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ORIGINAL ARTICLE

Prevalence and clinical characteristics of individuals with newly detected lean diabetes in Tamil Nadu, South India: a community-based cross-sectional study

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Abstract

Background and objectives Lean diabetes is an entity that has been observed to be higher in Asian populations. The estimates of the burden of lean diabetes in India are mainly from hospital-based studies. This study reports the prevalence of lean diabetes among individuals with newly detected diabetes, from Vellore, Tamil Nadu, South India.

Methods A cross-sectional WHO STEPS survey was conducted among adults aged 30–64 years, in one rural block and 48 urban wards, in Vellore. Physical and anthropometric parameters were assessed in addition to fasting lipid profile and plasma glucose. Newly detected diabetes was defined as fasting plasma glucose ≥ 126 mg/dl and lean diabetes as non-ketotic diabetes mellitus, without clinical features to suggest pancreatic diabetes, with a body mass index (BMI) < 18.5 kg/m^2.

Results Among 3445 rural and 2019 urban subjects, the proportion of lean diabetes among 280 subjects (146 rural, 134 urban) with newly detected diabetes was 5.5%, 95% CI: 1.7–9.3% (eight subjects) and 1.5%, 95% CI: 0–3.6% (two subjects), in the rural and urban areas respectively. The proportion of those with a normal BMI (18.5–22.9 kg/m^2) was 25.3% and 18.7% in the rural and urban populations, while 69.2% and 79.9% had a BMI ≥ 23 kg/m^2. Those with lean diabetes were more likely to be older, illiterate, and involved in manual labor, than those with non-lean diabetes ($p < 0.05$).

Conclusion The prevalence of lean diabetes was low (5.5% of newly detected rural diabetes, 1.5% of newly detected urban diabetes) in Vellore, South India. Further documentation of the burden of this condition across India is needed to assess the public health implications for prevention and control.

Keywords Lean diabetes · Prevalence · Population · Burden

Introduction

The rising prevalence of type 2 diabetes mellitus in low and middle-income countries over the last few decades has led to the emergence of a major public health problem [1, 2]. Risk factors such as obesity and unhealthy diets are also increasing, and the relationship between increasing weight and diabetes is well established [2]. However, type 2 diabetes among those with a low body mass index (BMI) is suspected to be higher in Asian and African populations as compared with others, in whom obesity is a more common risk factor [3, 4]. Lean diabetes has been defined as BMI < 18.5 kg/m^2 or as Ketosis Resistant Diabetes of the Young (KRDY) with a BMI < 18.0 kg/m^2, while studies from high income countries have taken higher cutoff values ranging from 18.0–24.9 kg/m^2 [4–6]. Although the exact etiopathology is still unknown, a large-scale analysis of data from multiple genome wide association studies has shown that diabetes in the non-obese may be related to genetic factors, which make individuals susceptible to developing type 2 diabetes, irrespective of obesity and lifestyle factors [7]. Knowledge regarding the burden of disease is essential to judge the public health importance of the condition. Although hospital-based studies of lean diabetes among those with suspected type 2 diabetes have been published, population level burden of this condition in India is not well documented [5, 8]. A study from a diabetes center in urban Chennai, Tamil Nadu, estimated that 3.5% of patients

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with diabetes had lean diabetes (BMI < 18.5 kg/m^2) [5]. A similar result was seen in a hospital-based study from Manipur where 3.9% of those with newly detected diabetes had a BMI < 19.0 kg/m^2 [8]. Given the paucity in population level prevalence of lean diabetes from South Asia, this study estimates the proportion of lean individuals (body mass index < 18.5 kg/m^2) aged 30–64 years with diabetes, in a rural and urban population from Vellore, Tamil Nadu, Southern India.

Methodology

A WHO STEPS cross-sectional survey was carried out in Vellore, in 2011–2012, among adults aged 30–64 years, in a rural block (Kaniyambadi) and in Vellore city [9, 10]. Nine randomly selected villages from the rural block and one randomly selected street in each of 48 urban wards were selected for this study. All adults aged 30–64 years in the nine villages were eligible for the study, while in the selected urban streets, adults aged 30–64 years from the first 40 households were invited for the study. Questionnaire-based data was collected at the homes of the participants by trained field workers, after obtaining consent, while physical and biochemical measurements were collected at a designated clinic, after ensuring 8 h of overnight fasting. The weight of the participants was checked with a digital weighing machine (Essae, Bangalore, India) and height with a SECA 13 (Hamburg, Germany) stadiometer. Further details of this study have been published previously [10]. Fasting plasma glucose (FPG) was used to screen for diabetes, as recommended for WHO STEPS surveys [9]. Biochemical tests were done in an accredited laboratory which is a part of the External Quality Assurance System (EQAS) of a tertiary health institution.

Hypertension was defined as blood pressure ≥ 140/90 mmHg or on medication, diabetes as FPG ≥ 126 g/dl or on medication, and dyslipidemia as on medication or presence of one of the following:

> total cholesterol ≥ 200 mg/dl, triglycerides ≥ 180 mg/dl, low HDL (< 40 mg/dl for males, < 50 mg/dl for females), or LDL cholesterol ≥ 100 mg/dl [9, 11].

Lean diabetes was defined as those with diabetes and a BMI of < 18.5 kg/m^2 [5].

Results

Of the 5464 participants (3445 rural, 2019 urban) aged 30–64 years, 510 (9.3%, 95% confidence interval CI: 8.5–10.5%) were on medications for diabetes (rural 5.9%, 95% CI: 5.1–6.7%; urban 15.3%, 95% CI: 13.7–16.9%). Of the remaining 4954, 90.3% (4474) were screened for diabetes. The prevalence of newly detected probable type 2 diabetes (FPG of ≥ 126 mg/dl) was 6.3% (rural 5.0%, 95% CI: 4.2–5.8%; urban 8.6%, 95% CI: 7.1–10.1%).

Of those who were newly detected to have diabetes (Table 1), 10 out of 280 (3.6%, 95% CI: 1.4–5.8%) had a BMI < 18.5 kg/m^2 (rural 5.5%, 95% CI: 1.7–9.3%; urban 1.5%, 95% CI: 0–3.6%). The proportion of those with newly detected diabetes and BMI of 18.5–22.9 kg/m^2 was 22.1% (rural 25.3%, urban 18.7%), while the remaining 74.3% (rural 69.2%, urban 79.9%) had BMI ≥ 23 kg/m^2. The proportion of those with newly detected type 2 diabetes with a BMI ≥ 25 kg/m^2 was 58.2%.

The overall population prevalence of lean diabetes (newly detected or previously diagnosed diabetes and with BMI < 18.5 kg/m^2) was only 0.6% (95% CI: 0.3–0.9%) in the rural area and 0.3% (95% CI: 0.1–0.5%) in the urban area. However, the overall prevalence of diabetes was 11.2% (95% CI: 10.1–12.3%) in the rural sample and 23.6% (95% CI: 21.7–25.6%) in the urban sample.

Physical and biochemical characteristics were compared between those with lean diabetes and non-lean diabetes, as well as those without diabetes, in 4472 subjects (280 with newly detected diabetes and 4192 without diabetes) for whom complete data was available, Table 1. Of 280 with newly detected diabetes in this study, 146 were from the rural area, while of those with no diabetes, 2757 were from the rural area, Table 1.

The mean BMI of those with newly detected lean diabetes was 16.6 kg/m^2 (SD 1.7 kg/m^2), as compared with 26.4 kg/m^2 (SD 4.1 kg/m^2) for those with newly detected non-lean diabetes and 23.8 kg/m^2 (SD 4.8 kg/m^2) for those without diabetes. Individuals with newly detected lean diabetes were older than others with non-lean diabetes and those without diabetes (Table 1). They were also more likely to be involved in manual labor and less likely to be literate than those with non-lean diabetes ($p < 0.05$). Although the number of those with lean diabetes is too small to make conclusions, most of those with lean diabetes (8 out of 10) were from the rural area, Table 1.

The only difference in physical/metabolic parameters between those with newly detected lean diabetes and non-lean diabetes was that the average diastolic blood pressure was lower for those with lean diabetes (lean diabetes 73.8 mmHg, SD 14 mmHg vs. non-lean diabetes 82.5 mmHg, SD 13.5 mmHg), p value for t test = 0.046.

The mean FPG in those with lean diabetes was 215.7 mg/dl (SD 72.1 mg/dl) as compared with 186.1 mg/dl (SD 74.7 mg/dl) for those with non-lean diabetes, p value for t test = 0.219. As compared with the general population of lean individuals without diabetes, those with lean diabetes were more likely to have hypertension (lean diabetes 30.0% vs. lean normal 6.1%, chi-square p value 0.023) and a higher mean total cholesterol (lean diabetes 193 mg/dl, SD 49.8 mg/dl vs. lean normal 162.5 mg/dl, SD 43.9 mg/dl, p value for t test = 0.029). Other lipid parameters were not significantly different between the lean-diabetic population and others ($p > 0.05$).

Table 1 Socio-demographic and behavioral characteristics of those with newly detected lean diabetes compared with others with and without diabetes

Characteristic (means with standard deviations, percentages within each group a–d)	Individuals with newly detected diabetes mellitus (DM) ($FPG \geq 126$ mg/dl), $n = 280$				Individuals without DM (normal) ($FPG < 126$ mg/dl), $n = 4192$			Lean DM (a) vs. lean normal (c) p value
	Lean DM (a)	Non-lean DM (b)		Lean DM (a) vs. non-lean DM (b) p value[b]	Lean normal (c)	Non-lean normal[c] (d)		
	$BMI < 18.5$ kg/m^2 $n = 10$	BMI 18.5–22.9 kg/m^2 $n = 62$	$BMI \geq 23.0$ kg/m^2 $n = 208$		$BMI < 18.5$ kg/m^2 $n = 570$	BMI 18.5–22.9 kg/m^2 $n = 1385$	$BMI \geq 23.0$ kg/m^2 $n = 2237$	
Age in years (SD)	52.8 (9.5)	48.8 (8.5)	46.3 (8.5)	0.034	45.4 (10.0)	44.8 (9.8)	44.1 (9.1)	0.020
Age 30–37 years[a]	1 (10.0)	5 (8.1)	38 (18.3)	0.016	156 (27.4)	391 (28.2)	650 (29.1)	0.012
38–44 years	1 (10.0)	14 (22.6)	49 (23.6)		121 (21.2)	321 (23.2)	567 (25.3)	
45–53 years	1 (10.0)	23 (37.1)	75 (36.1)		154 (27.0)	356 (25.7)	606 (27.1)	
53–64 years	7 (70.0)	20 (32.3)	46 (22.1)		139 (24.4)	317 (22.9)	414 (18.5)	
Males (%)	2 (20.0)	38 (61.3)	95 (45.7)	0.105	268 (47.0)	647 (46.7)	834 (37.3)	0.115
Rural residence (%)	8 (80.0)	37 (59.7)	101 (48.6)	0.106	445 (78.1%)	1044 (75.4)	1268 (56.7)	1.000
Literate (%)	3 (30.0)	39 (62.9)	164 (78.8)	0.004	331 (58.1)	877 (64.3)	1662 (74.3)	0.106
Manual laborers (%)	6 (60.0)	18 (30.0)	27 (13.7)	0.004	263 (46.5)	543 (39.8)	468 (21.4)	0.527
Physical inactivity (%)	4 (40.0)	26 (41.9)	127 (61.1)	0.343	202 (35.7)	578 (42.1)	1258 (56.5)	0.751
Family history of diabetes (%)	1 (10.0)	8 (13.1)	68 (32.9)	0.293	47 (8.3)	123 (8.9)	436 (19.5)	0.583
Tobacco use (%)	3 (30.0)	16 (25.8)	43 (20.7)	0.466	173 (30.4)	329 (23.8)	296 (13.2)	1.000

[a] Age quartiles

[b] t test for continuous variables, chi-square test/Fisher's exact test for categorical variables

[c] p values (chi-square test/Fisher's exact test) between lean normal (c) and non-lean normal (d) groups were < 0.001, except for age ($p = 0.08$) and % males ($p = 0.006$)

Discussion

This study documents the population level prevalence of lean diabetes, in a district in Tamil Nadu, a state in India which has been experiencing a high level of epidemiological transition [12]. The strength of the study is that the estimate of the proportion of lean diabetes has been obtained from a community-based survey which identified both previously and newly diagnosed diabetes, which enables better estimation of the burden of the disease than hospital-based estimates.

The limitations of the study included the lack of body fat measurement and a low power to assess risk factors for lean diabetes, due to the low numbers of lean diabetes obtained in this community-based study, although the number screened was more than 4000. As only FPG was used to detect diabetes, there is a chance of having missed some people with type 2 diabetes, although this methodology is considered acceptable for epidemiological surveys such as the WHO STEPS surveys [9]. In addition, the absence of GAD (Glutamic Acid Decarboxylase) antibody measurement and screening for pancreatic diabetes may not have identified patients with Type 1 or pancreatic diabetes in this lean cohort of patients. This low proportion of lean diabetes among all newly detected diabetes in the community was similar to the hospital-based prevalence reports from diabetes centers in urban Chennai, Tamil Nadu (3.5% of all diabetic patients had a BMI < 18.5 kg/m^2), and Manipur (3.9% of patients with diabetes had a BMI of < 19 kg/m^2) [5, 8].

Lean diabetes was more common in the rural area (5.5% of all newly detected diabetes) than the urban area (1.5% of all newly detected diabetes). Those with lean diabetes were more likely to be older as well of a lower socio-economic status, than those with non-lean diabetes. A nationally representative study from the USA has also found that hyperglycemia is associated with a lower lean body mass in older adults [13]. The mean FPG of those with lean diabetes was higher than those with non-lean diabetes, as seen in other studies, although not statistically significant [5]. Other metabolic characteristics of those with lean diabetes, such as low levels of hyperlipidemia and lower triglycerides/HDL ratio as have been reported previously [3, 14], were not significant in this study. This is probably because the number with lean diabetes in this population based cross-sectional survey was low when compared with hospital-based comparative studies of lean and non-lean diabetes, and the main objective of this analysis was to document the population level burden of the disease.

Total cholesterol and hypertension were higher in those with lean diabetes when compared with their lean counterparts without diabetes, indicating that among the lean group, these risk factors were independent of body weight, and could be due to other factors. A study from Chennai had also found that lean people with pre-diabetes or diabetes had higher systolic blood pressure compared with centrally obese individuals with normal blood sugars [15]. This implies that deranged blood sugars even in those who are not obese may be worse than central obesity with normal blood sugars [15].

The low prevalence of lean diabetes in this study confirms the results from a previous multicentric study of 900,000 individuals that showed even in Asia, a higher BMI is associated with a higher prevalence of diabetes [16]. However, the World Health Survey data from 49 countries showed that when compared with those who were of normal weight, diabetes was higher among both the underweight as well as the overweight and obese [17]. Although the highest risk of diabetes was among the obese, those who were underweight were more likely to have untreated diabetes than all the other groups (12.28% of underweight compared with 7.87% of obese individuals) [17]. This may indicate that lean diabetes is less likely to get detected when compared with those who are considered classically to be at risk (the overweight and the obese).

As the prevalence of overweight/obesity in the study district (Vellore) has increased by two to three times in the last 20 years [18], the overall proportion of individuals with a low BMI (< 18.5 kg/m^2) is decreasing. As it is not clear if leanness is the cause or effect of this kind of diabetes [17], it can be expected that the prevalence of lean diabetes will decrease if leanness is a causal factor but may remain the same or increase in the future, if it is the effect of the disease process of lean diabetes, a process possibly mediated by genetic factors [7].

Future WHO STEPS surveys being undertaken in the region for surveillance of noncommunicable diseases need to report the burden of lean diabetes, in addition to the overall prevalence of type 2 diabetes, in order to assess its public health significance and the need for interventions, especially better detection of diabetes in this group, whose risk is mostly under-recognized.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional research committee and with the 1964 Helsinki declaration and its later amendments.

Informed consent Written informed consent was obtained from all participants in the study.

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