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Muscle and cardiometabolic health in community-living adults with type 2 diabetes

Salud muscular y cardiometabólica en adultos con diabetes tipo 2 que viven en la comunidad

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ABSTRACT

Introduction: Type 2 diabetes (T2DM) is a chronic disease associated with alterations in muscle quantity and quality. The aim of this study was to evaluate metabolic and muscular health indicators in adults with T2DM.

Methods: Cross-sectional study conducted in outpatients of a primary care health center diagnosed with T2DM. The muscle health indicators were muscle mass (MM) and handgrip strength (HGS). MM was assessed through calf circumference (CC) corrected by body mass index (BMI); low muscle MM was determined with values ≤34 cm for men and ≤33 cm for women. HGS was assessed with a digital dynamometer and dynapenia was identified with values below the 10th percentile of HGS for age and sex. The cardiometabolic health indicators were waist-to-height ratio (WHtR) and neck circumference (NC). Cardiometabolic risk was identified as an WHtR ≥ 0.5 and/or a NC of 39.0 and 32.9 cm for men and women, respectively.

Results: A total of 60 participants with a mean age of 50.98 ± 11.86 years were evaluated. 67% (n=40) were female. 98.33% (n=59) and 65% (n=39) presented high cardiometabolic risk according to WHtR and NC, respectively. 73.33% (n=44) presented low MM and 28.33% (n=17) had dynapenia. A positive and significant correlation was found between NC and BMI (r=0.342; p = < 0.001) and between NC and waist circumference (r = 0.486; p = < 0.001). **Conclusions:** A high cardiometabolic risk profile according to the NC and the WHtR, as well as a high prevalence of low MM and dynapenia was found in this studied population.

Keywords: Type 2 diabetes; Muscle mass; Handgrip strength; Dynapenia; Cardiometabolic risk.

RESUMEN

Introducción: La diabetes tipo 2 (DM2) es una enfermedad crónica asociada a alteraciones en la cantidad y calidad muscular. El objetivo de este estudio fue evaluar indicadores de salud metabólica y muscular en adultos con DM2.

Metodología: Estudio transversal realizado en pacientes ambulatorios de un centro de salud de primer nivel de atención en salud con diagnóstico de DM2. Los indicadores de salud muscular fueron la masa muscular (MM) y la fuerza de prensión manual (FPM). La MM se valoró a través de la circunferencia de pantorrilla (CP) corregida por índice de masa corporal (IMC); la baja MM muscular se determinó con valores ≤34 cm para hombres y ≤33 cm para mujeres. La FPM se valoró con un dinamómetro digital y se identificó dinapenia con valores menores al percentil 10 de la FPM para la edad y el sexo. Los indicadores de salud cardiometabólica fueron el índice cintura-altura (ICA) y la circunferencia de cuello (CCu). Se identificó como riesgo cardiometabólico un ICA ≥ 0,5 y/o una CCu 39,0 y 32,9 cm para hombres y mujeres, respectivamente.

Resultados: Se evaluó a un total de 60 participantes con edad media de 50,98 ± 11,86 años. El 67% (n=40) fueron de sexo femenino. El 98,33% (n=59) y el 65% (n=39) presentó alto riesgo cardiometabólico según el ICA y la CCu, respectivamente. El 73,33% (n=44) presentó baja MM y el 28,33% (n=17) tuvo dinapenia. Se encontró una correlación positiva y significativa entre la CCu y el IMC (r=0,342; p = < 0,001) y entre la CCu y la circunferencia de cintura (r = 0,486; p = < 0,001).

Conclusiones: La población estudiada presenta un perfil de riesgo cardiometabólico elevado según la CCu y el ICA, así como una alta prevalencia de baja MM y dinapenia.

Financiación: Este proyecto fue autofinanciado por los autores.

Palabras clave: Diabetes mellitus tipo 2; Masa muscular; Fuerza de prensión manual; Dinapenia; Riesgo cardiometabólico

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KEY MESSAGES

- Subjects with type 2 diabetes mellitus (T2DM) present metabolic alterations that may affect cardiometabolic health and muscular.
- More than half of the subjects were living with obesity according to the body mass index (BMI) and 98.33% showed cardiometabolic risk according to the waist-to-height ratio (WHtR).
- 73.33% of participants had low blood mass muscular and 28.33% showed dynapenia.
- Neck circumference was positively correlated with BMI and waist circumference.

INTRODUCTION

Type 2 dibetes mellitus (T2DM) is a chronic disease that accounts for 90% of all diabetes cases worldwide[1]. The World Health Organization (WHO) estimates that currently 422 million people are diagnosed with T2DM in worldwide, and projections indicate that by 2040, this number is expected to rise to 109 million cases[2].

T2DM is distinguished by a series of metabolic alterations that include insulin resistance, inflammation, advanced accumulation of insulin end products advanced glycation, unbalanced protein turnover and increased oxidative stress[3]. These abnormalities adversely affect musculoskeletal health, reducing muscle mass and function[4]. Additionally, poorer glycemic control, as well as inadequate diet, aging, and excess ectopic fat could promote the deterioration of muscle health, which may contribute to the development and progression of T2DM[5].

Thus, the coexistence of T2DM and the loss of muscle tissue and weakness have become increasingly frequent phenomena[6]. The progressive and generalized loss of muscle mass is known as presarcopenia, while low muscle strength is called dynapenia[7]. The coexistence of both conditions, low muscle mass and low muscle strength is defined as sarcopenia, and have been associated with increased hospitalization, cardiovascular events, and mortality in subjects with T2DM[8].

On the other hand, excessive accumulation of fat in the body is a risk factor for the development of cardiometabolic diseases such as T2DM. In this sense, anthropometric indicators such as waist circumference (WC) and body mass index (BMI) have generally been used to assess cardiometabolic risk. However, the waist-to-height ratio (WHtR) and neck circumference (NC) have been proposed as simple and useful indicators for assessing cardiometabolic risk in individuals with non-communicable chronic diseases[9].

Despite the impact of T2DM on muscle mass and cardiometabolic risk, its assessment and management are still scarce at the primary level of healthcare. This gap in care may hinder the effective prevention and management of this condition in adults, highlighting a clear need for addressing this issue in medical care.

The aim of this study was to assess muscle and cardiometabolic health indicators in community-dwelling adults with T2DM.

METODOLOGY

Study design:

A cross-sectional observational study was conducted.

Context:

Data collection was carried out at the Centro de Salud 29 de Noviembre, located in the province of El Oro, Ecuador, between the months of April and June 2024.

Population and sample:

The population consisted of subjects diagnosed with T2DM who regularly attended outpatient consultations for the control of their underlying pathology. Individuals between the ages of 18 and 64 who agreed to participate in the study were included. Subjects undergoing cancer treatment, with degenerative disorders related to cognitive or motor function that could affect the outcome of the study, such as Alzheimer's disease, multiple sclerosis, advanced dementia, pregnant or breastfeeding women, cardiac, respiratory, or renal failure, or those who could not undergo anthropometric evaluations or could not perform the muscle strength test were excluded. The subjects who took part in the study signed an informed consent form prior to the assessment of their variables.

Study variables

Sociodemographic variables

The sociodemographic variables included age (years), marital status (married, in a free union, separated, divorced, widowed, single), educational level (none, basic education, middle or high school, higher education), residential area (urban, rural), and ethnicity (indigenous, Afro-Ecuadorian, Montubia, other).

Anthropometric variables

Weight (kg), height (cm), WC (cm), and CC (cm) were assessed. The WC was obtained by measuring from the midpoint between the lower costal margin and the iliac crest. From the weight and height, the BMI was calculated and classified according to the cut-off points of the

WHO: <18.5 kg/m^2 = underweight, between 18.5 and 24.9 kg/m^2 = normal range, 25.0 – 29.9 kg/m^2 = overweight, 30.00 – 34.9 kg/m^2 class I obesity, 35.0 – 39.9 kg/m^2 = class II obesity, and ≥40 kg/m^2 class III obesity.

Cardiometabolic health indicators

Waist-to-Height Ratio (WHtR): The WHtR was obtained by dividing the waist circumference in centimeters by the height in centimeters, and classified as no cardiometabolic risk < 0.50 and cardiometabolic risk with a value ≥ 0.50[10].

Neck circumference (NC): The NC was measured with the individual seated, using a metal tape measure immediately above the cricoid cartilage and perpendicular to the long axis of the neck. A value of 39.0 and 32.9 cm was considered an indicator of cardiometabolic risk for men and women, respectively[11].

Muscle health indicators

Muscle mass: Muscle mass was assessed through CC adjusted for BMI, for which 3, 7, or 12 cm (BMI 25–29, 30–39, and ≥40, respectively) were subtracted from the initial calf circumference measurement. In subjects with a BMI < 18.5 kg/m^2, this adjustment was not made because it is not applicable in cases of underweight or suspected weight loss or muscle atrophy. Based on the corrected CC, low muscle mass was determined with values ≤34 cm for men and ≤33 cm for women[12].

Muscle function: Muscle function was assessed using the HGS with a Camry® digital dynamometer model EH101 with a grip capacity of up to 90 kg[13]. Each participant was asked to sit with their arm extended and their elbow close to the trunk at a 90º angle, with their forearm, wrist, and shoulders in a neutral position. Subsequently, they were asked to hold the dynamometer in their dominant hand, exerting maximum effort against the device to accurately determine muscle strength with a minimum grip duration of 3 seconds. Three measurements were taken for each participant, and the average of the measurements was obtained.

Dynapenia was determined when the HGS value was below the 10th percentile of the sex- and age-specific mean according to the cohort points of the Colombian population[14].

Sarcopenia was diagnosis with low muscle mass (CC ≤34 cm for men and ≤33 cm for women) and low HGS (below the 10th percentile of the sex- and age-specific mean).

Sarcopenic obesity was identified with the coexistence of sarcopenia and obesity according of BMI.

Data sources/measurements

The data were obtained through the assessment of sociodemographic, anthropometric, and muscle function variables in the participants.

Biases:

The possible biases of this study include sample selection and the use of international cut-off points to identify low muscle mass and function.

Sample size:

The sample was selected through non-probabilistic sampling and consisted of a total of 60 participants. Figure 1 shows the flowchart of the sample selection.

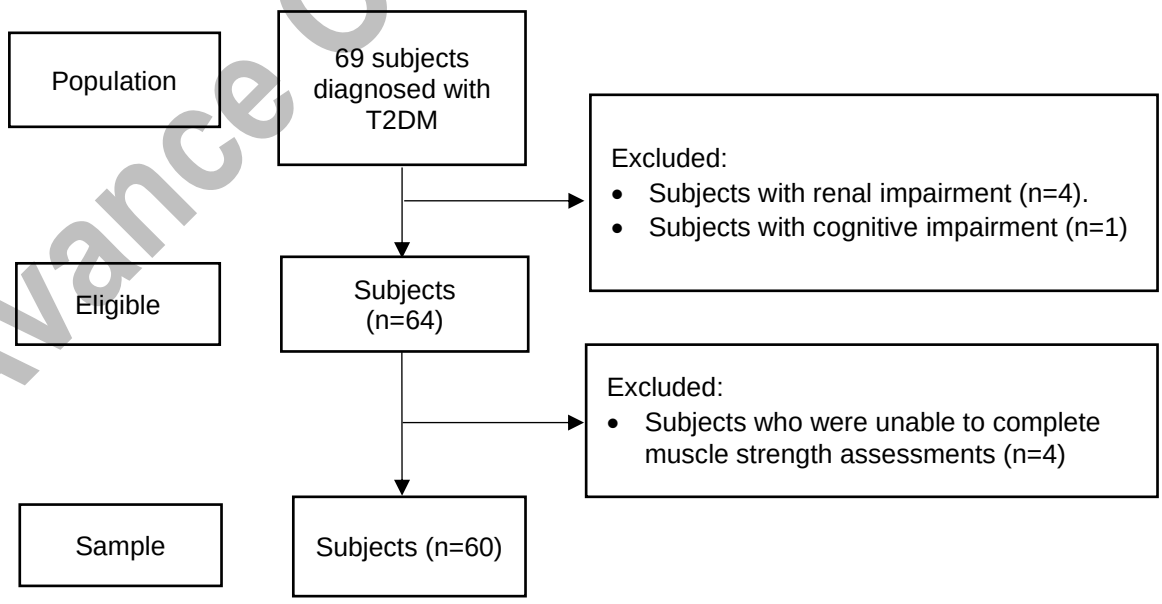

Figure 1. Sample selection flowchart

Statistical analysis

The statistical package SPSS version 25 was used for data analysis. Numerical variables are represented as mean ± standard deviation (SD). Numerical variables are presented as mean and standard deviation if their distribution was normal and as median and interquartile range if the distribution was skewed. Categorical variables are presented as absolute frequencies and percentages. The relationship between categorical variables was analyzed using Pearson's Chi-square test, while the correlation between numerical variables was tested through Pearson's correlation coefficient. A p-value < 0.05 was considered statistically significant.

Ethical aspects

The research topic was approved by the Research Council, Management of the Knowledge and Postgraduate Studies of the Faculty of Medical Sciences of the Universidad de Guayaquil (No UG-CIGCP-02-08-2024-R). For this research, the ethical principles of the 1964 Declaration of Helsinki were followed.

RESULTS

Sociodemographic variables

A total of 60 subjects were evaluated, of which 66.7% (n=40) were female and 33.3% (n=20) were male. The average age of the population was 50.97 ± 11.84 years. 88.3% (n=53) resided in the urban area, 75% (n=45) were mestizo, 23.3% (n=14) were single and 43.3% (n=26) had middle-high school education level. Table 1 summarizes the sociodemographic characteristics of the study population.

Table 1. Sociodemographic characteristics of the study population

Variable	Total (n=60)	Female (n=40)	Male (n=20)	p-value
Age (years)	50,97 ± 11,84	52,60 ± 12,38	47,70 ± 10,29	0,110
Residential area, n (%)				
Urban	53 (88,33)	37 (92,5)	16 (80)	0,155
Rural	7 (11,66)	3 (7,5)	4 (20)	
Ethnicity, n (%)				
Indigenous	1 (1,6)	0 (0)	1 (5)	0,532
Afro-Ecuadorian	9 (15)	6 (15)	3 (15)	
Montubia	5 (8,33)	3 (7,5)	2 (10)	
Mestiza	45 (75)	31 (77,5)	14 (70)	
Marital status, n (%)				
Married	20 (33,33)	12 (30)	8 (40)	0,541
Free union	12 (20)	7 (17,5)	5 (25)	
Divorced	9 (15)	7 (17,5)	2 (10)	
Widower	5 (8,33)	5 (12,5)	0 (0)	
Single	14 (23,33)	9 (22,5)	5 (25)	
Educational level, n (%)				
None	1 (1,66)	1 (2,5)	0 (0)	0,751
Basic	24 (40)	17 (42,5)	7 (35)	
Middle-High school	26 (43,33)	17 (42,5)	9 (45)	
Superior	9 (15)	5 (12,5)	4 (20)	

Age is presented as mean and ± standard deviation.

Anthropometric indicators

The average body weight of the participants was 50.97 ± 11.84 kg, and the height was 157.61 ± 11.99 cm. The average BMI was 30.26 ± 4.64 kg/m², from which it was identified that 53% (n=32) had obesity. On the other hand, the WC was 102.40 ± 11.01cm.

Cardiometabolic health indicators

The mean of the WHtR was 0.67 ± 0.07. Based on the WHtR, it was identified that 98.33% (n=59) of the participants presented cardiometabolic risk. On the other hand, the mean NC was 36.51 ± 5.27 cm, reflecting a prevalence of cardiometabolic risk in 65% (n=39) of the study subjects.

Indicators of muscle health

Regarding muscle health indicators, the mean CC was 30.46 ± 3.89 cm, reflecting low muscle mass in 73.33% (n=44) of the participants. Handgrip strength was 24.50 ± 9.45 kg, and dynapenia was identified in 28.33% (n=17) of the population. The HGS was significantly higher in men than in women (p = 0.00).

Sarcopenia was identified in 21.66% (n=13) and sarcopenic obesity in 13.33% (n=8) of the participants.

Table 2 summarizes the anthropometric and functional health indicators cardiometabolic and muscular according to sex.

Table 2. Anthropometric and functional indicators of cardiometabolic and muscular health

Variable	Total (n=60)	Female (n=40)	Male (n=20)	p-value
Weight (kg)	50.97 ± 11.84	70.27 ± 13.28	85.24 ± 10.58	0.000*
Height (cm)	157.61 ± 11.99	151.95 ± 9.32	168.95 ± 8.11	0.000*
BMI (kg/m^2)	30.26 ± 4.64	30.50 ± 5.41	29.80 ± 2.52	0.586
BMI categories, n (%)				
Normal range	6 (10)	6 (15)	0 (0)	0.105
Overweight	22 (36.66)	12 (30)	10 (50)	
Obesity	32 (53.33)	22 (55)	10 (50)	
WC (cm)	102.40 ± 11.01	101.57 ± 12.10	104.05 ± 8.47	0.362
WHtR	0.65 ± 0.07	0.61 ± 0.05	0.84 ± 0.01	0.012*
CMR according to WHtR, n (%)	59 (98.33)	39 (97.5)	20 (100)	0.476
NC (cm)	36.51 ± 5.27	35 ± 4.31	39.55 ± 5.79	0.001*
CMR according to NC, n (%)	39 (65)	24 (40)	15 (75)	0.390
CC (cm)	30.46 ± 3.89	29.97 ± 4.06	31.45 ± 3.42	0.147
Low muscle mass, n (%)	44 (73.33)	29 (65)	15 (75)	0.547
HGS, (kg)	24.50 ± 9.45	19.77 ± 5.94	33.96 ± 7.99	0.000*
Dynapenia, n (%)	17 (28.33)	13 (32.5)	4 (20)	0.242
Sarcopenia, n (%)	13 (21.66)	10 (25)	3 (15)	0.001*
Sarcopenic obesity, n (%)	8 (13.33)	7 (17.50)	1 (2.50)	0.000*

BMI, body mass index; WC, waist circumference; WHtR, waist-to-height ratio; CMR, cardiometabolic risk; NC, neck circumference, HGS, handgrip strength. *p < 0,05

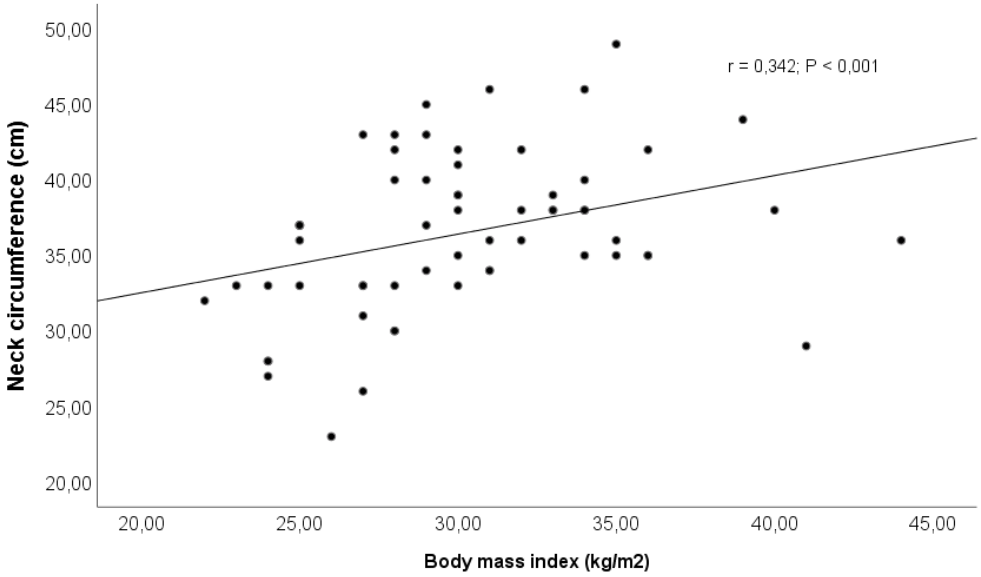

Fig. 2 Correlation between neck circumference and body mass index.

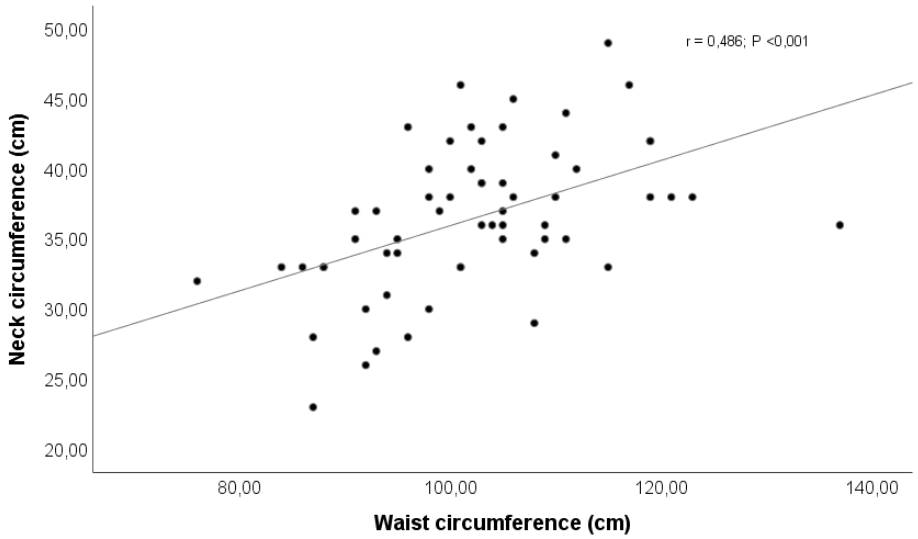

Fig. 3 Correlation between neck circumference and waist circumference

A statistically significant moderate positive correlation (r = 0.342; p = < 0.001) was found between NC and BMI (Figure 2), and between NC and WC (r = 0.486; p = < 0.001) (Figure 3).

DISCUSSION

In this study, anthropometric and functional indicators of cardiometabolic and muscular health were evaluated in community-dwelling adults with T2DM. WC and BMI reflected cardiometabolic risk in more than half of the population, while low muscle mass was a prevalent condition in most participants, although dynapenia was less frequent.

In the study population, a slight difference in CC was found between men and women, which could be related to a difference in the function and distribution of body fat between the sexes, given that women tend to accumulate more subcutaneous fat in the lower extremities and hips, while men usually accumulate more visceral fat at the abdominal level[15].

The relationship between WC and height has been proposed as an alternative measure to BMI because it considers the central distribution of weight and is strongly associated with a higher cardiometabolic risk in people with diabetes[16]. In this study, 98.33% of the participants presented cardiometabolic risk according to the WHtR. Similar results were described in a population study in Mexico, in which more than 90% of the subjects had a WHtR ≥ 0.50[17]. However, in a Chinese cohort of 3108 subjects with T2DM, it was reported that the prevalence of cardiovascular events was 21.3% in the highest quartile of WHtR[18].

The NC is a simple anthropometric parameter that reflects the subcutaneous fat content of the human trunk. A recent systematic review and meta-analysis that included 30,923 subjects reported that NC is significantly associated with the risk of T2DM[19]. In Latin America, it has been reported that NC is associated with various cardiometabolic risk factors such as insulin resistance, elevated cholesterol, triglycerides, LDL cholesterol, and obesity[20]. In our study, the mean NC was 36.51 ± 5.27 cm, and it was identified that 65% of the subjects presented cardiometabolic risk. Similar results were reported by a study at the Latin American level that included Ecuador, in which the mean NC was 35.1 ± 3.7 cm in our country[11].

The marked difference in the prevalence of cardiometabolic risk detected according to the WHtR and the NC may be related to the sensitivity of each of these to specific cardiometabolic risks. Thus, the WHtR is a more sensitive marker of central adiposity, closely associated with cardiovascular risk and insulin resistance, while the NC has been proposed as a more

practical and less invasive measure, with some correlation with subcutaneous and visceral adipose tissue, but also with cervical muscle mass.

The CC corrected by BMI has been described as one of the indicators of muscle mass quantity in the diagnosis of diabetic sarcopenia[21]. In our sample, the mean CC was 30.46 ± 3.89 cm and 73.33% of the subjects presented low muscle mass according to this indicator. However, an average of 37.2 ± 3.1 cm has been reported in a cohort of Spanish adults with T2DM [22], while Yoon et al. reported an average of 34.7 ± 2.9 cm in Asian adults with the same pathology [23]. The differences between these studies could be explained by the lack of correction of WC for BMI in previous research.

Patients with T2DM tend to have lower HGS values compared to those without this condition[24]. In the present study, the mean HGS was 24.50 ± 9.45 kg, similar to that reported by Hamasaki and Yanai[8] an Asian population with T2DM with values of 23.9 ± 9.7 kg. On the other hand, dynapenia was prevalent in 28.33% of our sample, a value significantly higher than that reported by Suda et al., who reported a prevalence of 17.9% in a Japanese cohort of 268 subjects with T2DM[25].

On the other hand, HGS exhibited a notable difference between women and men, with the latter presenting higher values. These findings could be explained by the physiological differences between the sexes, as men, on average, have a greater muscle mass and a higher density of fast-twitch muscle fibers, which enhances strength[26].

The moderate positive correlations found between NC and BMI and WC in this study suggest that NC could be a useful indicator in the assessment of cardiometabolic risks in individuals with T2DM at the community level, as reported by other authors[27]. In a cohort of 464 adults aged 18 to 65 with T2DM, it was found that NC correlated positively with anthropometric indicators such as BMI and WC[28]. These results highlight the use of NC as a simple and useful marker of cardiometabolic risk.

The coexistence of obesity and low muscle mass was identified as sarcopenia in our population, with a prevalence of 21.66%, and sarcopenic obesity with 13.33%. Those are common problems in T2DM patients, with a reported prevalence of sarcopenia of 18%[29] and 27% of sarcopenic obesity [30].

This study presents strengths such as the evaluation and interpretation of metabolic and muscular health indicators that are easy to apply and low-cost at the community level, which could have practical implications in primary health care services. Additionally, it provides statistics on the status of metabolic and muscular health indicators specifically in patients with T2DM at the local level, which highlights its relevance and contribution in this field of interest in nutrition.

However, limitations such as the cross-sectional design of the study, the limited sample size, the convenience sampling method, which makes it difficult to follow up with patients, as well as the extrapolation of the results to other population were found in this study. On the other hand, it is important to highlight that the participants voluntarily attended outpatient consultations, which could represent a bias in the selection of individuals more committed to their health and reflect limited information from those who do not regularly attend check-ups. Considering these limitations is essential for accurately interpreting the findings and designing future research on the topic.

Our findings highlight the need to implement strategies aimed at improving cardiometabolic and muscular health in patients with T2DM living in the community. Longitudinal studies are necessary to analyze the evolution of muscle mass and cardiometabolic risk in patients with T2DM.

CONCLUSIONS

The studied population with T2DM living in community presented a high cardiometabolic risk according to WHtR and NC, as well as a significant prevalence of obesity and low muscle mass, reflecting both metabolic and muscular health issues. On the other hand, positive correlations were found between neck circumference and BMI, as well as with waist circumference, suggesting their usefulness as risk indicators. According to these findings, and supported in previous studies, WHtR and NC are effective tools for assessing cardiometabolic risk. These findings underscore the need for interventions focused on reducing cardiometabolic risks and improving muscle health in individuals with T2DM.

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AUTHORSHIP CONTRIBUTION

A. E-R., J. G-C., and C. A-P. contributed to the creation and design of the study, designed the statistical plan, and interpreted the data. A. E-R. conducted the literature search, performed the analyses, and wrote the first draft with the help of C.A-P. and E.F-T. made the corrections and validated the final draft. All authors critically reviewed this and previous versions of the document.

FINANCING

The authors declare that there was no funding to carry out this study.

CONFLICT OF INTEREST

The authors declare that there are no conflicts of interest when writing the manuscript.

DATA AVAILABILITY

Data from this study are not available.

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