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Original Article

Association of glycaemic control with demographics, diabetes management information and body fat composition in persons with type 2 diabetes mellitus (T2DM): a need for multi-disciplinary management

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Abstract

Type 2 diabetes mellitus (T2DM) is a chronic condition that can cause complications due to poor glycaemic control. The demographic characteristics, information related to DM and management, anthropometric variables, and the body fat composition of T2DM individuals are important factors influencing glycaemic control. This study was conducted to explore the association between glycaemic control and selected demographic characteristics, information on T2DM management, and body fat composition in T2DM patients. This cross-sectional survey amongst people with T2DM was conducted in the Udupi district of South India. A number of 467 participants were selected for the study using a simple random sampling technique. The survey included three parts: a questionnaire, an anthropometric and body fat composition measurement, and a biochemical assessment. The multivariate logistic regression model showed that not consulting the dietician (OR=6.074); the presence of complications (OR=2.955); visceral fat ≥10 (OR=2.037); non-compliance to exercise (OR=2.007); availing treatment from the private sector (OR=1.85); and non-consumption of traditional remedies (OR=1.651) were the associated factors to poor glycaemic control in T2DM patients. Not consulting dieticians, complications, non-compliance to exercise, not consuming traditional remedies, visceral fat ≥10 and availing treatment at private setup were the significant associated factors for the poor glycemic control.

Keywords: T2DM, anthropometry, body fat, glycaemic control, HbA1c.

Introduction

Diabetes Mellitus (DM) is a long-term metabolic condition that leads to multiple complications. As per International Diabetes Federation (IDF), the global prevalence of diabetes in 2019 was 463 million, of which Type 2 Diabetes Mellitus (T2DM) contributed 90% of the cases [1]. The top three countries expected to have the highest prevalence of diabetes in the year 2045 are China (147 million), India (134 million), and Pakistan (37 million) [1]. Diabetes mellitus (DM) is classified into two main categories: type 1 and type 2 [2]. Several risk factors are associated with T2DM, including family history, obesity, unhealthy diet, physical inactivity, aging, and ethnicity [3].

T2DM is diagnosed and monitored by plasma glucose or/and glycated hemoglobin (HbA1c) levels. International Diabetes Federation (IDF), American Diabetes Association (ADA), and the Indian Council for Medical Research (ICMR) have recommended an HbA1c level of <7% as the target for optimal glycaemic control that helps prevent micro and macrovascular complications [1, 3, 4]. However, HbA1c goals are determined based on age, duration, and micro and macrovascular complications [4]. To attain effective glycaemic control, medication compliance, lifestyle modifications, periodic check-ups, and self-monitoring of blood glucose are essential.

While most DM guidelines endorse starting medication only after dietary/nutrition and physical activity interventions, it is rarely practiced. In many healthcare settings, other than specialized DM centers, due to the non-availability of trained dieticians and nutritionists/educators, advice on diet/nutrition and physical activity for diabetes is given, at best, in a written or printed menu. In a resource-poor setting, the persons with T2DM are off the clinic with only a list of updated prescriptions and little else [5]. Furthermore, body fat composition, related to insulin resistance in individuals with T2DM, is hardly assessed. In India, many people with T2DM also consume traditional herbal remedies. These herbs' intake is not documented, although anti-diabetic properties have been reported among some of these herbs [6].

Due to the colossal outpatient load and lack of trained personnel, dietary management and physical activity intervention in India, people with T2DM are neglected in most private and public sectors. Besides, the importance of diet and exercise in DM needs to be taken more seriously by T2DM patients due to a lack of education and poor communication. In contrast, some tertiary care hospitals, district-level hospitals, and non-Communicable Diseases Clinics provide dietician or diabetes educator services [7].

Therefore, it is essential to recognize the demographic characteristics, DM, and management information and ascertain the people with T2DM. Consequently, to determine the relationship of the above variables with the measure HbA1c. Nonetheless, there are no comprehensive studies concerning the south Indian context, particularly from Coastal Karnataka, India. Thus, this study aimed to explore the association between glycaemic control and selected demographic characteristics, information on T2DM management, and body fat composition.

Material and methods

Study design and setting

A cross-sectional survey was conducted at Udupi Taluk of Karnataka State, India.

Participants and study size

Persons with T2DM were the population. As per the sample size calculation, the obligatory sample size obtained for the study was 384. However, the estimated sample size was 512, including a 25% non-response rate. Further, 512 persons with diabetes were selected from the diabetes registry and contacted using a simple random technique. Out of these, 482 people responded to the researcher. Consequently, as per the exclusion criteria, the people with T1DM, T2DM on insulin therapy, critically ill, gestational diabetes, severe mental illness, self-reporting of excessive alcohol intake, and substance abuse were excluded from the study, 467 was the final tally of the participants in the study.

Variables

The study encompassed demographic characteristics, information related to Diabetes Management, Anthropometric Measurements, Body Fat Composition, and HbA1c.

Measurements and bias

The survey included three parts, a questionnaire, an anthropometric and a body fat composition measurement, and a biochemical assessment.

Questionnaire survey

The questionnaire included demographic characteristics and information related to diabetes and management. Age, gender, and educational qualification were the demographic characteristics. Dietary compliance, compliance with exercise, taking medication, consuming the traditional remedy, treatment sources, consultation with a dietician and diabetes educator and complications are diabetes and management-related information.

Anthropometric and body fat composition measurement

The body mass index (BMI) was measured using the formula BMI=weight (kg)/height (m^2) [4]. Waist circumference (WC) was measured at the midpoint between the top of the iliac crests and the lower margin of the last rib in the mid-axillary line at the end of several consecutive breaths [8]. Omron Karada HBF-375 Scan for Bioelectric Impedance Analysis (BIA) [9] was used for body fat composition, such as visceral fat and total body fat. We ensured that the participants had not consumed food, water, alcohol, and coffee, had no heavy exercise for at least two hours before measuring body fat composition and had a sound sleep of about 8 hours on the previous day. The normal values for both males and females are provided in Table 1 [4].

Biochemical assessments/laboratory tests

HbA1c is contemplated as the best biochemical marker for monitoring people with diabetes because its evaluation offers retrospective information on glycaemic control for the past 6–8 weeks [10]. Glycosylated HbA1c was measured with Tina-quant® HbA1c Third Generation immunoassay on a fully dedicated analyzer, the Cobas c511, by Roche Diagnostics (Mannheim, Germany). The assigned HbA1c and total hemoglobin values are certified with the National Glycohemoglobin Standardization Program (NGSP). Based on the clinical experience and ICMR, IDF, and ADA guidelines, we categorized the glycemic status as good glycemic control if HbA1c was ≤7% for ≤10 years of duration ≤7.5% for ≥10 years of duration [3, 4, 11].

Statistical analysis

Statistical analysis was performed with SPSS software (Version 16). A p-value<0.05 was considered statistically significant. Univariate analysis (Chi-square test) followed by multiple logistic regression was carried out to identify the poor glycaemic control's associated factors. We used HbA1c (control=0, poor control=1) in backward stepwise logistic regression analysis as the dependent variable. Age, sex, education, dietary and exercise compliance, medication, consumption of traditional remedies, sources of treatment, consultation with a dietician and diabetes educator, people with complications, Anthropometric Measurement (Body Mass Index, Waist Circumferences), Body Fat Composition (Total Fat and Visceral Fat) were used as independent variables.

Results

Univariate analysis

The Chi-square test indicated the significant association of HbA1c level (control/poor control) with age group (Table 2), dietary compliance, exercise compliance, consumption of traditional remedy, dietician consultation, consultation of diabetes educator and complications (Table 3). No significant association was observed between HbA1c and anthropometric and body fat composition measurements (Table 4).

Logistic regressions

We applied backward stepwise logistic regression to identify the associated factors for the poor control of HbA1c. For logistic regression, the HbA1c level

Table 1: Normal values for the BMI, WC, and body fat composition for males and females.

Parameters	Males	Females
BMI (kg/m^2)	18.5–22.99	18.5–22.99
Waist circumference (cm)	90 cm	80 cm
Total body fat (%)	10–19.99	20–29.99
Visceral fat	0.5–9.5	0.5–9.5

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Table 2: Comparing the HbA1c level with different demographic characteristics.

Variables	Levels	Control n (%)	Poor control n (%)	χ^2	P-Value
Age	<60	69 (24.0)	219 (76.0)	6.23	0.01
	≥60	62 (34.6)	117 (65.4)		
Gender	Males	73 (29.3)	176 (70.7)	0.42	0.51
	Females	58 (26.6)	160 (73.4)		
Education	Primary	43 (27.7)	112 (72.3)	0.15	0.98
	Secondary: up to 10th standard	31 (27.0)	84 (73.0)		
	Pre-University Course	25 (28.7)	62 (71.3)		
	Graduation ad above	32 (29.1)	78 (70.9)		

Table 3: Comparing the values of HbA1c level with information related to DM and management.

Variables	Levels	Control n (%)	Poor control n (%)	χ^2	P
Dietary compliance	Yes	103 (33.8)	202 (66.2)	14.25	<0.001
	No	28 (17.3)	134 (82.7)		
Exercise compliance	Yes	86 (36.3)	151 (63.7)	16.17	<0.001
	No	45 (19.6)	185 (80.4)		
Medication	On medication	13 (37.1)	22 (62.9)	1.55	0.21
	No medication	118 (27.3)	314 (72.7)		
Consumption of traditional remedy	Yes	98 (31.8)	210 (68.2)	6.36	0.01
	No	33 (20.8)	126 (79.2)		
Availing treatment	Government	37 (31.4)	81 (68.6)	0.85	0.35
	Private	94 (26.9)	255 (73.1)		
Dietician consultation	Yes	43 (66.2)	22 (33.8)	54.31	<0.001
	No	88 (21.9)	314 (78.1)		
Consultation on diabetes education	Yes	25 (62.5)	15 (37.5)	25.72	<0.001
	No	106 (24.8)	321 (75.2)		
Complications	Yes	44 (17.7)	205 (82.3)	24.48	<0.001
	No	87 (39.9)	131 (60.1)		

Table 4: Comparing the HbA1c level with anthropometric and body fat composition measurements.

Variables	Levels	Control n(%)	Poor control n (%)	χ^2	P
BMI	Normal	39 (32.8)	80 (67.2)	1.76	1.84
	Overweight and obese	92 (32.8)	256 (73.6)		
Waist circumference	Normal	26 (30.2)	60 (69.8)	0.25	0.62
	Risk	105 (27.6)	276 (72.4)		
Total fat	Normal	7 (26.9)	19 (73.1)	0.02	0.89
	High and very high	131 (28.1)	336 (71.9)		
Visceral fat	Normal	66 (31.0)	147 (69.0)	1.69	0.20
	High and very high	65 (25.6)	189 (74.4)		

Table 5: Logistic regression showing variables associated with HbA1c level.

	Category	HbA1C*		Sig.	Adj. OR	95% CI for Adj. OR	
		Control n (%)	Poor control n (%)			Lower	Upper
Compliance to exercise	Yes	86 (36.3)	151 (63.7)	.003	1		
	No	45 (19.6)	185 (80.4)		2.007	1.27	3.17
Consumption of traditional remedies	Yes	98 (31.8)	210 (68.2)	.048	1		
	No	33 (20.8)	126 (79.2)		1.651	1.003	2.72
Complications	Yes	44 (17.7)	205 (82.3)	<.001	2.955	1.65	5.31
	No	87 (39.9)	131 (60.1)		1		
Source of treatment	Private	94 (26.9)	255 (73.1)	0.20	1.85	1.10	3.1
	Govt.	37 (31.4)	81 (68.6)		1		
Consultation of dietician	Yes	43 (66.2)	22 (33.8)	<.001	1		
	No	88 (21.9)	314 (78.1)		6.074	3.197	11.54
Visceral fat	<10	66 (31)	147 (69)	.016	1		
	≥10	65 (25.6)	189 (74.4)		2.037	1.14	3.63

Note: *HbA1c level: Control – HbA1c ≤7% for the duration of T2DM ≤10 years and ≤7.5% for the duration of T2DM >10 Years. Poor control – HbA1c >7% for a duration of T2DM ≤10 years and >7.5% for a duration of T2DM >10 years.

(control=0, poor control=1) was treated as a dependent variable. Age, sex, education, diet and exercise compliance, medication, traditional remedy use, availing of treatment, dietician or diabetes educator consultation, people with complications, anthropometric variables (BMI, WC), and body fat composition (total fat & visceral fat) were taken as the independent variables for the logistic regression.

The analysis retained significant associated factors (P<0.05) for poor control of HbA1c in the model. Non-compliance to exercise, not consuming traditional remedies, complications, availing of treatment from the private health sector, not consulting dieticians, and visceral fat ≥10 were the significant associated factors for poor glycaemic control. The odds ratio corresponding to each of these associated factors is shown in Table 5.

Discussion

The results showed that T2DM patients not consulting a dietician (OR=6.074), the presence of complications (OR=2.955), visceral fat ≥10 (OR=2.037), non-compliance to exercise (OR=2.007), availing treatment from the private sector (OR=1.85), and non-consumption of traditional remedies (OR=1.651) were the most influential factors associated with the poor glycaemic control.

Consultation of dietician

The most apparent finding from this study is that people with T2DM on dietician consultation showed significantly better glycaemic control than those without consulting. Our results are similar to previous studies conducted in India. An audit of 7,490 medical charts demonstrated that patients receiving clinical nutrition education from registered dietitians had better glycaemic control than non-registered dietitians [12]. This highlights the significance of using an inter-professional collaboration model of care by utilizing a dietician known to enhance care indicators for patients with chronic diseases, including diabetic patients [13].

Our study results reflected that a dietician in health care settings helps achieve better glycaemic control among persons with T2DM. This is because dieticians can access the patient's medical progress, enabling them to instill clinically appropriate educational awareness on T2DM. Dieticians can also create an individualized diet plan and education, significantly influencing glycaemic control. Further, registered dieticians have better knowledge and skills to understand

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the complexity of nutritional issues while managing T2DM using nutrition therapy [14].

Presence of complications

Higher HbA1c levels increase the risk and worsen the severity of complications [15]. In this study, we found that diabetes complications were a significant factor associated with poor glycaemic control. Long-term exposure to hyperglycemia is a significant aspect of diabetic complications and atherosclerosis pathogenesis. Hyperglycaemia induces many alterations at the cellular level of vascular tissue, potentially accelerating the atherosclerotic process. Currently, three main mechanisms have developed that include most of the pathological changes found in the vasculature of diabetic animals and humans: 1) Nonenzymatic glycosylation of proteins and lipids; 2) oxidative stress; 3) protein kinase C (PKC) activation [16].

Visceral fat

Visceral adipose tissue is a better predictor of T2DM in the Asian Population [17]. This study established a significant association between visceral fat and levels of HbA1c, *i.e.*, increased visceral fat resulting in poor glycaemic control. Previous studies have related the increased visceral fat accumulation to the pathogenesis of insulin resistance and poor glycaemic control in persons with T2DM [18]. The previous studies also stated that visceral fat mass is associated with the risk of T2DM [17]. The visceral fat is positively associated with Retinol Binding Protein 4 (triggers the secretion of RBP 4); it may contribute to insulin resistance development [19]. Further, excess visceral fat reduces the glucose uptake sensitivity initiated by insulin and reduces the re-esterification rate of free fatty acids (FFA) [20].

Compliance to exercise

In this study, we found that non-compliance to exercise was significantly associated with poor glycemic control. Increased physical activity through different exercise regimes helps improve glycaemic control and reduce weight. This, in turn, lowers cardiovascular and other T2DM-related complications and enhances the quality of life in T2DM patients [21]. That is mainly due to exercise-induced increased uptake of glucose into active muscles and greater dependency on carbohydrates to sustain muscle activity as intensity increases. Insulin-mediated skeletal muscle glucose uptake is impaired in T2DM and prevails at rest. The muscle contractions promote blood glucose by a separate additive mechanism, causing acute improvements in systemic insulin action lasting for 2 to 72 hours post-exercise [22].

Consumption of traditional remedies

The World Health Organisation (WHO) reported that up to 90% of developing countries' populations use plants and traditional medicine for primary health care. It is about 70% in India [23]. According to the WHO, 21,000 plants are used for medicinal purposes worldwide, of which 2500 species are from India [24]. In this study, 66% of the participants were consuming some form of traditional remedy for the management of T2DM. Similarly, a study conducted in Tanzania reported that 67.2% of the population consumes the traditional remedy in the management of diabetes mellitus [25]. In this study, we found a significant association between consuming traditional remedies and controlling diabetes mellitus. About 800 plants have been reported to have shown anti-diabetic properties [26]. Further, a study conducted in Libya reported no significant association between the consumption of traditional remedies and glycaemic control [27].

Source of treatment

The majority of the participants in this study have availed of the treatment from the private health sector. In India, the public health sector renders 18% of the total outpatient care and 44% of inpatient care [28]. This study found that availing the treatment from the public sector was associated with better glycaemic control. Consequently, in terms of quality of care in India, the private sector has wide variations, delivering world-class services at one end and unregulated and underqualified low rates at the other end [28]. This study's private sector included polyclinics, nursing homes, hospitals, and tertiary/multispecialty and medical college hospitals. In the current research, the public health sector indicated that almost all participants obtained treatment primarily from a non-communicable disease clinic with a dedicated health team of a medical officer, counselor, staff nurse and lab technician [29].

Though a small percentage of participants availed diabetes care in the public health sector in the exclusive non-communicable disease clinic with a multi-disciplinary approach, it was positively associated with glycaemic control. Thus, it is essential to facilitate multi-disciplinary care for people with diabetes in the

primary health care setting. However, rural India has not reached the optimum stage in providing optimal multi-disciplinary care for individuals with diabetes in primary care settings [30].

Limitations and strengths

The participant's responses to the questionnaire were recorded as reported by the participants, which was the limitation of this study. Though Bio-electric Impedance Analyser used in this study was cost-effective and most feasible, CT and MRI are the golden standards for visceral fat assessment. Consequently, it was a community-based study, and participants were selected randomly from the comprehensive diabetes registry. Hence, a total representation of the whole population was the strength of this study.

As discussed, dietary consultation, compliance to exercise, consumption of traditional remedies, visceral fat less than 10, and complications are positively associated with diabetes mellitus. The service encompassing these components through a multi-disciplinary approach would provide a platform for rendering comprehensive care for persons with T2DM. The multi-disciplinary approach involves nutritional therapy, exercise training, an inquiry into the use of traditional remedies, assessment of complications, and evaluation of Body Fat Composition, which are prerequisites for further evaluation. The multi-disciplinary approach assists persons with T2DM to set targets and plan self-management. It highlights the importance of strengthening the primary healthcare setting and increasing the resources to cultivate a holistic care culture by incorporating dietary intervention, exercise intervention and comprehensive assessment. While planning such measures, cost-effective strategies appropriate for developing countries should be tested and adapted.

Conclusions

This study explores the relationship of selected demographic characteristics, information related to DM and management, anthropometric measurement, and body fat composition as an independent variable with the levels of HbA1c. This study concluded that not consulting the dieticians, the presence of complications, non-compliance to exercise, not consuming traditional remedies, visceral fat ≥10 and availing treatment at private setup were the significant factors associated with poor glycemic control T2DM. All variables are essentials of comprehensive diabetes care, thus necessitating the multi-disciplinary approach for comprehensive diabetes care. In developing countries, especially India, a cost-effective multi-disciplinary approach model may ease the burden of mortality and morbidity due to diabetes and comply with Sustainable Development Goal 2030's fourth goal of good health and well-being.

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Conflict of interest

The authors declare no conflict of interest.

Ethical permission

Before the data collection, the study protocol was approved by the Manipal Academy of Higher Education research committee, and Ethical clearance (IEC 453/2016) was obtained from the Ethics Committee of Manipal Academy of Higher Education. This study protocol is registered with the Clinical Trials Registry of India (bearing the registration number: CTRI/2017/02/007945).

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