Study of Association between BMI and HbA1c Level in Newly-Diagnosed Type-2-Diabetes-Mellitus Patients

Nirupoma Bag[a], Indrani Das[b], Md.Waliullah[a], Dipsikha Manna[c], Sarmishtha Chatterjee[c*]

[a]Department of Physiology, Murshidabad Medical College and Hospital, Berhampore, Murshidabad, West Bengal, India.
[b]Department of Forensic and State Medicine, Institute of Post Graduate Medical Education and Research, Kolkata, West Bengal, India.
[c]Department of Anatomy and Physiology, B.Sc. Medical Laboratory Technology (BMLT), Belur Sramajibi Swasthya Prakalpa Samity, Belur, Howrah, West Bengal, India.

Abstract

Background: Type-2-Diabetes-Mellitus (DM2), a major public-health problem in India, had a variable asymptomatic-phase. At the time of diagnosis, a large number of DM2 patients have already developed serious-complications. Diagnosis of DM2 is done by estimating, FBS, PPBS, RBS and HbA1c. HbA1c level is used both in diagnosis and determining lifestyle- modification, single or multi-drug therapy. Hence, longtime-management of DM2 requires regular-monitoring of BMI and HbA1c.

Objectives: The aim of this study was to examine the possible association between BMI and HbA1c among newly-diagnosed DM2.

Patients and methods: This study was performed in the Department of Physiology, M.M.C.H, Murshidabad, W.B, India for a period of 1year. This was an observational descriptive-study, cross-sectional in design with institution-based anonymous data-collection. The sampling-technique was complete enumeration. Newly diagnosed 80 DM2 patients (no therapeutic intervention-drug and or lifestyle modification initiated), attended different OPDs constituted the study-population. Data was obtained after taking proper informed consent, then compiled in Microsoft Excel and analyzed by using simple tables and applying Student's t-test.

Results: Among the study population 30% belongs to the 30-44 years while 43% belongs to the 45-59 years. 61% was either overweight/obese. 49% had HbA1c level < 8% and 51% had ≥8%. No association between BMI and HbA1c had been found in any age-group in this study.

Conclusion: No association is found between BMI and HbA1c among newly diagnosed DM2 in this study. This may be due to the long variable asymptomatic-phase of the disease. BMI and HbA1c are considered independently during the initiation and long-term-management of DM2.

Keywords: Newly diagnosed; Type-2-Diabetes Mellitus (DM2); HbA1c; BMI

DOI: **10.21608/svuijm.2022.181455.1473**

*__Correspondence__: sarmishthaobesity@gmail.com

Received: 1 December,2022.

Revised: 21 December,2022.

Accepted: 22 December,2022.

Published: 15 March, 2023

Cite this article as: Nirupoma Bag, Indrani Das, Md.Waliullah, Dipsikha Manna, Sarmishtha Chatterjee (2023). Study of Association between BMI and HbA1c Level in Newly-Diagnosed Type-2-Diabetes-Mellitus Patients. *SVU-International Journal of Medical Sciences*. Vol.6, Issue 2, pp: 1-9. .

Introduction

Type 2 Diabetes Mellitus (DM2) is one of the most widespread chronic diseases, having an alarmingly rising prevalence rate. DM2 propensity varies to a great extent around the globe, with Pacific Islanders, Asian Indians, and Native Americans having a considerably higher peril of developing the disorder (**Mohan and Pradeepa, 2017**). In India, the burden of diabetes has been escalating steadily since 1990 and has leaps at a faster pace since the year 2000 (**Pradeepa and Mohan, 2021**). The pervasiveness of diabetes in India has risen from 7.1% in 2009 to 8.9% in 2019 (**Wu et al., 2014**). The prevalence of new cases of **diabetes in India is 5.1% (Joshi** et al., 2012).WHO studies reported total diabetic in India was 31.7 million in the year 2002, likely to increase to 79.4 million by 2030 (**Aghamollaei et al., 2003**). There is a long variable asymptomatic period that exists before DM2 is diagnosed. Diagnosis of DM2 is done by estimating fasting blood sugar, postprandial blood sugar, and HbA1c (any of them). Body mass index (BMI) has a strong relationship with diabetes and insulin resistance (**Al-Goblan et al., 2014**).

During long time management of DM2, obesity (measured in terms of BMI) and glycaemic control (measured in terms of HbA1c) are the two most important parameters to consider. According to **ICMR (2018)** for the Indian population 18.5 to 22.9 BMI is normal, 23 to 24.9 are considered overweight and a BMI of ≥25 is considered obese. The prevalence of obesity is rising in proportion to glycated hemoglobin in DM2 (**Sisodai and Chouhan, 2019**). HbA1c may be suggested as a diagnostic criterion that detects more diabetic and prediabetic cases than oral glucose tolerance tests and fasting glucose (**Chivese et al., 2022**).

Our Study aims to find out whether there is any association between BMI and HbA1c level among the newly diagnosed case of DM2 patients (no therapeutic intervention-drug and or lifestyle modification initiated).

Patients and methods

The study was done in the Department of Physiology, Murshidabad Medical College for a period of 1 year (May 2021 to April 2022) after obtaining Ethical clearance from the Institutional Ethics committee and research advisory committee. This was an observational descriptive study, cross-sectional in design with institution-based anonymous data collection. The sampling technique is a complete enumeration. Newly diagnosed eighty (n=80) DM2 patients, who attended in different OPD of the institution, were recruited in the study. Informed consent was taken from all allotted patients and was subjected to a detailed history taking, clinical examination, and blood examination for FBS, PPBS, and HbA1c. The diagnosis of DM2 was done as per the results of blood examination for FBS, PPBS, and HbA1c level (anyone).

In this study, the age of the subjects was grouped as <30 years (onset of MODY) (Kant et al. 2022), 30-44years (age for screening of early diagnosis of DM2) (**ICMR, 2018**), 45-59years (usual age of diagnosis of DM2), >59years(elderly age group) (**WHO, 2011**). HbA1c values were divided into normal (<5.7%), prediabetic level (5.7-6.4%), Diabetic ideal control (6.5 - <7%), Diabetic Satisfactory

Control (7-<8%), Diabetic Candidate for Mono Drug Therapy (8-<9%) and Diabetic Candidate for Multidrug Therapy (≥9%). Weight measured in the nearest Kg was recorded in a properly calibrated digital weighing machine and height was measured in the nearest cm by stadiometer. BMI was calculated by using formulae weight in kg/height in meter ^{2} and grouped as Underweight (≤18.5), Normal (18.5 to 22.99), Overweight (23 to 24.99), and Obesity (≥25) (**ICMR, 2018**).

Statistical analysis

The compilation of data was done in Microsoft Excel and analyzed by using a simple table. Significant differences among groups were determined using Student's t-test. All differences were determined to be significant at the $p<0.05$ level.

Results

Out of 80 newly diagnosed DM2 patients included in this study, 30% of the study population belongs to the age of screening for early diagnosis of DM2 30-44years age group while 44% of the study population belongs to 45-59 years age groups shown in (**Table .1**).

Table 1. Distribution of study population according to age

	<30years	**30-44years**	**45-59years**	**>59years**
F	6	24	35	15
%	7	30	44	19

Among 80 newly diagnosed DM2 patients, 61% of the study population was overweight or obese and 39% was either underweight or normal, shown in (**Table .2**). In the <30 years of age group, about 67% of the study population was overweight or obese and 34% was either underweight or normal. Similarly, in the 30-44 years age group 75% of the study population was overweight or obese and 25% was either underweight or normal, whereas in the 45-59 years of age group about 71% of the study population was overweight or obese and 29% was either underweight or normal. In >59 years of age group, about 33% of the study population was overweight or obese and 67% was either underweight or normal.

Table 2. Distribution of study population according to age and BMI

BMI	**All age**		**<30**		**30-44**		**45-59**		**>59**	
	f	**%**	**f**	**%**	**f**	**%**	**f**	**%**	**f**	**%**
Underweight	5	6	3	50	0	0	2	6	0	0
Normal	26	33	1	17	6	25	8	23	10	67
Overweight	19	24	1	17	12	50	13	37	3	20
Obese	30	37	1	17	6	25	12	34	2	13
Total	80	100.00	6	100.00	24	100.00	35	100.00	15	100.00

In all age groups, about 49% population has an HbA1c level under control (<8%), whereas about 51% have an HbA1c level that needs either monotherapy or multidrug therapy, shown in (**Table .3**). In the <30 years age group, 34% have HbA1c level under control (<8%) and 66% have an HbA1c level that needs either monotherapy or multidrug therapy. Similar to this group, other age groups also had 40 - 57% population under control level of HbA1c, whereas about 43% - 60% populations need either monotherapy or multidrug therapy.

Table 3. Distribution of study population according to age and HbA1c level

HbA1c	All age		<30		30-44		45-59		>59	
	f	%	f	%	f	%	f	%	f	%
Normal (<5.7%)	1	1	0	0	1	4	0	0	0	0
Prediabetic (5.7-6.4%)	8	10	0	0	4	17	4	11	0	0
Diabetic(6.5- <7) Ideal Control	11	14	1	17	1	4	8	23	2	13
Diabetic (7-<8) Satisfactory Control	19	24	1	17	6	25	8	23	4	27
Diabetic (8-<9%) Candidate for Mono Drug Therapy	16	20	3	50	5	21	6	17	3	20
Diabetic (>=9%) Candidate for Multidrug Therapy	25	31	1	16	7	29	9	26	6	40
TOTAL	80	100	6	100	24	100	35	100	15	100

Table .4 shows that the 1st group/2nd group /3rd group /4th group indicate <30 years age group, 30-44 years age group, 45-59years age group, and >59 years age group respectively. Frequency was calculated according to the total number of respective age group. Among 5 underweight subjects, 2 were diabetic under control, and 3 diabetic candidates needed either single drug therapy or multidrug therapy, among 26 normal weight subject 15 were under control, and 11 subjects needed either single drug therapy or multidrug therapy, among 19 overweight subjects 8 were diabetic under control and 11 subjects need either single drug therapy or multidrug therapy, among 30 obese subjects 1 has normal HbA1c level, 13 subject was diabetic under control and 16 subjects need either single drug therapy or multidrug therapy.

Table 4. Distribution of study population according to BMI and HbA1c level (p=0.08)

HbA1c	BMI							
	Underweight <18.5		Normal 18.5-22.99		Overweight 23-24.9		Obese >=25	
	f	%	F	%	f	%	f	%
Normal (<5.7%)	0/0/0/0 (0)	0/0/0/0 (0)	0/0/0/0 (0)	0/0/0/0 (0)	0/0/0/0 (0)	0/0/0/0 (0)	0/1/0/0 (1)	0/4/0/0
Pre-diabetic (5.7-6.4%)	0/0/0/0 (0)	0/0/0/0 (0)	1/1/2/0 (4)	16/4/6/0	0/1/0/0 (1)	0/4/0/0	0/2/2/0 (4)	0/8/6/0
Diabetic(6.5- <7) Ideal Control	0/0/0/0 (0)	0/0/0/0 (0)	0/1/3/2 (6)	0/4/8/13	0/0/3/1 (4)	0/0/8/7	0+0+3+0 (3)	0/0/9/0
Diabetic(7-<8) Satisfactory Control	1/0/0/1 (2)	16/0/0/7	0/1/1/3 (5)	0/4/3/20	0/1/2/0 (3)	0/4/6/0	0+4+2+0 (6)	0/17/6/0
Diabetic (8-<9%) Candidate for Mono Drug Therapy	1/0/0/0 (1)	17/0/0/0	1/2/0/1 (4)	17/8/0/7	0/1/3/0 (4)	0/4/9/0	1+2+2+1 (6)	17/8/6/7
Diabetic (>=9%) Candidate for Multidrug Therapy	0/0/2/0 (2)	0/0/6/0	0/1/3/3 (7)	0/4/9/20	1/3/1/2 (7)	17/13/3/13	0+3+6+1 (10)	0/13/17/6
Total	5		26		19		30	

Hence there is no overall significant association (p=0.08) between BMI and HbA1c level in any age groups of this study.

Discussion

Diabetes has already become a leading menace to public health globally (**IDF, 2019; WHO, 2021**). The picture becomes grimmer for low- and middle-income countries like India, where the burden has risen notably in recent decades as well as will prolong to rise in the coming decades (**Pradeepa and Mohan, 2021**). T2DM has indicated that overweight and obese amplify the risk of cardiovascular and other diseases in addition to making it harder to sustain glycemic control (**Mavian et al., 2010**). The prognostic potential of HbA1c lies in its unique capability of assessing retrospective glycemic control (**Sherwani et al., 2016**) for testing and monitoring diabetes, specifically DM2 (**WHO, 2011**).

Age has been reported to be an independent factor among T2DM (**Nuttall 1999; Yang et al., 1997; Pani et al., 2008**) which is similar to our study. According to **Hashimoto et al (1995**), the 30-39 year age group showed the highest T2DM. **Kuroki et al (1990)** reported that the age-dependent increase in T2DM was small in the older age group. However, our study is mismatched with all of these findings.

According to **Mungreiphy (2011)** body weight increased with age till the age of 49

years and slightly decreased after 50 years. The increase in body weight and BMI with age and decline in advanced age have also been reported by **Kapoor and Tyagi (2002)** and **Tandon (2006).** All of these above studies are corroborating our findings.

Jha et al (2022) accounted that all individuals with a BMI >30 (obese group) had HbA1c levels of more than 8% which is similar to our findings. BMI increased over the time period from 2012 to 2019 and higher BMI was associated with higher HbA1c (**Norberg et al., 2006; Woo et al., 2015; Babikr et al., 2016; Boye et al., 2021**). These studies are not analogous to our study findings. There is a burly negative correlation between BMI and HbA1c (**Komatsu and Majima 2006). Boye et al (2021)** stated that there is a trend in BMI augmentation and a diminishing percentage of individuals achieving glycemic control among adults with DM2. **Jha et al (2022)** accounted that abnormal BMI was found as a statistically significant predictor of poor glycemic control. All these studies have shown an indirect correlation between BMI and HbA1c which is contradictory to our observations. Though some studies have found a contrasting association between BMI and HbA1c (**Edqvist et al., 2019; Sisodai and Chouhan, 2019**). Henceforth all those observations have already been in therapeutic intervention in contrast to our research findings.

In this observational, cross-sectional study, there was no correlation between BMI and HbA1c among newly diagnosed DM2 patients. Henceforth, BMI and HbA1c levels are to be considered independently during the initiation and long-term management of DM2. This may be due to the variable asymptomatic phase of the ailment.

Hereafter, to curtail the epidemic of diabetes and its associated hindrances, a multi-pronged approach is required, concerning the early diagnosis of diabetes, screening for its obstacles, and contributing optimal therapy at all levels of care.

Conclusions

Our investigations provide no overall momentous association between BMI and HbA1c among newly diagnosed DM2. Based on the current study, this may be due to the variable asymptomatic phase of the disease. Consequently, BMI and HbA1c levels are to be contemplated independently throughout the initiation & long-term management of DM2.

Conflicts of Interest

No potential conflicts of interest were disclosed.

Acknowledgments

The authors are thankful to the Department of Physiology, Murshidabad Medical College which enabled the present study. Authors gratefully acknowledge Dr. Kanad Bag, Assistant Professor, Department of Physiology, Prafulla Chandra Sen Government Medical College, Arambagh, Hooghly, West Bengal, India for his critical suggestions.

References

- **Aghamollaei T, Eftekhar H, Shojaeizadeh D, Mohammad K, Nakhjavani M, Pour FG(2003).** Behavior, metabolic control and

health-related quality of life in diabetic patient at Bander Abbas diabetic clinic Iranian Journal of Public Health, 32 (3): 54-59.

- **Al-Goblan AS, AAl-Alfi M, Z Khan MZ(2014).** Mechanism linking diabetes mellitus and obesity. Diabetes Metabolic Syndrome and Obesity: Targets and Therapy, 7: 587–591.
- **Babikr WG, Alshahrani AS, Hamid HG, Abdelraheem AH, Shalayel MH(2016).** The correlation of HbA1c with body mass index and HDL-cholesterol in type 2 diabetic patients, Biomed Research, 27 (4): 1280-1283.
- **Boye KS, Lage MJ, Shinde S, Thieu V, Bae JP (2021).** Trends in HbA1c and Body Mass Index Among Individuals with Type 2 Diabetes: Evidence from a US Database 2012-2019. Diabetes Therapy, 12 (7): 2077-2087.
- **Chivese T, Hirst J, Matizanadzo JT, Custodio M, Farmer A, Norris S, et al. (2022).** The diagnostic accuracy of HbA1c, compared to the oral glucose tolerance test, for screening for type 2 diabetes mellitus in Africa—A systematic review and meta-analysis. Diabetic Medicine, 39 (4): e14754.
- **Edqvist J, Rawshani A, Adiels M, Björck L, Lind M, Svensson AM, et al. (2019).** Contrasting Associations of Body Mass Index and Hemoglobin A1c on the Excess Risk of Acute Myocardial Infarction and Heart Failure in Type 2 Diabetes Mellitus. Journal of the American Heart Association, 8(24): e013871.
- **Hashimoto Y, Futamura A, Ikushima M.(1995).** Effect of aging on HbA1c in a working male Japanese population. Diabetes care, 18 (10):1337–1340.
- **ICMR. (2018).** Guidelines for management of Type 2 Diabetes 2018.
- **International Diabetes Federation. (2019)**. IDF Diabetes Atlas. 9th ed. Brussels, Belgium: International Diabetes Federation.
- **Jha SC, Dey S, Rajan R.(2022).** To determine the correlation between BMI and Glycated Hemoglobin (HbA1c) Levels in Patients of Type 2 Diabetes Mellitus. European Journal of Molecular & Clinical Medicine, 9(3): 3014-3018.
- **Joshi SR, Saboo B, Vadivale M, Dani SI, Mithal A, Kaul U, et al.(2012).** Prevalence of Diagnosed and Undiagnosed Diabetes and Hypertension in India—Results from the Screening India's Twin Epidemic (SITE) Study. Diabetes Technology & Therapeutics, 14: 1 (8-15).
- **Kant R, Amanda D, Verma V(2022).** Maturity-Onset Diabetes of the Young: Rapid Evidence Review, 105(2):162-167.
- **Kapoor S , Tyagi S.(2002).** Fatness, fat patterns and changing body dimensions with age in adult males of a high altitude population in Science of Man in the service of Man. M. K. Bhasin and S. L. Malik, Eds., 8; 129–136.
- **Komatsu Y , Majima T(2006).** Negative correlation between BMD and HbA1C in patients with type 2 diabetes. Clin Calcium, 16(8): 1327 – 1331.

- **Kuroki S, Tsushima T, Yoshii H, Nakano Kuroki S, Tsushima T, Yoshii H, et al. (1990).** Measurement of HbAlc as a method to diagnose diabetes mellitus for nursing home residents. Japanese Journal of Geriatrics – Resurchify, 27:40-44.
- **Mavian AA, Miller S, Henry RR. (2010).** Managing Type 2 Diabetes: Balancing HbA1c and Body Weight. Postgraduate Medicine, 122 (3): 106-117.
- **Mohan V , Pradeepa R. (2017).** The Global Burden of Diabetes and Its Vascular Complications (Chapter 1). In: Mechanisms of Vascular Defects in Diabetes Mellitus. Advances in Biochemistry in Health and Disease. Kartha, C.C. Ramachandran, S. and R.M. Pillai, (Eds). Springer International Publishing AG. pp: 3 - 23.
- **Mungreiphy NK, Kapoor S, Sinha R. (2011).** Association between BMI, Blood Pressure, and Age: Study among Tangkhul Naga Tribal Males of Northeast India, doi:10.1155/2011/748147.
- **Norberg M, Eriksson JW, Lindahl B, Andersson C, Rolandsson O, Stenlund H, et al. (2006).** A combination of HbA1c, fasting glucose and BMI is effective in screening for individuals at risk of future type 2 diabetes: OGTT is not needed. Journal of Internal Medicine, 260 (3): 263-271.
- **Nuttall FQ.(1999).** Effect of age on the percentage of hemoglobin A1c and the percentage of total glycohemoglobin in non-diabetic persons (2006) The Journal of laboratory and clinical medicine, 134(5):451–3.
- **Pani LN, Korenda L, Meigs JB, Driver C, Chamany S, Fox CS.(2008).** Effect of aging on A1C levels in individuals without diabetes: evidence from the Framingham Offspring Study and the National Health and Nutrition Examination Survey 2001–2004. Diabetes Care, 31(10):1991–6.
- **Pradeepa R, Mohan V.(2021).** Epidemiology of type 2 diabetes in India. Indian Journal of Ophthalmology, 69 (11): 2932-2938.
- **Sherwani SI, Khan HA, Ekhzaimy A, Masood A, Sakharkar MK. (2016)**.Significance of HbA1c Test in Diagnosis and Prognosis of Diabetic Patients. Biomark Insights, 11: 95–104.
- **Sisodia RK , Chouhan M.(2019).** The study of the correlation between Body Mass Index and glycemic control-HbA1c in diabetes type 2 patients. International Journal of Advances in Medicine, 6 (6): 1788-1791.
- **Tandon K (2006).** Obesity, its distribution pattern, and health implications among Khatri population, Ph.D. thesis, Department of Anthropology, University of Delhi, Delhi, India.
- **Woo YC, Cheung BM, Yeung CY, Lee CH, Hui EY, Fong CH, et al. (2015).** Cardiometabolic risk profile of participants with prediabetes diagnosed by HbA1c criteria in an urban Hong Kong Chinese population over 40 years of age. Diabetic Medicine, 32 (9): 1207-1211.

- **World Health Organization. (2011).** Use of Glycated Haemoglobin (HbA1c) in the Diagnosis of Diabetes Mellitus Abbreviated Report of a WHO Consultation. Geneva: WHO.
- **World Health Organization. (2021).** The top 10 causes of death. Available from: http://www.who.int/en/news-room/fact-sheets/detail/ the-top-10-causes-of-death.
- **Wu Y, Ding Y, Tanaka Y, Zhang W. (2014).** Risk Factors Contributing to Type 2 Diabetes and Recent Advances in the Treatment and Prevention. International Journal of Medical Sciences, 11 (11): 1185–1200.
- **Yang YC, Lu FH, Wu JS, Chang CJ. (1997).** Age and sex effects on HbA1c. A study in a healthy Chinese population. Diabetes Care. 20(6):988–991.