosado, G; Ribeiro, RC; Franceschini, S; Geloneze, B. Indicadores antropométricos de resistência à insulina. *Arq. Bras. Cardiol*. **2010**, 95, e14–23, <https://doi.org/10.1590/S0066-782X2010001100025>.

18. Schiborn, C; Schulze, MB. Precision prognostics for the development of complications in diabetes. *Diabetologia*. **2022**, 65, 1867-1882, <https://doi.org/10.1007/s00125-022-05731-4>.
19. Ferreira, PL; Morais, C; Pimenta, R; Ribeiro, I; Amorim, I; Alves, SM; Santiago L. Knowledge about type 2 diabetes: its impact for future management. *Front Public Health*. **2024**, 12, 1328001, <https://doi.org/10.3389/fpubh.2024.1328001>.
20. Permana, H; Koesoemadinata, RC; Soetedjo, BNM; Dewi, NF; Jayanti, N; Imaculata, S; Ruslami, R; Alisjahbana, B; McAllister, SM. Diabetes mellitus patients in Indonesia: management in a tertiary hospital compared to primary health care. *Universa Medicina*. **2022**, 41, 157-168, <https://doi.org/10.18051/UnivMed.2022.v41.157-168>.
21. Jendly, M; Santschi, V; Tancredi, S; Konzelmann, I; Raboud, L; Chiolero, A. eHealth profile of patients with diabetes. *Front Public Health*. **2023**, 11, 1240879, <https://doi.org/10.3389/fpubh.2023.1240879>.
22. Cunha, GHD; Fontenele, MSM; Siqueira, LR; Lima, MAC; Gomes, MEC; Ramalho, AKL. Insulin therapy practice performed by people with diabetes in Primary Healthcare. *Rev Esc Enferm USP*. **2020**, 54, e03620, <https://doi.org/10.1590/S1980-220X2019002903620>.
23. Sayeed, KA; Qayyum, A; Jamshed, F; Gill, U; Usama, SM; Asghar, K; Tahir, A. Impact of Diabetes-related Self-management on Glycemic Control in Type II Diabetes Mellitus. *Cureus*. **2020**, 12, e7845, <https://doi.org/10.7759/cureus.7845>.
24. Negash, Z; Tadiwos, A; Urgessa, EM; Gebretekla, GB; Abebe, E; Fentie, AM. Insulin injection practice and health related quality of life among individuals with diabetes at Tikur Anbessa Specialized Hospital, Ethiopia: a cross-sectional study. *Health Qual Life Outcomes*. **2023**, 21, 38, <https://doi.org/10.1186/s12955-023-02123-z>.
25. McCoy, RG; Galindo, RJ; Swarna, KS; Van Houten, HK; O'Connor, PJ; Umpierrez, GE; Shah, ND. Sociodemographic, Clinical, and Treatment-Related Factors Associated With Hyperglycemic Crises Among Adults With Type 1 or Type 2 Diabetes in the US From 2014 to 2020. *JAMA Netw Open*. **2021**, 4, e2123471, <https://doi.org/10.1001/jamanetworkopen.2021.23471>.
26. Lamy, S; Ducros, D; Diméglio, C; Colineaux, H; Fantin, R; Berger, E; Grosclaude, P; Delpierre, C; Bouhanick, B. Disentangling the influence of living place and socioeconomic position on health services use among diabetes patients: A population-based study. *PLoS One*. **2017**, 12, e0188295, <https://doi.org/10.1371/journal.pone.0188295>.
27. Pereira, FGF; Diógenes, MAR; Ataíde, MBC; Mendonça Júnior, JO; Leal, DE; Xavier, ATF. Factors associated with the use of insulin in diabetic patients monitored by the family health strategy. *Rev. APS*. **2016**, 19, 58-66. Available online: <https://periodicos.ufrf.br/index.php/aps/article/view/15532/8151> (accessed on 26 June 2025).
28. Veloso, J; Guarita-Souza, LC; Lima Júnior, E; Ascari, RA; Précoma, DB. Perfil clínico de portadores de Diabetes Mellitus em acompanhamento multiprofissional em saúde. *Revista Cuidarte*. **2020**, 11, e1059, <https://doi.org/10.15649/cuidarte.1059>.
29. Lima, LR; Funghetto, SS; Volpe, CRG; Santos, WS; Funez, MI; Stival, MM. Quality of life and time since diagnosis of Diabetes Mellitus among the elderly. *Rev. Bras. Geriatr. Gerontol*. **2018**, 21, 180-190, <https://doi.org/10.1590/1981-22562018021.170187>.
30. Chwal, BC; Reis, RCP; Schmidt, MI; Duncan, BB; Barreto, SM; Griep, RH. Levels and correlates of risk factor control in diabetes mellitus –ELSA-Brasil. *Diabetol Metab Syndr*. **2023**, 15, 1-9, <https://doi.org/10.1186/s13098-022-00961-3>.
31. Sabag, A; Chang, CR; Francois, ME; Keating, SE; Coombes, JS; Johnson, NA; Pastor-Valero, M; Rey Lopez, JP. The Effect of Exercise on Quality of Life in Type 2 Diabetes: A Systematic Review and Meta-analysis. *Med Sci Sports Exerc*. **2023**, 55, 1353-1365, <https://doi.org/10.1249/MSS.0000000000003172>.
32. Dimore, AL; Edosa, ZK; Mitiku, AA. Glycemic control and diabetes complications among adult type 2 diabetic patients at public hospitals in Hadiya zone, Southern Ethiopia. *PLoS One*. **2023**, 18, e0282962, <https://doi.org/10.1371/journal.pone.0282962>.
33. Lira-Merigüete, AM; Santos, MP; Viana, VCS; Gonçalves, NAZ; Guimarães, FC; Ayres, LR; Guimarães, DAM; Goncalves, RCR. Pharmaceutical care improves medication adherence and quality of life in type 2 diabetes mellitus. *Pharm Pract (Granada)*. **2024**, 21, 1-7, <https://doi.org/10.18549/pharmpract.2023.4.2869>.

34. Galdón Sanz-Pastor, A; Justel Enríquez, A; Sánchez Bao, A; Ampudia-Blasco, FJ. Current barriers to initiating insulin therapy in individuals with type 2 diabetes. *Front Endocrinol* (Lausanne). **2024**, 15, 1366368, <https://doi.org/10.3389/fendo.2024.1366368>.
35. Campos, LFR; Lira Neto, JCG; Pacheco, ES; Araújo, MFM; Damasceno, MMC. Fatores Que Influenciam na Autogestão do Diabetes Mellitus e da Insulinoterapia: Revisão Integrativa da Literatura. *Saúde Coletiva* (Barueri). **2025**, 15, 15518–15551, <https://doi.org/10.36489/saudecoletiva.2025v15i95p15518-15551>.
36. Saberi-Karimian, M; Mansoori, A; Bajgiran, MM; Hosseini, ZS; Kiyoumarsioskouei, A; Rad, ES; Zo, MM; Khorasani, NY; Poudineh, M; Ghazizadeh, S; et al. Data mining approaches for type 2 diabetes mellitus prediction using anthropometric measurements. *J Clin Lab Anal*. **2023**, 37, e24798, <https://doi.org/10.1002/jcla.24798>.
37. Lucha-López, MO; Vidal-Peracho, C; Hidalgo-García, C; Rodríguez-Sanz, J; Tricás-Vidal, H; Hernández-Secorún, M; Monti-Ballano, S; Tricás-Moreno, JM; Lucha-López, AC. Anthropometric Measurements, Metabolic Profile and Physical Fitness in a Sample of Spanish Women with Type 2 Diabetes. *Int J Environ Res Public Health*. **2021**, 18, 11955, <https://doi.org/10.3390/ijerph182211955>.
38. Leyns, CC; Stilma Memelink, D; Bullinga, L; De Maeseneer, J; Willems, S; Campman Melssen, C. Integrated person- and people-centred primary care for diabetes in low- and middle-income countries: The nurses' perspective on patient needs. *J Adv Nurs*. **2023**, 79, 4044-4057, <https://doi.org/10.1111/jan.15760>.
39. Bai, K; Chen, X; Song, R; Shi, W; Shi, S. Association of body mass index and waist circumference with type 2 diabetes mellitus in older adults: a cross-sectional study. *BMC Geriatr*. **2022**, 22, 1-10, <https://doi.org/10.1186/s12877-022-03145-w>.
40. Ramírez-Vélez, R; Pérez-Sousa, MA; González-Jiménez, E; Correa-Rodríguez, M; Calderón-González, JC; Dávila-Grisales, A; Schmidt-RioValle, J. Using different anthropometric indices of obesity as predictors for type 2 diabetes mellitus in older adults. *Curr Probl Cardiol*. **2025**, 50, <https://doi.org/10.1016/j.cpcardiol.2024.102924>.
41. Jayedi, A; Soltani, S; Motlagh, SZ; Emadi, A; Shahinfar, H; Moosavi, H; Shab-Bidar, S. Anthropometric and adiposity indicators and risk of type 2 diabetes: systematic review and dose-response meta-analysis of cohort studies. *BMJ*. **2022**, 376, e067516, <https://doi.org/10.1136/bmj-2021-067516>.
42. Ma, L; Li, Y; Li, G; Sun, J; Zhang, X; Shi, Z; Yan, Y; DuanBa, Y; Wang, J; Li, Z; et al. Adiposity indicators exhibit depot- and sex-specific associations with multimorbidity onset: A cohort study of the UK Biobank. *Diabetes Obes Metab*. **2024**, 26, 2890-2904, <https://doi.org/10.1111/dom.15610>.
43. Zanchetta, FC; Trevisan, DD; Apolinario, PP; Silva, JB; Lima, MH. Clinical and sociodemographic variables associated with diabetes-related distress in patients with type 2 diabetes mellitus. *Einstein* (São Paulo). **2016**, 14, 346-351. Available online: <https://journal.einstein.br/pt-br/article/variaveis-clinicas-e-sociodemograficas-associadas-com-o-estresse-relacionado-ao-diabetes-em-pacientes-com-diabetes-mellitus-tipo-2/> (accessed on 26 June 2025).
44. Demir, G; Er, E; Atik Altınok, Y; Özen, S; Darcan, Ş; Gökşen, D. Local complications of insulin administration sites and effect on diabetes management. *J Clin Nurs*. **2022**, 31, 2530-2538, <https://doi.org/10.1111/jocn.16071>.
45. Tripathi, P; Kadam, N; Kathrikolly, T; Tiwari, D; Vyawahare, A; Sharma, B; Ganla, M; Saboo, B. Baseline clinical and biochemical profiles of type 2 diabetes patients enrolled in a lifestyle management program in India, a cross-sectional study. *Scientific Reports*. **2025**, 15, 1-9, <https://doi.org/10.1038/s41598-025-94694-8>.
46. Tripp, J; Santana-Quinteros, D; Pérez Estrada, R; Rodríguez-Moran, MF; Arcos-Gonzalez, C; Mercado-Ríos, J; Cristobal-Perez, F; Hernandez-Martinez, BR; Nava-Aguilar, MA; Gonzalez-Arroyo, G; et al. DiabetIA: Building Machine Learning Models for Type 2 Diabetes Complications. *MedRxiv*. **2023**, <https://doi.org/10.1101/2023.10.22.23297277>.
47. Pitak, P; Tasai, S; Kumpat, N; Na Songkla, P; Fuangchan, A; Krass, I; Dhippayom, T. The prevalence of glycemic control in patients with type 2 diabetes treated with insulin: a systematic review and meta-analysis. *Public Health*. **2023**, 225, 218-228, <https://doi.org/10.1016/j.puhe.2023.10.015>.
48. Riangkam, C; Sanguanthammarong, S; Lertwattanarak, R. Determinants of Glycemic Control in Thai Adults with Insulin-Treated Type 2 Diabetes Mellitus: A Cross-Sectional Study. *Patient Prefer Adherence*. **2025**, 19, 1909-1922, <https://doi.org/10.2147/PPA.S521692>.

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