Original Article

The Hidden Battle Within: Shedding Light on the Co-existence of Sarcopenia and Sarcopenic Obesity among Participants with Type 2 Diabetes in a Tertiary Care Hospital, Gujarat

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Abstract

Introduction: Type 2 diabetes (T2DM) is characterised by chronic hyperglycaemia due to abnormal insulin secretion and/or utilisation. Currently, sarcopenia has emerged as a new complication of T2DM, which increases the risk of physical disability, and even death. The study aims to estimate the prevalence of sarcopenia and sarcopenic obesity (SO) as well as their association with various other factors related to T2DM. **Methods:** The study was an observational hospital-based cross-sectional study conducted among diabetic patients who came to the non-communicable diseases (NCD) clinic of a tertiary care hospital in Gujarat, India, from April 2023 to June 2023. Adult patients with T2DM attending follow-ups were included, with a diagnosis of T2DM for at least 1 year from the date of their electronic medical records, regardless of their mode of therapeutic treatment. They were on regular medical reviews with two or more visits to the study site in the past 1 year. Then a self-structured standard questionnaire was used to collect the data, containing socio-demographic characteristics, clinical profiles, anthropometric assessment (comprising weight, height and body mass index [BMI]), bio-impedance indices like body fat%, skeletal muscle% and handgrip by hand dynamometer. **Results:** In the study, a total of 404 participants participated. Their mean age was 55 ± 13.5 years and their mean body fat (BF) % was 30 ± 7.4%. BF%-defined obesity was found in 260 (64.4%) participants. A total of 362 (89.6%) had possible sarcopenia, 183 (45.3%) had sarcopenia and 124 (30.7%) had SO. Age (OR: 2.6, CI: 1.7–3.9), duration of diabetes for more than 7 years (OR: 7.5, CI: 3.65–15.4) and BF%-defined obesity (OR: 2.2, CI: 3.6–15) were statistically associated with Sarcopenia, in similar pattern age (OR: 2.4, CI: 1.5–3.7), and duration of diabetes more than 7 years (OR: 18.9, CI: 5.7–62) were associated with SO ($P < 0.05$). **Conclusion:** Older age, longer diabetes duration and BF%-defined obesity are associated with an increased likelihood of developing sarcopenia and sarcopenic obesity. Healthcare providers should prioritise regular screening for sarcopenia and SO in elderly individuals with diabetes to facilitate early detection and intervention.

Keywords: Adiposity, diabetes mellitus type 2, risk factors, sarcopenia, sarcopenic obesity

Introduction

Type 2 diabetes mellitus (T2DM) is characterised by chronic hyperglycaemia brought on by problems with insulin secretion and/or utilisation. According to epidemiological data, 387 million persons globally suffer from diabetes.[1]

Sarcopenia, characterised by the progressive loss of muscle mass, strength and function, has emerged as a significant public health concern, particularly in the aging population. The condition has been associated with various adverse health outcomes, including physical disability, impaired quality of life and increased mortality and sarcopenia has also been regarded as a new complication of T2DM.[2]

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Sarcopenic obesity (SO) is a condition characterised by the coexistence of sarcopenia and obesity in the same individual. Sarcopenia is defined as low skeletal muscle mass, whereas obesity is defined as high body fat percentage.[3,4] SO was first defined by Baumgartner as a muscle mass index less than

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2 SD below the sex-specific reference for a young, healthy population.[5] SO is a major concern as it is associated with several adverse health outcomes, including frailty, physical disability, cardiovascular disease, fractures, dementia, cancer and increased all-cause mortality. The incidence of SO is increasing rapidly, mainly owing to the aging of the worldwide population and the current obesity epidemic.[3-5]

The coexistence of sarcopenia and T2DM, particularly in the form of sarcopenic obesity, may synergistically impact overall health and further complicate disease management.

Several studies have investigated the prevalence of sarcopenia and SO in individuals with diabetes, providing valuable insights into the relationship between these conditions and diabetes-related complications.[6-8]

Despite the existing body of research, there is still a need for further investigation to establish a consensus on the prevalence of sarcopenia and SO in individuals with diabetes, across the globe. So, this current study aims to estimate the prevalence of sarcopenia and SO as well as to determine the association with various other factors of T2DM.

Materials and Methods

The study was an observational hospital-based cross-sectional study conducted among diabetic patients who came to the non-communicable diseases (NCD) clinic of a tertiary care hospital in Gujarat, India, from April 2023 to June 2023. Utilising the prevalence estimate (16%) for sarcopenia among older persons regardless of diabetes status,[9] the sample size was computed to be 396, at 4% precision and 97% confidence level, using the following sample size formula: $Z^2P(1-P)/d^2$, where Z is Z statistic for a level of confidence, *P* is the expected prevalence and d is precision level. This was projected as a conservative estimate, as the prevalence was anticipated to be higher in the presence of T2DM. Patients with T2DM attending follow-ups were included, with a diagnosis of T2DM for at least 1 year from the date of their electronic medical records, regardless of their mode of therapeutic treatment. Patients were line-listed and selected by a simple random sampling technique. They were on regular medical reviews with two or more visits to the study site in the past 1 year. The participants can be treated with any therapeutic options compatible with their glycaemic control, ranging from diet control alone, oral hypoglycaemic agents alone, or a combination of oral hypoglycaemic agents with insulin injections. Those with known risks that hindered or compounded sarcopenia assessment, such as a history of stroke, carpal tunnel syndrome, severe hip or knee osteoarthritis, dysarthria or dysphasia, hearing difficulties, use of walking aid, physical disabilities that affect handgrip and/or walking, use of electronic implants such as a pacemaker, any kidney or liver dysfunction and living in residential care facilities were excluded. Patients with any form of other disabilities, such as cognitive impairment, which rendered them incapable of providing informed written consent were also excluded. Then a self-structured standard questionnaire was used to collect the data, containing socio-demographic characteristics, Clinical profiles, anthropometric assessment (comprising weight, height and body mass index [BMI]), bio-impedance indices like body fat % and skeletal muscle % were measured by bio-impedance analyser (Omron-Karada scan 720T, Manufactured from Gurugram, Haryana) and handgrip by hand dynamometer. Informed written consent was taken in their own vernacular language. Good clinical care guidelines were followed and guidelines as per the Helsinki Declaration (2008).

Data collection procedure

The self-structured standard questionnaire was administered to them that recorded their socio-demographic characteristics and clinical profiles. Simultaneously, an anthropometric assessment was performed to measure their weight, height and body mass index (BMI).

Finally, the sarcopenia assessment was performed as follows:

(1) Body muscle mass was measured using a Bio-Electrical Impedance analysis machine (OMRON Body composition monitor, Model HBF-702T). The skeletal muscle index was then calculated as body muscle mass divided by squared body height in metres.

(2) Lafayette Hand-Held Dynamometer is a portable measurement device used for assessing muscle function. The Lafayette Hand-Held Dynamometer features a wide range of customisable options for data storage, force overtime graphs, pre-set test times and force thresholds. The device is a valid and proven assessment tool used for objectively quantifying muscle strength.[10] Handgrip strength was measured twice on each hand, using a dynamometer with the subject seated with the elbow flexed at 90 degrees, forearm in a neutral position and wrist between 0 and 30 degrees of dorsiflexion and supported on a table, according to the American Society of Hand Therapists' guidelines.[11] The average handgrip strength of the dominant hand was used for analysis; cut-off values for body fat (BF) %, skeletal muscle index (SMI) and SO are mentioned in Table 1.

Sarcopenia was diagnosed according to the Asian Working Group of Sarcopenia (AWGS criteria).[14] Sarcopenia was diagnosed when there was low muscle mass (defined as skeletal muscle index [SMI] <7 kg/m^2 in males and < 5.7 kg/m^2 in females), together with either low muscle strength (defined as handgrip strength < 28 kg in males and < 18 kg in females) or low physical performance (defined as 6-m gait speed ≤0.8 m/s) or both. For this study, handgrip measurements for muscle strength were used. The participant's medical records were accessed to retrieve information on the latest random blood sugar levels, renal function tests (RFTs) and liver function tests (LFTs) from the laboratory test results. The study was conducted after being reviewed and approved by the Institutional Ethical Review Board. (Shri MP Shah Medical College and Guru Gobind Singh Hospital, Jamnagar) (36/01/2023,11.04.2023).

Table 1: Operational definitions

Variables	Classification
Body fat percentage, BF%[12]	
Male	Essential fat: 2–5
	Athletes: 6–13
	Fitness: 14–17
	Acceptable: 18–24
	Obese: ≥25
Female	Essential fat: 10–13
	Athletes: 14–20
	Fitness: 21–24
	Acceptable: 25–31
	Obese: ≥32
BMI, kg/m^2[13]	Underweight <18.5
	Normal: 18.5–22.9
	Overweight >23
	At risk: 23–24.9
	Obese: ≥25
Possible Sarcopenia, Handgrip, kg[14]	
Male	Possible Sarcopenia: <28
Female	Possible Sarcopenia: <18
Skeletal Mass Index in BIA machine, kg/m^2[14]	
Male	Sarcopenia: < 7.0
Female	Sarcopenia: < 5.7
Sarcopenic Obesity[3]	
Male	Sarcopenia+Body Fat %: ≥25%
Female	Sarcopenia+Body Fat %: ≥ 32%

Statistical analysis

All the collected data were entered into Microsoft Excel. Analysis was done using the Statistical Package for Social Science (SPSS) software (IBM, Version 26). Prevalence of sarcopenia (in stages) and categorical demographic and clinical variables were reported in frequencies and percentages. Logistic regression analysis was performed to explore the factors associated with the presence of sarcopenia. In the same way, an analysis of SO was also done except BF% defined was not included because BF%-defined obesity is regarded as a component of SO. Statistical significance was set at P <0.05 for significance. P value <0.001 was considered highly significant.

Ethical aspect

The study was conducted after getting ethical clearance from the Shri MP Shah Medical College and GG Hospital Ethical Committee (REF No.36/01/2023). A written informed consent was taken. The procedures followed the guidelines laid down in the Declaration of Helsinki (2013).

Results

About 404 T2DM individuals participated in the study, and the mean age of the participants was 55 ± 13.5 years. In addition, 96% of participants were on oral diabetes medication (biguanides >sulfonylureas).

Table 2 shows the study participants' socio-demographic parameters. In that, 211 (52.2%) of the study participants were aged less than 60 years and 193 (47.8%) were aged above or equal to 60 years. There were 220 (54.5%) males and 184 (45.5%) females.

Table 2: Socio-demographic data, *n*=404

Variables	Frequency, %
Age, (in years)	
18–60 years	211 (52.2)
Above and equal to 60 years	193 (47.8)
Sex	
Male	220 (54.5)
Female	184 (45.5)

Table 3: Anthropometric and clinical characteristics of patients enrolled

Variables	Males	Females	Total (*n*=404)
Anthropometric measures			
Mean BMI, kg/m^2	23.8±4.1	24.7±4.3	24.2±4.2
Mean body fat percentage, %	29.8±4.5	31.2±5.0	30±7.4
BF%-defined obesity, *n*			
BF% values	≥25%	≥32%	
	155	105	260 (64.4%)
BMI-defined obesity			
Present	58	61	119 (29%)
Absent	162	123	285 (71%)
Possible Sarcopenia, *n*			
Handgrip strength	<28 kg	<18 kg	
	182	180	362 (89.6%)
Sarcopenia, *n*			
SMI	< 7.0 kg/m^2	< 5.7 kg/m^2	
	92	91	183 (45.3%)
Sarcopenic Obesity, *n*			
Sarcopenia+BF%-defined obesity			
	66	58	124 (30.4%)
Duration of diabetes			
1–3 years	30	28	58 (14%)
3–6 years	67	86	153 (37.8%)
≥7 years	123	70	193 (47.7%)

Table 3 shows that the mean BF % of participants was 30 ± 7.4%, which was higher in females (33%). It also shows that BF%-defined obesity was found in 260 (64.4%) patients, whereas BMI-defined obesity was found only in 119 (29%), respectively. In addition, 362 (89.6%) had possible sarcopenia, 183 (45.3%) had sarcopenia and 124 (30.7%) were having SO.

Table 4 shows the association between sarcopenia and age (P value < 0.001*) with an Odds Ratio (OR) of 2.6, which means patients who are aged 60 years and above have 2.6 times higher odds of having sarcopenia than those < 60 years of age. The duration of diabetes is also associated with sarcopenia with OR of 2.0 (P value < 0.05*) and 7.5 (P value <0.001**), when patients with 1–3 years duration of diabetes (taken as

a reference) were compared with those having the disease for 3–6 years and ≥ 7 years, respectively. This is explained as participants having diabetes for 3–6 years have 2.0 times more odds of getting sarcopenia, and those with diabetes for more than 7 years have 7.5 times higher chances of getting sarcopenia, than the ones who have diabetes for 1–3 years. In regards to BF%-defined obesity, patients with BF%-defined obesity have 2.2 times more odds of developing sarcopenia than those without.

Table 5 shows the association between SO and age (*P* value < 0.001*) with an OR of 2.4, which means patients who are aged 60 years and above have 2.4 times more odds of having sarcopenia than those with <60 years of age. The duration is also associated with SO (*P* value < 0.001**), with OR of 5.8 and 18.9, when patients with 1–3 years duration of diabetes (taken as a reference) were compared with those having the disease for 3–6 years and ≥ 7 years, respectively. This signifies that participants who had diabetes for 3–6 years have 5.8 times more odds of having sarcopenic obesity, and those with diabetes for more than 7 years have 18.9 times higher chances of having sarcopenic obesity, than the ones who have had diabetes for 1–3 years.

Discussion

The present hospital-based cross-sectional study investigated the prevalence of sarcopenia and SO in individuals with diabetes and its association with various risk factors. This study found that the prevalence of sarcopenia and SO in patients with T2DM was 45.3% and 30.4%, respectively. It seems lower compared with a Malaysian study (59.8%) by Norshafarina *et al.* with a multi-ethnic Asian study population. However, Norshafarina *et al*.[15] applied the European working group on sarcopenia (EWGS) diagnostic criteria and cut-off values for sarcopenia instead of those recommended by AWGS. Korean

Table 4: Association of sarcopenia with various risk factors

	Frequency of Sarcopenia	Normal	Total	Percentage of Sarcopenia	*P*	Odds Ratio	95% CI
Age (years)							
≥60	111	82	193	60.6	0.001**	2.613	1.7–3.9
< 60	72	139	211	39			
Gender							
Male	92	128	220	50.2	0.124	0.73	0.49–1.089
Female	91	93	184	49.7			
Duration of T2DM (years)							
1–3	11	47	58	6	[1]	[1]	[1]
3–6	49	104	153	27	0.04*	2.0	1.1–4.1
≥7	123	70	193	67	0.001**	7.5	3.65–15.4
BF%-defined obesity							
Present	136	124	260	74	0.002**	2.2	1.47–3.4
Absent	47	97	144	26			
BMI-defined obesity							
Present	61	58	119	33	0.120	0.710	0.468–1.09
Absent	122	163	285	67			

P value <0.05*, *P*<0.001**

Table 5: Association of sarcopenic obesity with various risk factors

Variables	Sarcopenic Obesity	Normal	Total	Percentage of Sarcopenic Obesity	*P*	Odds Ratio	95 % CI
Age (years)							
≥60	78	115	193	62.9	0.001**	2.43	1.57–3.76
< 60	46	165	211	37			
Gender							
Male	66	154	220	53	0.74	0.93	0.60–1.42
Female	58	126	184	47			
Duration of T2DM (years)							
1–3	3	55	58	2.4	[1]	[1]	[1]
3–6	23	130	153	18.5	0.001**	5.831	3.44–9.86
≥7	98	95	193	79	0.001**	18.912	5.72–62
BMI-defined obesity							
Present	41	78	119	33	0.290	0.782	0.49–1.23
Absent	83	202	285	67			

P value <0.05*, <0.001**.

and Japanese studies reported lower sarcopenia prevalence of 15.7% and 13.3%, respectively.[16,17]

The variation between these findings may be attributed to different measurement methods and/or diagnostic criteria. Both the Korean and Japanese studies used Dual-Energy X-ray Absorptiometry (DEXA) to quantify muscle mass, whereas the present study used bio-electrical impedance analysis for the measurement. Furthermore, different definitions of low muscle mass and cut-off values were used in the Korean study.[17]

Despite using the AWGS criteria, only muscle mass and muscle strength were measured in the Japanese study.[18] The findings revealed that for those aged above 60 years and with a duration of diabetes, the two factors were significantly associated with sarcopenia and sarcopenic obesity. The present study also investigated the association between age above 60 years with sarcopenia and sarcopenic obesity, revealing a significant relationship with OR of 2.6 and 2.4, respectively. Comparing these findings with previous studies, the results align with several investigations that have reported similar findings. For instance, a study by Park *et al*.[18] (2019) also found a significant association between age and the prevalence of Sarcopenia in individuals with type 2 diabetes, with older age being a risk factor for muscle loss. This consistency in findings highlights the robustness of age as a determinant for sarcopenia across different populations and settings.

A study conducted in Tokyo Medical and Dental Hospital concerning T2DM also found a significant association between age with sarcopenia and SO in adults with diabetes. This study also suggests that advancing age is an established risk factor for the development of sarcopenia and SO, highlighting the importance of diagnosis of sarcopenia (low ASM) and SO (high A/G ratio or android fat mass with low ASM) to determine the risk of cardiovascular disorder events in patients with T2DM.[19] A study by Johnson Stoklossa *et al*.[20] (2019) reported a synonymous conclusion and stated that basic anthropometric measurements alone are inadequate to identify sarcopenia and SO in diabetic individuals.

Statistically, the duration of diabetes is associated with sarcopenia and sarcopenic obesity. The present study's findings are consistent with prior research by Chen *et al*.[14] (2020), which reported a significant association between longer diabetes duration and an increased risk of sarcopenia and SO among individuals with type 2 diabetes. These findings suggest that the chronicity of diabetes may contribute to the development of sarcopenia and SO, potentially through mechanisms such as chronic hyperglycaemia, insulin resistance, adiposity and inflammation, which can negatively affect muscle mass and function.

This study has several other limitations. The causal and chronological relationship of the associated factors with sarcopenia cannot be established from this cross-sectional study. The potential recall bias, as well as the data reliability and accuracy, cannot be objectively ascertained in the self-reported variables. As patients with cognitive impairment or significant physical disabilities and/or pacemakers dependent on walking aids were excluded, the findings are not generalisable to the wider, heterogeneous population of older patients with T2DM. As for potential confounders like glycaemic control by HBA1c, type of medication used, diet history and physical activity were not captured in this study. Bio-impedance analyser parameters are largely dependent on the patient's hydration status. BIA enables the determination of body composition parameters in subjects without significant fluid and electrolyte abnormalities. However, BIA may not be accurate in patients with fluid and electrolyte abnormalities. The fact that the current study calculated body fat % using bioelectrical impedance is one of the study's limitations. Although it is mentioned as a drawback in this article, bioelectrical impedance is regarded as a suitable alternative to DXA scanning for determining body fat, particularly in the community setting.[21]

Moreover, further follow-up studies (with age and sex-matched comparison groups) are also needed to understand this association, and interventional studies are needed to understand the impact of lifestyle modification and physical activity intervention in people with sarcopenia and SO.

So, the current study gives insights into the sarcopenia and SO distribution in Indian patients with T2DM and also highlights the importance of effectively identifying risk factors (**primordial prevention)** by screening the sarcopenia, SO through BIA, diagnosing early (**primary prevention**), managing sarcopenia and SO with intensive diet and exercise interventions to reduce complications and comorbidities (**secondary prevention**). Regarding sarcopenic obesity, the study underscores the role of age and diabetes duration as risk factors. Older individuals with diabetes and those with longer diabetes duration are more likely to develop sarcopenic obesity, which presents a dual challenge of muscle loss and excessive adiposity. It is crucial for healthcare providers to address both components muscle loss and adiposity in the management of diabetes. Comprehensive approaches that integrate exercise, resistance training, dietary modifications and glycaemic control are necessary to mitigate the adverse effects of SO and promote better metabolic health in individuals with diabetes.

Conclusion

This study explored the prevalence and associated risk factors of sarcopenia and SO in individuals with diabetes. The findings revealed that age above 60 years and duration of diabetes were significantly associated with both sarcopenia and sarcopenic obesity. These results contribute to the existing body of knowledge surrounding these conditions and have important implications for clinical practice.

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Conflicts of interest

There are no conflicts of interest.

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Authors' contributions

YM, MM, NM SR, JP, and SS contributed to the conceptualization, data curation, formal analysis, investigation, methodology, resources, supervision, validation, writing (original draft), and writing (review and editing). YM, MM, NM SR, JP, and SS contributed to conceptualization, data curation, formal analysis, investigation, writing (original draft), and writing (review and editing). YM, MM, NM SR, JP, and SS contributed to the methodology, resources, supervision, validation, and writing (review and editing). YM, MM, NM SR, JP, and SS contributed to the formal analysis, investigation, writing (original draft), and writing (review and editing). All the authors read and approved the final manuscript.

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