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Characterization of the Distribution of Body Mass Index in People with Type 2 Diabetes in the Portuguese Population

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Keywords
Type 2 diabetes · Body mass index · Portuguese population · Obesity · Waist circumference

Abstract

Introduction: Type 2 diabetes (T2D) is a global health concern, closely linked to the obesity epidemic. In Portugal, the high prevalence of T2D, alongside important rates of overweight and obesity, highlights the need for targeted interventions. ***Methods:*** This multicentre, cross-sectional observational study aimed to characterize the Portuguese T2D population based on body mass index (BMI) and waist circumference (WC), while examining associated sociodemographic, clinical, and therapeutic factors. Adult patients with self-reported T2D were recruited from community pharmacies in June 2024. Data on anthropometric characteristics, clinical history, lifestyle, and antidiabetic medication were collected via questionnaires and pharmacy records. ***Results:*** A total of 1,132 participants were included (mean age 68.3 years [SD 10.8]; 51.0% female), 41.3% were overweight, 37.7% presented obesity (26.2% class I, 8.8% class II, 2.7% class III), and 21.0% had a BMI <25 kg/m^2. Higher BMI correlated with younger age, female gender, unemployment, increased WC, and higher rates of comorbidities like hypertension, sleep apnoea, and chronic venous insufficiency of the lower limbs. Overall, 98.2% of participants were treated with non-insulin glucose-lowering agents, most commonly fixed-dose combinations of oral therapies (44.0%). ***Conclusion:*** Our findings highlight a high prevalence of overweight/obesity among individuals with T2D in Portugal. This finding emphasizes the need to optimize clinical follow-up and implementing more effective interventions for the prevention and management of obesity among individuals with T2D. Routine BMI and WC assessments are vital, and integrated, for individualized T2D management that should address both glycaemic control and obesity-related risks to improve quality of life and prevent premature morbidity and mortality.

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Introduction

Type 2 diabetes (T2D) stands as a substantial global health concern, representing a multifaceted metabolic disorder characterized by hyperglycaemia and carrying an elevated risk of cardiovascular and microvascular complications [1]. According to the International Diabetes Federation (IDF), the prevalence of diabetes has surged to alarming proportions, affecting 11.1% of the global adult population aged 20–79 years, with approximately 589 million individuals affected, the majority of whom diagnosed with T2D [2].

The escalating prevalence of T2D is closely linked to the worldwide obesity epidemic, driven by socioeconomic shifts and unfavourable lifestyle choices, including reduced physical activity and unhealthy dietary patterns [3]. The World Health Organization (WHO) emphasizes the importance of adopting a healthy lifestyle, including regular physical activity and balanced nutrition, as key measures to prevent and manage obesity-related diseases such as T2D [4].

Portugal is facing a growing public health challenge, with an estimated diabetes prevalence of 14.1% among the adult population in 2021, the second highest rate in European Union countries [5–7]. Furthermore, the country has a considerably high prevalence of individuals with a body mass index (BMI) of 25 or above, with 53.6% of the adult population in Portugal presenting overweight and 16.9% classified with obesity, in 2019. This places Portugal among the countries with a big proportion of people living with overweight and obesity [8]. Considering the firmly established link between obesity and T2D, Portugal is on the verge of experiencing an increase in T2D prevalence in the upcoming years.

Diabetes and obesity are both linked to higher cardiovascular morbidity and mortality rates. Together, obesity and diabetes have a compounding effect, being jointly associated with worsened cardiovascular biomarkers and an increased risk of mortality [9, 10].

The strong correlation between the two conditions, obesity and T2D, gave rise to the term "diabesity," underscoring the observation that most people with diabetes also experience overweight or obesity [11]. Recognizing the prevalent occurrence of excessive body weight in those with T2D is crucial for strategic management and complications' prevention.

This study aimed to determine obesity and overweight prevalence among individuals with T2D in Portugal. It also seeks to analyse these trends concerning gender, age group, other sociodemographic and clinical characteristics within the studied sample. These insights aim to inform targeted interventions and healthcare strategies.

Objectives

This study aimed to determine obesity and overweight prevalence among individuals with T2D in Portugal. The primary objective of this study was to characterize the T2D population in Portugal according to BMI.

The secondary objective was to characterize the T2D population according to waist circumference (WC). The study characterizes participants according to sociodemographic characteristics (age, gender, employment status, educational level, region of Portugal [using the pharmacy region-district as a proxy]), diabetes duration, presence of self-reported comorbidities, smoking status, dietary and exercise habits, and diabetes medications (both dispensed and prescribed but not dispensed) at the date of recruitment.

Exploratory Objective

Exploratory objective was to explore whether abdominal obesity, as measured by WC, provides additional clinically relevant information beyond BMI, through further stratification of participants by WC within each BMI category.

Methods

Study Design and Population

This was a non-interventional, multicentre, cross-sectional, observational study conducted in a real-world setting in Portugal, through community pharmacies affiliated to the National Association of Pharmacies (ANF) (approximately 94% of all Portuguese community pharmacies). Subjects who presented to the community pharmacy to fill a prescription for their own use of an antidiabetic medication were screened for eligibility in this study. All adult individuals (aged 18 years or older) with self-reported diagnosis of T2D, who gave their verbal informed consent to participate, were included in this study. Individuals who did not demonstrate sufficient understanding of the study's objectives during the explanation of the study or who were not interested or available to participate were excluded from the study.

Data Collection

The study used data specifically collected for the purpose of this study (primary data) at the pharmacy, during the dispense of the antidiabetic medication and secondary data extracted from the dispense software (Sifarma®) of community pharmacies. The primary data for this study were collected using a structured electronic questionnaire. In pharmacies equipped with Sifarma® software, the questionnaire was automatically triggered at the time of dispensing any antidiabetic medication. Pharmacies that did not use the Sifarma® system were invited to complete the survey manually if they have patients meeting the study's eligibility criteria.

The pharmacist interviewed the patient and filled out the questionnaire based on the patient's self-reported information. The variables assessed included anthropometric (weight, height, and WC), sociodemographic characteristics (age, gender, level of education, and employment status), and clinical characteristics (diabetes diagnosis, age at diagnosis, comorbidities selected from a predefined list), as well as health habits (smoking habits, levels of physical activity, adherence to dietary plans for weight management or diabetes, and the source of recommendations for dietary plans). Additionally, the following information was retrieved from the pharmacy software system (Sifarma®): pharmacy region and prescribed antidiabetic medication, dispensed and not dispensed in the prescription that triggered the electronic-based questionnaire. Although this information may not exhaustively represent all the medication the patient uses for diabetes treatment, it reflects the antidiabetic medications that were on the prescription that the patients presented at the pharmacy on the day data were collected.

The anthropometric characteristics were measured by the pharmacist and filled in the questionnaire during the interview. BMI categories were defined in accordance with WHO as follows: underweight or normal weight (BMI <25 kg/m^2), overweight (BMI ≥25 kg/m^2 and <30 kg/m^2), class I obesity (BMI ≥30 kg/m^2 and <35 kg/m^2), class II obesity (BMI ≥35 kg/m^2 and <40 kg/m^2), and class III obesity (BMI ≥40 kg/m^2). The following WC cut-off values were used, based on previously established associations with cardiometabolic risk: normal WC (WC <80 cm in women and <94 cm in men), high risk (WC ranging from 80 to 87 cm in women, and 94 to 101 cm in men), or very high risk (equal to or above 88 cm in women and 102 cm in men) [12]. A leaflet was delivered to each pharmacy to assure correct and standardized measurements, according to the WHO guidelines [12].

Sample Size

Anticipated prevalence levels of BMI categories defined in this study were expected to be higher than 2%[1]. BMI categories with lower prevalence are associated with reduced sampling likelihood. To enhance the probability of recruiting individuals from these categories and to ensure low absolute error in estimates, a sample size of 1,000 participants was proposed.

This sample size was projected to sufficiently estimate the prevalence of different BMI categories outlined in the study, with a maximum absolute error of 3.1% at a 95% confidence level. Consequently, the goal was to recruit a minimum of 20 individuals and a maximum of 500 individuals per BMI category.

Statistical Analysis

Questionnaire responses were coded in Microsoft Excel, and data analysis was performed using SAS software (SAS Institute, Cary NC, USA). Statistical significance level adopted was $\alpha = 0.05$. Manual quality-control checks were performed during data cleaning to ensure one record per participant, by comparing age, gender, height, weight, pharmacy identifier, and comorbidities and merging confirmed duplicates.

Summary tables and/or figures are provided for the description of all variables through descriptive statistics or frequency tables. Categorical variables are summarized by absolute and relative frequencies, using the total number of subjects for whom data are available. Numerical variables are summarized using measures of central tendency and dispersion, the mean, standard deviation (SD), median, and interquartile range (IQR).

The sociodemographic, anthropometric, clinical, and therapeutic characteristics are described and presented for all participants and stratified by BMI class. The 95% confidence interval for proportions was computed for the primary outcome. Subgroups of participants were compared using the appropriate test – chi-square or Fisher's exact test for discrete variables, and *t* test or nonparametric Wilcoxon test for continuous variables. The 95% confidence interval for proportions was computed for the primary outcome.

The prevalence of each BMI category was determined by dividing the number of participants in that BMI category by the total number of participants in the study (all of whom have diagnosis of T2D). Participants for whom BMI has not been determined were excluded from the study.

[1]Estimates that took into account data from Instituto Nacional de Estatística, Relatório do Observatório Nacional da Diabetes 2023 and previous CEFAR studies.

Description of participating pharmacies, including regional and setting comparison with the universe of Portuguese pharmacies, was also performed. The missing values were stated in the corresponding summary table.

Results

From a total of 2,737 pharmacies invited to participate in the study, 266 (9.7%) accepted the invitation, and 210 (7.7%) pharmacies (all of them using Sifarma® software) recruited at least 1 patient between the June 3 and 6, 2024, resulting in 1,703 individuals screened. Regarding the representativeness of the pharmacies, there was no difference between the distribution of registered pharmacies by country district and the overall distribution of pharmacies across continental Portugal. However, there was a difference between the regional distribution (NUTS II) of recruiting pharmacies (pharmacies that recruited at least one participant) and its nationwide distribution. Specifically, the study included a higher proportion of recruiting pharmacies from North (8.3%) and Central (9.7%) Portugal, and a lower proportion from the Lisbon metropolitan area (5.1%) and Alentejo (5.2%) regions (p = 0.0112). Conversely, there was no significant difference when compared by setting (urban/suburban/rural) (p = 0.0649).

Among the screened individuals, 229 reported having type 1 diabetes, 183 were unsure of their diabetes type, 140 did not have diabetes, 12 had gestational diabetes, and 1,139 reported to have T2D. Reported anthropometric characteristics were not considered valid for 7 participants, resulting into 1,132 eligible individuals.

Of the 1,132 individuals included, 567 (51.0%) were female, with an average age of 68.3 years (SD = 10.8), ranging from 23 to 98 years. Most participants (64.0%) were between 60 and 80 years old, while 19.2% were between 40 and 60 years old. The age group with the lowest representation consists of individuals aged <40 years, who represent only 0.8% of the sample. Regarding educational level, 50.6% of the sample had a low educational level (4th grade or below). In terms of employment status, 65.4% were retired or in other non-working situations, while 28.8% were employed. Regionally, the majority were from the Northern (39.8%) and the Central (30.5%) regions of the country.

Most individuals (58.5%) were diagnosed between 40 and 60 years old. The mean age at diagnosis was 55.6 years (SD = 10.7), with a median of 55 years (IQR: 14). A total of 93.2% of participants had at least one comorbidity, with the most common being arterial hypertension (81.1%), dyslipidaemia (75.9%), and chronic venous insufficiency of the lower limbs (CVILLs) (24.9%).

In terms of health habits, 8.2% of participants were current smokers, while 91.8% were non-smokers, with an average smoking duration of 34.8 years (SD = 13.0). Regarding physical activity, 27.2% reported to engage in at least 30 min of daily exercise, while 72.8% did not. Additionally, 15.8% referred to follow a dietary plan related to excessive body weight or diabetes; among these, 64.8% received recommendations from healthcare professionals (HCPs), 30.1% initiated the plans themselves, and 4.5% had a combination of HCP and self-initiative recommendations.

Regarding the antidiabetic medication on the prescription that triggered the questionnaire, it was only possible to characterize 1,050 individuals. Among those, almost all patients (98.2%) were treated with glucose-lowering medications (ATC A10B). Of these, 44% of patients were on combinations of oral blood glucose-lowering drugs, followed by 26.9% on Biguanides and 26.4% on sodium-glucose co-transporter 2 (SGLT2) inhibitors. Less commonly used medications included dipeptidyl peptidase 4 inhibitors, used by 8.4% of patients, and glucagon-like peptide (GLP-1) receptor analogues, used by 11.6%. Alpha-glucosidase inhibitors and thiazolidinediones were rarely used: only 0.3% and 0.4% of patients on these medications, respectively. These figures include both monotherapy and combination therapy.

Regarding the anthropometric characteristics of the study population, the mean BMI was 29.1 kg/m^2 (SD = 5.0), with a median of 28.6 kg/m^2 and an IQR of 6.4 kg/m^2. BMI values ranged from 14.7 kg/m^2 to 55.3 kg/m^2.

Among men, the mean WC was 104.7 cm (SD = 15.3), with 22.9% having a WC below 94 cm, 20.5% between 94 cm and 102 cm, and 56.6% at or above 102 cm. For women, the mean WC was 97.8 cm (SD = 14.5), with 8.7% having a WC below 80 cm, 13.3% between 80 cm and 88 cm, and 78.0% at or above 88 cm.

The distribution of BMI categories within the study sample is depicted in Table 1. The largest proportion of participants fell into the overweight category, accounting for 41.3% (95% CI: 38.4–44.1) of the sample (n = 467). Obesity was present in 37.7% (95% CI: 34.9–40.5) of the participants, with 26.2% (95% CI: 23.7–28.8) of participants with class I obesity (n = 297), 8.8% (95% CI: 7.2–10.5) with class II obesity (n = 100), and 2.7% (95%

Table 1. Characterization of the population by BMI category (kg/m^2)

Characteristics at recruitment	Total
	1,132 (100.0)
BMI, *n* (%)	
Normal or underweight (BMI <25)	238 (21.0)
Overweight (25≤ BMI <30)	467 (41.3)
Class I obesity (30≤ BMI <35)	297 (26.2)
Class II obesity (35≤ BMI <40)	100 (8.8)
Class III obesity (BMI ≥40)	30 (2.7)

CI: 1.7–3.6) with class III obesity (n = 30). Individuals with a BMI under 25 kg/m^2 made up 21.0% (95% CI: 18.6–23.4) of the study population (n = 238).

Table 2 summarizes the distribution of BMI across different sociodemographic characteristics. The distribution of BMI categories varied by sex, with female patients presenting higher BMI categories (classes II and III of obesity) compared to males, who were more represented in lower BMI categories (normal weight and overweight) (p = 0.0007).

Regarding age, participants in higher BMI categories tend to be younger, as the median age decreases with increasing BMI: from 73 years (BMI <25 kg/m^2) to 64 years (BMI ≥40 kg/m^2). The mean age follows a similar trend, decreasing from 70.7 years in the BMI <25 kg/m^2 category to 63.9 years in class III obesity (p < 0.0001).

When examining the distribution of BMI across age groups, we found that participants aged 80 and above are more represented in the BMI <25 category (23.9%) and less in the higher BMI categories. Additionally, the percentage of individuals aged 40–60 in the classes II and III is higher compared to the percentage of these individuals in the other classes (p < 0.0001).

The percentages of individuals in each BMI category are relatively similar across different educational levels. The proportion of retirees in the BMI groups is primarily concentrated in the normal and overweight categories, with a slight decrease as BMI increases, from 72.3% in the BMI <25 category to 51.7% in class III obesity. Employed individuals have a moderate representation across all BMI categories, with a higher concentration in the higher BMI ranges. Although the overall unemployment rate of the study population is relatively low (5.6%), there is a higher proportion of unemployed individuals in higher BMI categories (class II and III obesity) (p = 0.0002).

Regarding the regional distribution of the sample, Northern region has the largest representation across all BMI categories, followed by Central region of Portugal. Lisbon metropolitan area has a consistent distribution with a lower percentage in the highest BMI categories. Nevertheless, these results are not statistically significant.

The clinical characteristics stratified by BMI categories are depicted in Table 3. As expected, the percentage of individuals with WC in the high and very high metabolic risk ranges increases in accordance with an increase in BMI. Nevertheless, in the normal BMI class, almost 50% of men and nearly 73% of women have WC in the high or very high cardiometabolic risk range. In the overweight category, the percentage of men with WC in the high or very high cardiometabolic risk range is 77.1%, while for women it is 93.5%; in the class I obesity, 93% of men and 97.2% of women have WC in the high or very high cardiometabolic risk range. In the higher BMI classes, 100% of individuals, both men and women, present WC in the high and very high cardiometabolic risk categories. These data highlight the association between higher BMI and increased WC, with a notable shift towards higher WC classes in both men and women as BMI increases (p < 0.001 for both men and women).

Most individuals (58.5%) were diagnosed between the ages of 40 and 60 years. The mean age at diagnosis was consistent across BMI categories (p > 0.05), ranging from 54.3 to 56.3 years.

The proportions of individuals that reported at least one diabetes-related comorbidity increased with higher BMI categories (p = 0.0453). All 26 individuals with class III obesity reported comorbidities (varying from 1 to 8). Dyslipidaemia and arterial hypertension are particularly common, affecting a large proportion of individuals across all BMI categories.

The proportion of patients with arterial hypertension seems to increase (p = 0.0027) with BMI levels peaking at 88% in the class II obesity group. CVILLs also showed a trend, with its prevalence increasing from 21.5% in the overweight group to 57.7% in the class III obesity group (p < 0.0001). Similarly, obstructive sleep apnoea displayed a marked rise, from just 2.1% in the BMI <25 group to 26.9% in those with class III obesity group (p < 0.0001). No statistically significant differences were observed for other comorbidities such as dyslipidaemia, stroke/transient ischaemic attack, diabetic retinopathy, myocardial infarction, diabetic neuropathy, or diabetic nephropathy across the different BMI categories.

Table 4 provides an overview of health habits across different BMI categories. The highest prevalence of smokers was found in the overweight and in class II

Table 2. Sociodemographic characterization of the population by BMI category (kg/m^2)

Characteristics at recruitment	Total	BMI< 25	25≤ BMI <30	30≤ BMI <35	35≤ BMI <40	BMI ≥40	*p* value
	1,132	238	467	297	100	30	
Gender, *n* (%)							
Female	567 (51.0)	115 (48.3)	219 (46.9)	148 (49.8)	60 (60.0)	25 (83.3)	0.0007[a]
Male	565 (49.9)	123 (51.7)	248 (53.1)	149 (50.2)	40 (40.0)	5 (16.7)	
Age, years							
Mean (SD)	68.3 (10.8)	70.7 (11.1)	68.8 (10.6)	67.2 (10.2)	65.4 (11)	63.9 (11.6)	
Median (IQR)	68 (14)	73 (15)	69 (14)	67 (12)	67 (14)	64 (17)	<0.0001[a]
Min-max	23–98	29–91	28–93	23–98	39–91	43–90	
NR = 1							
Age, *n* (%)							
[18–40[	9 (0.8)	2 (0.8)	2 (0.4)	4 (1.3)	1 (1.0)	0 (0.0)	
[40–60[	217 (19.2)	34 (14.3)	93 (20.0)	50 (16.8)	30 (30.0)	10 (33.3)	<0.0001[a]
[60–80[	724 (64.0)	145 (60.9)	289 (62.0)	213 (71.7)	59 (59.0)	18 (60.0)	
≥80	181 (16.0)	57 (23.9)	82 (17.6)	30 (10.1)	10 (10.0)	2 (6.7)	
NR	1	0	1	0	0	0	
Educational level, *n* (%)							
Below 4th grade	134 (11.9)	30 (12.6)	58 (12.4)	34 (11.5)	6 (6.0)	6 (20.0)	
4th grade	437 (38.7)	93 (39.1)	171 (36.6)	116 (39.3)	46 (46.0)	11 (36.7)	
6th grade	126 (11.2)	25 (10.5)	63 (13.5)	27 (9.2)	10 (10.0)	1 (3.3)	0.8172
9th grade	173 (15.3)	38 (16.0)	68 (14.6)	45 (15.3)	17 (17.0)	5 (16.7)	
12th grade	165 (14.6)	30 (12.6)	73 (15.6)	44 (14.9)	12 (12.0)	6 (20.0)	
Bachelor	79 (7.0)	18 (7.6)	29 (6.2)	24 (8.1)	7 (7.0)	1 (3.3)	
Master/PhD	16 (1.4)	4 (1.7)	5 (1.1)	5 (1.7)	2 (2.0)	0 (0.0)	
NR	2	0	0	2	0	0	
Employment status, *n* (%)							
Unpaid student	2 (0.2)	0 (0.0)	0 (0.0)	1 (0.3)	1 (1.0)	0 (0.0)	
Unemployed	63 (5.6)	14 (6.0)	23 (5)	10 (3.4)	8 (8.0)	8 (27.6)	0.0002[a]
Retired or other[b]	733 (65.4)	170 (72.3)	304 (65.9)	187 (63.4)	57 (57.0)	15 (51.7)	
Employed or job	322 (28.8)	51 (21.7)	134 (29.1)	97 (32.9)	34 (34.0)	6 (20.7)	
NR	12	3	6	2	0	1	
Region (NUTSII), *n* (%)							
Alentejo	60 (5.3)	15 (6.3)	26 (5.6)	15 (5.1)	3 (3.0)	1 (3.3)	
Algarve	39 (3.5)	12 (5.0)	14 (3.0)	6 (2.0)	5 (5.0)	2 (6.7)	
LMA	231 (20.4)	48 (20.2)	96 (20.6)	65 (21.9)	18 (18.0)	4 (13.3)	0.7137
Centre	345 (30.5)	59 (24.8)	148 (31.7)	98 (33.0)	30 (30.0)	10 (33.3)	
North	451 (39.8)	102 (42.9)	181 (38.8)	111 (37.4)	44 (44.0)	13 (43.3)	
Madeira region	6 (0.5)	2 (0.8)	2 (0.4)	2 (0.7)	0 (0.0)	0 (0.0)	

IQR, interquartile range; NR, non-respondents/do not know; BMI, body mass index; LMA, Lisbon metropolitan area. [a]Statistically significant (*p* value <0.05). [b]Other was asked as "Another State of Economic Inactivity."

obesity categories. However, these results are not statistically significant. There was a varied smoking pattern (number of cigarettes per day and smoking years) among individuals with T2D across different BMI categories.

The proportion of patients engaging in at least 30 min of daily physical activity is higher in the BMI <25 group (37.2%); this proportion seems to decrease with higher levels of BMI ($p < 0.0001$). Regarding dietary plans, the higher result was found in the class III obesity group (32.1%) and lower in the normal and underweight (14.1%) and class II obesity groups (11.2%). Yet, the observed differences did not reach statistical significance ($p = 0.0677$).

When it came to recommendations for dietary plans, results varied across different BMI categories but these differences were not statistically significant. Exploratory analysis, presented as online supplementary Tables 1, 2 (for all online suppl. material, see https://doi.org/10.

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Table 3. Clinical characteristics of the population by BMI category (kg/m^2)

Characteristics at recruitment	Total	BMI <25 kg/m^2	25≤ BMI <30 kg/m^2	30≤ BMI <35 kg/m^2	35≤ BMI <40 kg/m^2	BMI ≥40 kg/m^2	*p* value
	1,132	238	467	297	100	30	
WC men, cm							
Mean (SD)	104.7 (15.3)	94.7 (13.4)	102.1 (13.6)	111.1 (12.5)	121.7 (12.8)	132.5 (13.5)	<0.0001*
Median (IQR)	104 (19)	93 (10)	102 (16)	111 (14)	120 (16)	133 (22)	
Min-max	70–150	70–150	70–150	80–145	96–150	117–147	
NR = 28							
WC men, *n* (%)							
<94 cm	123 (22.9)	58 (52.7)	55 (22.9)	10 (6.9)	0 (0.0)	0 (0.0)	<0.0001*
≥94 cm and <102	110 (20.5)	30 (27.3)	61 (25.4)	16 (11.1)	3 (7.7)	0 (0.0)	
≥102 cm	304 (56.6)	22 (20.0)	124 (51.7)	118 (81.9)	36 (92.3)	4 (100.0)	
NR	28	13	8	5	1	1	
WC women, cm							
Mean (SD)	97.8 (14.5)	84.6 (10.8)	94.9 (10.9)	104.3 (13.2)	111.8 (9.5)	112.3 (16.6)	<0.0001*
Median (IQR)	98 (19)	85 (13)	95 (11)	105 (14)	111 (14)	116 (26)	
Min-max	60–134	60–110	67–130	60–130	86–130	80–134	
NR = 0							
WC women, *n* (%)							
<80 cm	47 (8.7)	29 (27.4)	14 (6.5)	4 (2.8)	0 (0.0)	0 (0.0)	<0.0001*
≥80 cm and <88 cm	72 (13.3)	31 (29.2)	29 (13.4)	10 (6.9)	1 (1.8)	1 (5.6)	
≥88 cm	422 (78)	46 (43.4)	173 (80.1)	130 (90.3)	56 (98.2)	17 (94.4)	
NR	26	9	3	4	3	7	
Age at diagnosis, *n* (%)							0.1908
[18–40[	44 (4.2)	13 (5.8)	14 (3.2)	10 (3.7)	6 (6.3)	1 (4.0)	
[40–60[	613 (58.5)	123 (54.7)	243 (56.4)	169 (62.4)	62 (65.3)	16 (64.0)	
[60–80[	365 (34.9)	82 (36.4)	163 (37.8)	90 (33.2)	23 (24.2)	7 (28.0)	
≥80	25 (2.4)	7 (3.1)	11 (2.6)	2 (0.7)	4 (4.2)	1 (4.0)	
NR	85	13	36	26	5	5	
Age at diagnosis, years							0.3356
Mean (SD)	55.6 (10.7)	55.7 (11.6)	56.3 (10.5)	54.8 (10.0)	54.9 (11.0)	54.3 (11.0)	
Median (IQR)	55 (14)	55 (16)	55 (13)	55 (14)	55 (12)	54 (15)	
Min-max	35–91	35–87	35–89	35–82	35–91	37–80	
NR	85	13	36	26	5	5	
Comorbidities (at least one), *n* (%)							0.0453*
Yes	968 (93.2)	192 (88.9)	396 (93.8)	262 (93.9)	92 (95.8)	26 (100.0)	
No	71 (6.8)	24 (11.1)	26 (6.2)	17 (6.1)	4 (4.2)	0 (0.0)	
NR	93	22	45	18	4	4	
Comorbidities, *n*							0.0010*
Mean (SD)	2.3 (1.2)	2.1 (1)	2.2 (1)	2.5 (1.3)	2.5 (1.2)	2.8 (1.7)	
Median (IQR)	2.0 (1)	2 (2)	2 (1)	2 (1)	2 (1)	3 (1)	
Min-max	1–8	1–6	1–8	1–7	1–8	1–8	
NR = 164							

Table 3 (continued)

Characteristics at recruitment	Total	BMI <25 kg/m^2	25≤ BMI <30 kg/m^2	30≤ BMI <35 kg/m^2	35≤ BMI <40 kg/m^2	BMI ≥40 kg/m^2	*p* value
	1,132	238	467	297	100	30	
Comorbidities, *n* (%)							
Arterial hypertension	785 (81.1)	142 (74.0)	322 (81.3)	223 (85.1)	81 (88)	17 (65.4)	0.0027*
Dyslipidaemia	735 (75.9)	145 (75.5)	293 (74.0)	207 (79.0)	68 (73.9)	22 (84.6)	0.4826
CVILL	241 (24.9)	45 (23.4)	85 (21.5)	63 (24.1)	33 (35.9)	15 (57.7)	<0.0001*
Sleep apnoea	93 (9.6)	4 (2.1)	31 (7.8)	35 (13.4)	16 (17.4)	7 (26.9)	<0.0001*
Stroke/TIA	89 (9.2)	15 (7.8)	36 (9.1)	27 (10.3)	8 (8.7)	3 (11.5)	0.9052
Diabetic retinopathy	82 (8.5)	15 (7.8)	27 (6.8)	30 (11.5)	8 (8.7)	2 (7.7)	0.3392
Myocardial infarction	82 (8.5)	13 (6.8)	42 (10.6)	17 (6.5)	8 (8.7)	2 (7.7)	0.3548
Diabetic neuropathy	71 (7.3)	13 (6.8)	25 (6.3)	24 (9.2)	6 (6.5)	3 (11.5)	0.6008
Diabetic nephropathy	48 (5.0)	10 (5.2)	12 (3.0)	21 (8.0)	3 (3.3)	2 (7.7)	0.0536
NR	164	46	71	35	8	4	

The comorbidities are not mutually exclusive, for which proportions do not add up to 100%. IQR, interquartile range; NR, non-respondents/do not know; BMI, body mass index; CVILL, chronic venous insufficiency of the lower limb; TIA, transient ischaemic attack. *Statistically significant (*p* value <0.05).

1159/000549592), suggested that 47.3% of men with normal BMI had elevated WC, though no significant differences in comorbidities were observed. Among men within the obesity groups, higher WC was significantly associated with increased dyslipidaemia. Even among women with normal BMI, 72.6% had an elevated WC (≥80 cm; 29.2% at 80–87 cm; and 43.4% at ≥88 cm). In this group of individuals, WC was also significantly associated with higher prevalence of dyslipidaemia.

The analysis of patients' prescriptions for antidiabetic medications that triggered participant inclusion in the study is represented in Tables 5–7. Table 5 presents the characteristics of the antidiabetic medications that were in the prescription that triggered the study invitation. The percentage of individuals using insulins and analogues (A10A) varied between 3.4% in the class III obesity group and 9.6% in the normal BMI group. Regarding blood glucose-lowering drugs, excluding insulins, the percentage varied between 96.6% in class III obesity and 100% in class II obesity.

The profile of antidiabetic drug use varies within BMI categories, and the most common regimen was the combination of oral blood glucose-lowering drugs (ATC A10BD), followed by biguanide (ATC A10BA) and SGLT2 (ATC 10BK) across all BMI categories. On the other side, the most commonly used type of insulin/insulin analogues was the long-acting insulin analogues (A10AE), and its use was more common among lower BMI categories.

Table 6 presents a detailed breakdown of antidiabetic medications on the prescription classified under ATC Code A10BD, specifically focusing on fixed combinations of oral blood glucose-lowering drugs among a total sample of 1,050 individuals. Among all, metformin and dapagliflozin (A10BD15) was the most commonly used combination with 17.0% of patients. This combination varied between 14.5% in the group with class I obesity and 20.2% in those with a BMI less than 25 kg/m^2. Metformin and sitagliptin (A10BD07) accounted for 8.3% of patients, maintaining similar percentages across the BMI categories except for class II obesity group. Metformin and empagliflozin (A10BD20) and metformin and vildagliptin (A10BD08) each represented 7.4% of patients. The former showed the same proportion to A10BD15 in those with class III obesity (17.2%).

Table 7 presents the number (and percentage) of individuals treated with insulin and insulin analogues only, the number of individuals treated with other antidiabetic drugs, and the number of individuals treated with both. The majority of patients across all BMI categories were treated with blood glucose-lowering drugs,

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Table 4. Health habits by BMI category (kg/m^2)

Health habits at recruitment	Total	BMI <25 kg/m^2	25≤ BMI <30 kg/m^2	30≤ BMI <35 kg/m^2	35≤ BMI <40 kg/m^2	BMI ≥40 kg/m^2	*p* value
	1,132	238	467	297	100	30	
Smoker, *n* (%)							0.1291
Yes	92 (8.2)	18 (7.6)	46 (10)	16 (5.4)	11 (11.1)	1 (3.3)	
No	1,026 (91.8)	218 (92.4)	413 (90)	278 (94.6)	88 (88.9)	29 (96.7)	
NR	14	2	8	3	1	0	
Smoking years							0.1455
Mean (SD)	34.8 (13.0)	39.7 (12.5)	33.7 (11.6)	35.8 (15.0)	33.5 (12.6)	–	
Cigarettes per day, *n* (%)							0.1558
[1–5[	8 (8.8)	0 (0.0)	5 (11.1)	1 (6.3)	1 (9.1)	1 (100)	
[5–10[	16 (17.6)	4 (22.2)	9 (20.0)	1 (6.3)	2 (18.2)	0 (0.0)	
[10–15[	18 (19.8)	3 (16.7)	8 (17.8)	4 (25)	3 (27.3)	0 (0.0)	
[15–20[	6 (6.6)	2 (11.1)	2 (4.4)	2 (12.5)	0 (0.0)	0 (0.0)	
[20–25[	33 (36.3)	9 (50.0)	16 (35.6)	7 (43.8)	1 (9.1)	0 (0.0)	
≥25	10 (11.0)	0 (0.0)	5 (11.1)	1 (6.3)	4 (36.4)	0 (0.0)	
NR	1	0	1	0	0	0	
Current practice of at least 30 min of daily physical activity, *n* (%)							<0.0001
Yes	304 (27.2)	87 (37.2)	137 (29.4)	62 (21.2)	13 (13.3)	5 (17.2)	
No	815 (72.8)	147 (62.8)	329 (70.6)	230 (78.8)	85 (86.7)	24 (82.8)	
NR	13	4	1	5	2	1	
Current dietary plan related to excessive body weight or diabetes, *n* (%)							0.0677
Yes	176 (15.8)	33 (14.1)	71 (15.3)	52 (17.9)	11 (11.2)	9 (32.1)	
No	938 (84.2)	201 (85.9)	393 (84.7)	238 (82.1)	87 (88.8)	19 (67.9)	
NR	18	4	3	7	2	2	
Recommendation, *n* (%)							0.3701
Self-initiative	53 (30.1)	10 (30.3)	24 (33.8)	12 (23.1)	4 (36.4)	3 (33.3)	
HCP	114 (64.8)	22 (66.7)	43 (60.6)	39 (75.0)	5 (45.5)	5 (55.6)	
HCP and self-initiative	8 (4.5)	1 (3.0)	3 (4.2)	1 (1.9)	2 (18.2)	1 (11.1)	
Other	1 (0.6)	0 (0.0)	1 (1.4)	0 (0.0)	0 (0.0)	0 (0.0)	
NR	956	205	396	245	89	21	

IQR, interquartile range; NR, non-respondents/do not know; BMI, body mass index; HCP, healthcare professional (doctor, nurse, nutritionist, or pharmacist).

Table 5. Characterization of antidiabetics use by BMI category (kg/m^2)

Antidiabetic drug (ATC Code A10), *n* (%)	Total	BMI <25 kg/m^2	25≤ BMI <30 kg/m^2	30≤ BMI <35 kg/m^2	35≤ BMI <40 kg/m^2	BMI ≥40 kg/m^2
	1,050	218	436	275	92	29
A10A – insulins and analogues	77 (7.3)	21 (9.6)	29 (6.7)	21 (7.6)	5 (5.4)	1 (3.4)
A10AB – fast-acting	15 (1.4)	4 (1.8)	4 (0.9)	6 (2.2)	1 (1.1)	0 (0.0)
A10AC – intermediate-acting	3 (0.3)	2 (0.9)	1 (0.2)	0 (0.0)	0 (0.0)	0 (0.0)
A10AD – intermediate- or long-acting combined with fast-acting	10 (1.0)	1 (0.5)	3 (0.7)	5 (1.8)	1 (1.1)	0 (0.0)
A10AE – long-acting	64 (6.1)	18 (8.3)	25 (5.7)	16 (5.8)	4 (4.3)	1 (3.4)
A10B – blood glucose-lowering drugs, excl. insulins, *n* (%)	1,031 (98.2)	212 (97.2)	429 (98.4)	270 (98.2)	92 (100.0)	28 (96.6)
A10BA – biguanides	282 (26.9)	46 (21.1)	120 (27.5)	92 (33.5)	18 (19.6)	6 (20.7)
A10BB – sulfonylureas	79 (7.5)	16 (7.3)	35 (8.0)	19 (6.9)	8 (8.7)	1 (3.4)
A10BD – combinations of oral blood glucose-lowering drugs	462 (44.0)	103 (47.2)	204 (46.8)	101 (36.7)	41 (44.6)	13 (44.8)
A10BF – alpha-glucosidase inhibitors	3 (0.3)	2 (0.9)	1 (0.2)	0 (0.0)	0 (0.0)	0 (0.0)
A10BG – thiazolidinediones	4 (0.4)	0 (0)	2 (0.5)	2 (0.7)	0 (0.0)	0 (0.0)
A10BH – DPP-4 inhibitors)	88 (8.4)	29 (13.3)	35 (8.0)	20 (7.3)	1 (1.1)	3 (10.3)
A10BJ – GLP-1 analogues	122 (11.6)	10 (4.6)	47 (10.8)	42 (15.3)	17 (18.5)	6 (20.7)
A10BK – SGLT2 inhibitors	277 (26.4)	62 (28.4)	108 (24.8)	74 (26.9)	27 (29.3)	6 (20.7)

These categories are not mutually exclusive for which proportions do not add up to 100%; patients may be receiving multiple antidiabetic medications simultaneously. IQR, interquartile range; NR, non-respondents/do not know; BMI, body mass index; DPP-4, dipeptidyl peptidase 4; GLP-1, glucagon-like peptide; SGLT2, sodium-glucose co-transporter 2.

Table 6. Characterization of combinations of oral blood glucose-lowering drugs at the prescription (ATC Code A10BD) by BMI category (kg/m^2)

Antidiabetic drug (ATC Code A10BD), *n* (%)	Total	BMI <25 kg/m^2	25≤ BMI <30 kg/m^2	30≤ BMI <35 kg/m^2	35≤ BMI <40 kg/m^2	BMI ≥40 kg/m^2
	1,050	218	436	275	92	29
A10BD15 – metformin and dapagliflozin	179 (17.0)	44 (20.2)	73 (16.7)	40 (14.5)	17 (18.5)	5 (17.2)
A10BD07 – metformin and sitagliptin	87 (8.3)	18 (8.3)	34 (7.8)	27 (9.8)	8 (8.7)	0 (0.0)
A10BD20 – metformin and empagliflozin	78 (7.4)	18 (8.3)	33 (7.6)	16 (5.8)	6 (6.5)	5 (17.2)
A10BD08 – metformin and vildagliptin	78 (7.4)	18 (8.3)	43 (9.9)	11 (4.0)	4 (4.3)	2 (6.9)
A10BD others[a]	43 (4.1)	6 (2.8)	21 (4.8)	9 (3.3)	6 (6.5)	1 (3.4)

[a]A10BD13, A10BD16, A10BD11, A10BD19, A10BD23, A10BD09, and A10BD05.

excluding insulins, with percentages ranging from 90.4% (BMI <25 kg/m^2 group) to 96.6% (BMI ≥40 kg/m^2). Insulin and insulin analogue-only treatments are the least common (1.8%), and their use slightly decreases with higher BMI classes, except for a slight rise in those with class III obesity. However, these results are not statistically significant.

Discussion

The findings of this study provide relevant insights into the BMI distribution and related characteristics of the T2D population in Portugal, highlighting some critical issues in the management of this population. The high prevalence of overweight (41.3%) and obesity

Table 7. Characterization of antidiabetics (A10A, A10B, A10A, and A10B) use by BMI category (kg/m^2) (p = 0.6194)

Antidiabetic drug (ATC Code A10), *n* (%)	Total	BMI <25 kg/m^2	25≤ BMI <30 kg/m^2	30≤ BMI <35 kg/m^2	35≤ BMI <40 kg/m^2	BMI ≥40 kg/m^2
	1,050	218	436	275	92	29
A10A – insulins and analogues	19 (1.8)	6 (2.8)	7 (1.6)	5 (1.6)	0 (0.0)	1 (3.4)
A10B – blood glucose-lowering drugs, excl. insulins	973 (92.7)	197 (90.4)	407 (93.3)	254 (92.4)	87 (94.6)	28 (96.6)
A10A – insulins and analogues and A10B – blood glucose-lowering drugs, excl. insulins	58 (5.5)	15 (6.9)	22 (5.0)	16 (5.8)	5 (5.4)	0 (0.0)

(37.7%) among individuals with T2D is a significant concern. The fact that nearly four-fifths of the study population falls into the overweight or obese categories underscores the urgent need for targeted interventions to address body weight management in T2D patients, as stated by the last EASD/ADA guidelines [13]. This is particularly important given the well-documented association between higher BMI and increased risk for comorbidities, which in this study was verified for arterial hypertension, sleep apnoea, and CVILL.

Our results revealed that BMI distribution varies by age, sex, and employment status. Higher BMI categories are more commonly in females in line with figures reported for general Portuguese population [14]. Regarding age, participants in higher BMI categories tend to be younger, with median ages decreasing from 73 years to 64 years as BMI increases. This may be linked to the substantial impact of excessive body weight on mortality and the fact that older patients have a longer duration of disease and therefore have some catabolism linked to the associated insulinopenia. However, the cross-sectional design and limited glycaemic control information preclude causal inference [15, 16].

Although BMI varied slightly across educational levels, these differences were not large enough to suggest that education is a strong predictor of obesity in this T2D cohort – unlike what is often reported for the general population [14, 17, 18]. Several factors may explain this: (i) people with T2D typically receive regular medical care, which may attenuate education-related differences in body weight; (ii) sample size was limited in some strata, particularly at the highest obesity classes; (iii) the overall prevalence of overweight/obesity in our cohort was very high (~79%), reducing between-group contrast; and (iv) in Portugal, diabetes is more common among adults with lower educational attainment, so within a T2D-only sample BMI tends to be high across education groups, compressing any education gradient [14]. The association between BMI and WC in this study further emphasizes the importance of comprehensive risk assessment in the management of T2D [19]. While BMI is widely used to assess general obesity, it does not fully capture the distribution of body fat, particularly abdominal fat, which plays a crucial role in metabolic risk. WC, on the other hand, is a well-established marker of abdominal obesity and is strongly correlated with global cardiometabolic risk, including insulin resistance, cardiovascular disease, and hypertension [20–22]. The results from online supplementary tables, which present a more detailed analysis within BMI categories, showed that even among women with a normal BMI, a substantial proportion had elevated WC and significantly higher prevalence of self-reported dyslipidaemia. This finding highlights the presence of abdominal obesity and cardiometabolic risk in individuals who would otherwise be considered low risk based on BMI alone. Among men, WC was significantly associated with cardiometabolic risk markers in those with obesity. These results underscore the added value of WC in identifying metabolic risk beyond BMI classification. As a result, several international health organizations, including the WHO [12] and the IDF [23], recommend using WC as a preferred parameter for stratifying metabolic risk. Incorporating WC alongside BMI in routine clinical assessments allows for a more accurate identification of individuals at high risk, especially those who may not be flagged by BMI alone. This more nuanced approach to risk assessment is critical in ensuring timely and effective interventions for preventing cardiometabolic complications in patients with T2D.

The clinical data, particularly the high prevalence of comorbidities such as dyslipidaemia and arterial hypertension, underscore the complexity of managing T2D across all BMI categories. While there is a clear correlation between higher BMI and increased risk of comorbidities – such as the

significant rise in arterial hypertension, chronic venous insufficiency, and obstructive sleep apnoea in individuals with higher BMI – our findings show that the prevalence of complications remains elevated even in those without obesity.

These results suggest that although BMI is a useful marker for predicting the risk of certain complications, it should not be relied upon in isolation to assess metabolic or cardio-renal risk. Individuals without obesity can still experience a high burden of comorbidities, reinforcing that cardiometabolic and renal risks should not be forgotten in patients with T2D who fall within the lower BMI ranges. This highlights the need for comprehensive, individualized risk assessments that consider not only BMI but also other factors such as WC and the presence of diabetes-related complications. Such an approach ensures that patients at high risk are identified early, regardless of their BMI, allowing for timely and integrated management strategies to reduce the overall disease burden [9, 11].

This study also revealed important insights into the lifestyle behaviours of individuals with T2D, particularly concerning physical activity and dietary habits. The low levels of physical activity, especially among those in the highest BMI categories, are of major importance and suggest that more effective interventions are needed to promote physical activity in this population. Exploring the barriers to these behaviours, such as lack of motivation, access to resources, or technical support, could provide insights into how to improve lifestyle interventions. Most dietary plans were recommended by HCPs, but engagement to a dietary plan was low, raising questions about the effectiveness of these approaches. Discussing ways to enhance the impact of healthcare advice, such as through personalized or culturally sensitive approaches, could be a productive area of focus. These results demonstrate the need to consider these behaviours as outcomes of the treatment of obesity and not as treatments per se in line with the most recent guidelines to treat obesity [24, 25].

As expected, according to the therapeutic guidelines [13, 26], almost all patients (98.2%) were treated with blood glucose-lowering drugs (ATC A10B). The increased use of GLP-1 receptor analogues in individuals with higher BMI categories may reflect the well-known benefits on body weight reduction with this class [13]. However, the cardiovascular benefits of GLP-1 receptor analogues in T2D are not modified by BMI class [27] and most patients with T2D benefit from weight loss [28]. It is noticeable that, comparing to other classes, drugs with known cardiovascular protective effects (GLP-1 receptor analogues and SGLT2 inhibitors) are still underused in clinical practice. The lower use of GLP-1 receptor analogues in these individuals suggests potential gaps in treatment optimization that may need to be addressed to improve outcomes [19]. Furthermore, reimbursement for this therapeutic class is currently limited to individuals with T2D and BMI over 35 kg/m^2. However, given the evidence that individuals at high cardiovascular risk exist across all BMI categories, this restriction does not align with the needs of the Portuguese population. Any findings related to medication use should be interpreted with caution, as the medications presented in this study only reflect the antidiabetic drugs listed on patients' prescriptions at the time of their inclusion, rather than their entire ongoing treatment regimen.

The study's limitations, including the low pharmacy participation rate, regional disparities, and the absence of screening/refusal logs at the point of care to assess selection bias, may affect the generalizability of these findings. It is important to consider how these factors could be addressed in future research to ensure that the results are more representative of the overall T2D population in Portugal.

Conclusions

This study characterized the Portuguese population with T2D in relation to BMI, revealing a high prevalence of overweight and obesity. This underscores the urgent need for targeted strategies to manage abnormal adiposity levels in this population.

Furthermore, the analysis highlighted significant differences in terms of gender, age, and employment status. The additional data collected emphasize the need to improve healthcare for this population, focusing on optimizing clinical follow-up and implementing more effective interventions for the prevention and management of obesity among individuals with T2D. These measures aim to enhance the quality of life and reduce the risk of premature morbidity and mortality in this population. Moreover, routine assessment of BMI and WC should be integrated into clinical practice to better control associated risk factors. This would allow a more comprehensive and individualized approach in the management of patients with T2D in Portugal.

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Statement of Ethics

This study was performed in accordance with the Declaration of Helsinki. This human study was approved by Comissão de Ética para a Investigação em Ciências da Vida e da Saúde (CEICVS) board of the University of Minho, Braga, Portugal – Approval No. CEICVS 037/2024. All participants provided verbal informed consent, as approved by the Ethics Committee. Verbal consent was taken because no personal data were collected, minimizing potential privacy risks. The verbal consent process was recorded/documented by the pharmacist, who read a standardized script approved in the study protocol (electronic Case Report Form) to each participant and confirmed their agreement to participate before proceeding with data collection.

Conflict of Interest Statement

V.C. is an employee of Novo Nordisk Portugal, Lda. (the funder of this study). Prof. José Silva-Nunes and Dr. João Sérgio Neves were members of the journal's Editorial Board at the time of submission. All other authors have no conflicts of interest to declare.

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Author Contributions

All authors contributed to the conceptualization and development of the methodology for the study, read and approved the final manuscript, and had full access to all data (including statistical reports and tables) in the study, taking responsibility for the integrity of the data and the accuracy of the data analysis. Supervision was provided by J.S.-Nu., J.S.Ne., and A.T.-R. Data curation was performed by J.G. Project administration was carried out by M.C. The first draft of the manuscript was written by M.C. and C.R. J.S.-Nu., J.S.Ne., A.T.-R., V.C., and J.G. reviewed and provided feedback on previous versions of the manuscript. V.C. (Novo Nordisk Portugal, Lda.) is an employee of the study sponsor and contributed to critical review of the manuscript.

Data Availability Statement

The data that support the findings of this study are not publicly available due to containing information that could compromise the privacy of pharmacies that collected the data but are available from the corresponding author, M.C., upon reasonable request.

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