**"EXPLORING THE RELATIONSHIP BETWEEN BITTER GOURD (MOMORDICA CHARANTIA) CONSUMPTION AND HBA1C% IN TYPE 2 DIABETES AND DIABETIC HYPERTENSION COMORBIDITY"**

**Abstract**

In India, approximately 72.9 million individuals suffer from diabetes, and 317 million experience hypertension. Bitter gourd (Momordica charantia) is traditionally used for the management of type 2 diabetes mellitus (T2DM). The objective of this study was to examine the association between the frequency of bitter gourd consumption and HbA1c% levels among patients with T2DM and those with both T2DM and hypertension (T2DM\*HTN). A hospital-based, cross-sectional descriptive study was conducted with 320 patients aged 20 years and older, who were diagnosed with T2DM and/or hypertension. The frequency of bitter gourd consumption was assessed using a formative scale, and statistical analysis was performed using Fisher’s exact test and Somers’ *d* statistic to evaluate associations. Among the 320 patients, 31.3% had T2DM, 50.0% had HTN, and 19% showed co-prevalence of T2DM and HTN (T2DM\*HTN). The mean age of participants was 47.6 ± 1.07 years for T2DM and 54.5 ± 1.1 years for T2DM\*HTN. The mean HbA1c% levels were 8.6 ± 0.2% for T2DM and 8.2 ± 0.1% for T2DM\*HTN. The mean systolic and diastolic blood pressures for T2DM\*HTN patients were 136.5 ± 3.4 mmHg and 92.0 ± 2.6 mmHg, respectively. The study identified a modest but significant negative association between bitter gourd consumption and HbA1c levels in patients with only diabetes (*p* < 0.05) suggesting that frequent bitter gourd intake may contribute to a gradual reduction in glycemic levels. However, In diabetic hypertensive patients, no statistically significant association was observed (*p* > 0.05). The findings indicate a potential role of bitter gourd in managing glycemic levels in T2DM, though further research is required to clarify its effects, particularly in patients with comorbid conditions.

**Keywords:** Type 2 Diabetes Mellitus, Bitter gourd, RDA, HbA1c% Level

**Introduction**

Cardiovascular diseases (CVDs), including coronary heart disease, stroke, and hypertension, are responsible for 31% of global deaths attributable to non-communicable diseases (NCDs), while diabetes accounts for 3% of such deaths. In India, CVDs and diabetes contributed to 27% and 3% of NCD-related deaths, respectively, in 20161. Globally, an estimated 425 million adults are living with diabetes, of which 87%–91% have type 2 diabetes mellitus (T2DM). India ranks as the second most affected country, with approximately 72 million individuals diagnosed with diabetes2. Additionally, 1.13 billion people worldwide have hypertension (defined as systolic blood pressure ≥140 mm Hg and diastolic blood pressure ≥90 mm Hg), including an estimated 317 million adults aged over 18 years in India in 20151.

 According to the American Diabetes Association, hypertension is commonly associated with diabetes, with its prevalence influenced by the type and duration of diabetes mellitus, as well as factors such as age, sex, body mass index, and history of glycemic control3,4. Hypertension is a significant risk factor for both macrovascular and microvascular complications, making it a leading cause of morbidity and mortality in individuals with diabetes. It is also a major contributor to the direct and indirect healthcare costs associated with diabetes5. A study conducted by the Madras Diabetes Research Foundation reported that hypertension affects approximately 50% of individuals with diabetes in India6,7,8. The coexistence of hypertension and diabetes increases the risk of cardiovascular diseases (CVDs) by 75% compared to having either condition alone, thereby significantly elevating the likelihood of adverse health outcomes9,10.

The World Health Organization (WHO) has identified an unhealthy diet as a modifiable risk factor significantly associated with the development of diabetes and hypertension1. According to the Global Burden of Disease study, poor nutrition is linked to approximately 11 million deaths worldwide, accounting for one in five global fatalities. Of these, cardiovascular diseases (CVDs) were responsible for 9.13 lakh deaths, while type 2 diabetes contributed to 3.39 lakh deaths. These findings underscore the critical role of dietary interventions in mitigating the burden of these chronic conditions.

Furthermore, According to WHO data on chronic disease prevention, approximately 80% of diabetes- and hypertension-related events can be mitigated through the adoption of a balanced and nutritious diet. Key dietary measures include regular consumption of fruits and vegetables, limiting the intake of saturated fats, reducing sodium consumption, and minimizing the consumption of sugar-sweetened beverages. These dietary modifications play a crucial role in reducing the risk of these conditions11,12. Bitter gourd is one of the traditional medicine which helps in the treatment of T2DM13. Most scientific studies suggest that frequent consumption of bitter gourd can reduce several health-related problems either by its prophylactic or therapeutic effects14. It contains bitter chemicals such as charantin, vicine, glycosides and karavilosides along with polypeptide-plant insulin, which is hypoglycemic in nature and improves glycemic levels by rising glucose uptake and glycogen synthesis in the liver, muscles and fat cells15. Wehash et al. observed that bitter melon seems to be exerting in decreasing capillary permeability compared to fenugreek extract. Generally, the increase in capillary permeability is a sign of microvascular dysfunction at the arteriolar and capillary level that is a common and critical complication of diabetes16. Furthermore, a review paper regarding medicinal properties of bitter melon and concluded that bitter melon might have properties that can help lower blood glucose level17. Another systematic review and meta-analysis conducted by Yin et al. in which he looked at four randomized controlled trials (RCTs) that compared the effects of bitter melon supplements with those of no diabetes treatment at all and concluded that no evidence that bitter melon had any significant effects on A1C levels or FBG level18.

Moreover, Bitter melon extract has shown promise in managing hypertension when combined with dietary modifications and exercise. Some studies suggest it may reduce blood pressure by improving vascular function and inhibiting ACE activity19. Studies also suggest that peptides derived from bitter melon can inhibit angiotensin-converting enzyme (ACE), a critical enzyme in blood pressure regulation. This activity, combined with its antidiabetic effects, makes it potentially beneficial for individuals with metabolic syndrome, which often includes both diabetes and hypertension19,20.

 Bitter melon (Momordica charantia) has demonstrated potential benefits for managing both type 2 diabetes mellitus (T2DM) and hypertension. Despite its observed benefits, no studies have specifically explored the relationship between bitter melon consumption, HbA1c levels, and the coexistence of diabetes and hypertension. Further research is needed to clarify these effects. Thus, present descriptive study aims to examine the connection between bitter melon consumption and HbA1c% in individuals with T2DM and comorbid diabetic hypertension.

**Methodology**

**Research Design and Participants**

This hospital-based cross-sectional study was conducted on patients with type 2 diabetes mellitus (T2DM) and hypertension (HTN) attending the outpatient clinics of the Endocrinology and General Medicine Departments at Jawaharlal Nehru Medical College and Hospital (JNMCH), Aligarh. Participants included male and female patients aged 20 years or older from diverse socioeconomic backgrounds residing in Aligarh city and who were regular visitors to JNMCH. Pregnant women and patients with severe illness were excluded from the analysis. This design ensured a representative sample of individuals with comorbid T2DM and HTN for analysis.

**Sampling Design**

On the basis of the earlier prevalence of the disease in Aligarh21 A calculated sample size of diabetes and hypertension were 160 and 110, by using the simplified sample size formula for proportions n = 4pq/ l22 with 5 % relative error respectively. Quota sampling technique was used to select the sample. Furthermore, patients were stratified based on their disease situation such as patients with T2DM and HTN and T2DM\*HTN. During the study period of 6 months from August 2017 to January 2018, approximately 336 cases were identified. Out of which around 320 cases were selected for the final study. Moreover, nearly 60 cases of diabetic hypertensive (T2DM\*HTN) were extracted among the total sample (N = 320).

**Tools For Data Collection**

A valid and reliable (Cronbach's alpha = 0.896) self-prepared questionnaire cum interview schedule was designed to collect data regarding demographic information, anthropometric, clinical history, and detailed dietary habits from patients. A signed informed verbal consent was also taken. The height and weight were measured with the help of the standard stature meter (MCP Stature-meter04, manufactured by MCP, India) and digital platform weighing scale (Stand scale 7830.01.001 manufactured by Soehnle Backnang, Germany), respectively. BMI was calculated with the help of the equation proposed by Garrow and Webster (1985)23 (weight/height kg/m2) and categorized as per Indian adult standard24,25.

**Nutritional Assessment**

A structured 24-hour diet recall method was employed over three consecutive days, including two weekdays and one holiday, allowing participants to recall their food and beverage consumption. Standardized weights and measures were used to ensure accurate quantification of food items in grams and liters. The nutrient content of the reported foods was analyzed using DietCal software 8.0, adapted to the Indian Food Composition Table26,27. "During data collection, it was observed that some patients incorporated functional foods such as fenugreek, bitter gourd, and bottle gourd into their treatment regimens alongside prescribed medications. The frequency of their consumption was assessed using a formative scale and compared against the ICMR (2018) glycemic control guidelines for type 2 diabetes: HbA1c < 7% (ideal), HbA1c ≥ 7 and < 8% (satisfactory), and HbA1c ≥ 8% (unsatisfactory)”28.

This analysis focused solely on patients with T2DM and T2DM\*HTN, as hypertensive patients without diabetes did not report using functional foods for managing blood pressure. Therefore, the evaluation of special food consumption (e.g., fenugreek seeds, bottle guard, bitter gourd) was limited to diabetic patients.

**Definitions:**

**Diabetes Mellitus**

Glycated hemoglobin (HbA1c) levels were used as a key outcome measure for assessing glycemic control in diabetic patients, obtained from their medical case records. Diabetes mellitus was diagnosed as per the criteria of WHO (2006)29 and ADA (2017)30 and recommendations as HbA1c ≥ 6.5%. Glycaemic control was categorized as per the recent guidelines provided by Indian Council of Medical Research (2018) for the management of type 2 diabetes mellitus (< 7 for ideal, ≥ 7 - < 8 for satisfactory and ≥ 8 for unsatisfactory glycaemic control)28. This categorization facilitated the evaluation of diabetes management among the study population.

**Hypertension**

Blood pressure was measured using a standardized sphygmomanometer (Model EHL DIAMOND-BPMR 120, manufactured by Diamond Pvt Ltd., India) employing the auscultation method. Hypertension was identified based on the use of prescribed antihypertensive medications or if blood pressure readings exceeded 140/90 mmHg, in accordance with JNC VIII criteria. The blood pressure goal for diabetic patients was defined as per the JNC VIII recommendations, with target levels set at < 140 mmHg for systolic blood pressure (SBP) and < 90 mmHg for diastolic blood pressure (DBP). This ensured the classification and management of hypertension aligned with the latest clinical guidelines31.

**Statistical Analysis**

Data were analyzed using SPSS version 20.0 with both descriptive and inferential statistical methods. For the general features of patients, a univariate analysis in which mean and standard error of the mean was calculated for each metric variables and frequency and percentages were calculated for non-metric variables.

A non-parametric fisher exact test was applied to check the association between two non-metric categorical variables. Additionally, Somers’ *d* was computed as an index of effect size for nominal and ordinal data in Fisher’s exact test of association. This methodology provided a comprehensive analysis of the data, ensuring the robustness of findings.

**Ethical Approval**

The study received ethical clearance from the Institutional Ethics Committee of Jawaharlal Nehru Medical College and Hospital, Aligarh Muslim University (Approval No. D. No. 367/FM, dated 14 March 2018).

**Results and Discussion**

As shown in Table 1, among the 320 samples, 31.3% of patients had T2DM, 50.0% had HTN and 19% showed co-prevalence of diabetes and hypertension (T2DM\*HTN).

The co-prevalence rate in Aligarh city (19%) is notably lower compared to other national studies: Gujarat (47%)32, Kerala (30%)33, and Tamil Nadu (61.4%)34. International studies report even more variation in co-prevalence rates, with Nigeria ranging from 14% to 54.2%35,36, Japan at 62%37, Morocco and Iran at 70.4%38,39, and Northeast Ethiopia at 43.3%40. The mean age of patients with T2DM was 47.6 ± 1.0 years, while those with T2DM\*HTN had a higher mean age of 54.5 ± 1.1 years. A majority of the patients were female across both groups (T2DM: 60%; T2DM\*HTN: 76.7%).

**Table 1: Baseline Characteristics of the Patients (*N* = 320)**

|  |  |  |
| --- | --- | --- |
| Parameters | T2DM (*n* = 100) | T2DM\*HTN (*n* = 60) |
| Prevalence of diseases, *% (n)* | 31.3 (100) | 18.8 (60) |
| Gender, *% (n)* |  |  |
| Male: Female | 40.0 (40); 60.0 (60) | 23.3 (14): 76.7 (46) |
|  |  |  |
| Age (years), *M ± SE* |
| Overall | 47.6 ± 1.0 | 54.5 ± 1.1 |
| Male: Female | 49.8 ± 1.8; 46.1 ± 1.2 | 60.6 ± 1.97; 52.6 ± 1.19 |
|  |  |  |
| Mean BMI, (kg/m2) |
| Overall | 25.6 ± 0.5 | 27.5 ± 0.7 |
| Male: Female, % (*n*) | 24.7 ± 0.7; 26.2 ± 0.7 | 25.6 ± 0.7; 28 ± 0.8 |
|  |  |  |
| HbA1c% |
| Overall | 8.6 ± 0.1 | 8.2 ± 0.2 |
| Male: Female | 8.7 ± 0.3; 8.5 ± 0.2 | 7.7 ± 0.5; 8.3 ± 0.3 |
|  |  |  |
| SBP (mmHg), *M ± SE* |
| Overall | − | 136.5 ± 3.4 |
| Male: Female | − | 129.7 ± 7.4; 138.6 ± 3.9 |
|  | − |  |
| DBP (mmHg), *M ± SE* |
| Overall | − | 92 ± 2.6 |
| Male: Female | − | 96.7 ± 7.7; 90.5 ± 2.5 |
| *Note.* N: Number of sample, M: Mean; SE: Standard error of mean; %/n: percentage and number of the samples, figure in parentheses represents frequencies; HbA1c%; Glycosylated Hemoglobin; T2DM: Type 2 diabetes mellitus; T2DM\*HTN: Diabetic hypertensive; BP: Blood pressure; SBP: Systolic Blood Pressure; DBP: Diastolic blood pressure; BMI: Body mass index. |

The mean BMI was 25.6 ± 0.5 kg/m² for T2DM patients and 27.2 ± 0.4 kg/m² for T2DM\*HTN patients. The average HbA1c% levels were comparable between T2DM (8.6 ± 0.2%) and T2DM\*HTN (8.2 ± 0.1%) patients. Male and female T2DM patients had similar HbA1c% levels (*M*: 8.7 ± 0.3, F: 8.5 ± 0.2), while among T2DM\*HTN patients, females exhibited a slightly higher mean HbA1c% level compared to males (M: 7.7 ± 0.5, F: 8.3 ± 0.3). For patients with T2DM\*HTN, the average systolic blood pressure (SBP) was 136.5 ± 3.4 mmHg, and the diastolic blood pressure (DBP) averaged 92.0 ± 2.6 mmHg.

As shown in Table 2, among T2DM patients, the analysis of bitter gourd consumption frequency revealed notable trends in glycemic control. Among those who never included bitter gourd in their meals (*n* = 68), 58.8% exhibited unsatisfactory glycemic control (HbA1c ≥ 8), while nearly 41% demonstrated satisfactory or ideal glycemic control. For patients who consumed bitter gourd occasionally (*n* = 16), over 80% had unsatisfactory glycemic control, with only 18.8% achieving ideal control. Conversely, among those who regularly consumed bitter gourd (*n* = 12), approximately 60% fell within the satisfactory or ideal range of glycemic control. Notably, among patients who always included bitter gourd in their diet (*n* = 4), about 75% achieved ideal glycemic control. Fisher's exact test statistic of 16.72 (*p* = 0.004) and Somers’ *d* value (*d* = -0.115, *p* < 0.05) indicated a low but significant negative association between bitter gourd consumption and HbA1c levels in T2DM patients. In simpler terms, frequent consumption of bitter gourd is associated with a gradual reduction in HbA1c levels.

 Previous studies have highlighted the potential benefits of bitter melon (Momordica charantia) for managing metabolic conditions. For example, research has demonstrated that bitter melon contains bioactive compounds such as charantin, vicine, and polypeptide-p, which exhibit hypoglycemic effects through enhanced glucose uptake and insulin sensitivity. A review by Kwatra et al. emphasized that bitter melon has properties that can help lower blood glucose levels, supporting its potential as a dietary adjunct for diabetes management17.

As observed in the T2DM\*HTN column, among patients who never included bitter gourd in their meals (n = 36), approximately 40% achieved ideal glycemic control, followed by 16.7% with satisfactory control and 45% with unsatisfactory glycemic control. Among those who consumed bitter gourd occasionally (*n* = 9), over 65% demonstrated unsatisfactory glycemic control, while 35% achieved healthy glycemic levels. For patients who consumed bitter gourd regularly (n = 10), nearly 70% successfully maintained their HbA1c% levels within the satisfactory or ideal range. Furthermore, ideal glycemic control was observed in all patients who consistently consumed bitter gourd. Despite these trends, the Fisher exact test statistic of 8.29 (p = 0.185) indicated that the association between bitter gourd consumption and HbA1c% levels in T2DM\*HTN patients was not statistically significant (p > 0.05). Although differences were noted, their lack of statistical significance underscores the need for further research with larger sample sizes and controlled settings to validate these findings.

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| **Table 2** |  |  |  |  |  |  |  |  |  |  |  |  |
| **Association between Frequency of Consuming bitter gourd and Control of HbA1c % Level among the Patients of T2DM and T2DM\*HTN** |
| Special Food | Frequency | T2DM  |   |   | T2DM\*HTN |   |
| Control of HbA1c % level | Total |  Fishers Exact Test |  | Control of HbA1c % level | Total | Fishers Exact Test |
| **< 7** | **≥7 - <8** | **≥ 8** |   | **< 7** | **≥7 - <8** | **≥ 8** |
| Bitter gourd | Never | 11.8 (8) | 29.4 (20) | 58.8 (40) | 68.0 (68) | \* Fisher Exact statistics= 16.72,  |  | 38.9 (14) | 16.7 (6) | 44.4 (16) | 60 (36) | Fisher Exact statistics = 8.29,  |
| Sometimes | 18.8 (3) | 0.0 (0) | 81.2 (13) | 16.0 (16) | *p* = .004, |  | 2 2.2 (2) | 11.1 (1) | 66.7 (6) | 15.0 (9) | *p* = .185  |
| Usually, | 33.3 (4) | 25.0 (3) | 41.7 (5) | 12.0 (12) | *d* = -.115  |  | 30.0 (3) | 40.0 (4) | 30.0 (3) | 16.7 (10) |  |
| Always | 75.0 (3) | 0.0 (0) | 25.0 (1) | 4.0 (4) |   |  | 60 (3) | 40.0 (2) | 0.0 (0) | 8.3 (5) |   |
| *Note.* Figures in parentheses indicates frequencies; \**p* < 0.05; *d* = Somers’d;  |
| Glycemic control: < 7: Ideal glycemic control, ≥7 -< 8: Satisfactory glycemic control, ≥ 8: Unsatisfactory glycemic control (ICMR, 2018). |

In the context of hypertension, bitter melon has also shown promise. Studies suggest that peptides derived from bitter melon inhibit angiotensin-converting enzyme (ACE), a key enzyme in blood pressure regulation. This dual effect on glucose metabolism and vascular function is particularly beneficial for individuals with comorbid diabetes and hypertension19,20. Moreover, a study by Wehash et al. indicated that bitter melon may exert effects on reducing capillary permeability, which could complement its antidiabetic properties16. However, contrasting evidence exists. For instance, Yin et al. conducted a systematic review and meta-analysis and found no significant effect of bitter melon on HbA1c or fasting plasma glucose levels, suggesting variability in outcomes based on population, dosage, and study design18.

 In conclusion, while bitter gourd shows promise as a functional food with potential benefits for glycemic and blood pressure control, the lack of statistically significant findings in this study underscores the need for robust, large-scale clinical trials to better understand its role in managing diabetic and diabetic hypertensives.

**References**

1. World Health Organization. (2018). Noncommunicable diseases country profiles 2018. Geneva (CH): License CC BY-NC-SA 3.0 IGO2018.
2. International diabetes federation. IDF Diabetes Atlas, 8th edition, Brussels Belgium: international diabetes federation, 2017.
3. De Ferranti, S. D., De Boer, I. H., Fonseca, V., Fox, C. S., Golden, S. H., Lavie, C. J., ... & Zinman, B. (2014). Type 1 diabetes mellitus and cardiovascular disease: a scientific statement from the American Heart Association and American Diabetes Association. Circulation, 130(13), 1110-1130.
4. Fox, C. S., Golden, S. H., Anderson, C., Bray, G. A., Burke, L. E., De Boer, I. H., ... & Inzucchi, S. E. (2015). American Heart Association Diabetes Committee of the Council on Lifestyle and Cardiometabolic Health; Council on Clinical Cardiology, Council on Cardiovascular and Stroke Nursing, Council on Cardiovascular Surgery and Anesthesia, Council on Quality of Care and Outcomes Research; American Diabetes Association. Update on prevention of cardiovascular disease in adults with type 2 diabetes mellitus in light of recent evidence: a scientific statement from the American Heart Association and the American.... Diabetes Care, 38(9), 1777-803.
5. De Boer, I. H., Bangalore, S., Benetos, A., Davis, A. M., Michos, E. D., Muntner, P., ... & Bakris, G. (2017). Diabetes and hypertension: a position statement by the American Diabetes Association. Diabetes care, 40(9), 1273-1284.
6. Singh, A., & Masuku, M. (2014). Sampling Techniques & Determination of Sample Size in Applied Statistics Research: an Overview. Ijecm.Co.Uk, II (11), 1–22. Retrieved from http://ijecm.co.uk/wp-content/uploads/2014/11/21131.pd
7. Jain, S., & Patel, J. C. (1983). Diabetes and hypertension. Journal of the Diabetic Association of India, 23, 83-86.
8. Mohan, V., Seedat, Y. K., & Pradeepa, R. (2013). The rising burden of diabetes and hypertension in Southeast Asian and African regions: need for effective strategies for prevention and control in primary health care settings. International journal of hypertension, 2013, 409083-409083.
9. Sowers, J. R., Epstein, M., & Frohlich, E. D. (2001). Diabetes, hypertension, and cardiovascular disease: an update. Hypertension, 37(4), 1053-1059.
10. Shah, A., & Afzal, M. (2013). Prevalence of diabetes and hypertension and association with various risk factors among different Muslim populations of Manipur, India. Journal of Diabetes and Metabolic Disorders, 12(1), 1–10. https://doi.org/10.1186/2251-6581-12-52
11. NCD Risk Factor Collaboration. (2016). Worldwide trends in diabetes since 1980: a pooled analysis of 751 population-based studies with 4· 4 million participants. The Lancet, 387(10027), 1513-1530.
12. World Health Organization, Public Health Agency of Canada, & Canada. Public Health Agency of Canada. (2005). Preventing chronic diseases: a vital investment. World Health Organization
13. Ahmad, N., Hasan, N., Ahmad, Z., Zishan, M., & Zohrameena, S. (2016). Momordica charantia: for traditional uses and pharmacological actions. Journal of Drug Delivery and Therapeutics, 6(2), 40-44.
14. Anilakumar, K. R., Kumar, G. P., & Ilaiyaraja, N. (2015). Nutritional, pharmacological and medicinal properties of Momordica charantia. International Journal of Nutrition and Food Sciences, 4(1), 73-83.
15. Gupta, M., Sharma, S., Gautam, A. K., & Bhadauria, R. (2011). Momordica charantia Linn.(Karela): Nature’s silent healer. International Journal of Pharmaceutical Sciences Review and Research, 11(1), 32-37.
16. Wehash, F. E., Abpo-Ghanema, I. I., & Saleh, R. M. (2012). Some physiological effects of Momordica charantia and Trigonella foenum-graecum extracts in diabetic rats as compared with cidophage®. World Academy of Science, Engineering and Technology, 64, 1206-1214.
17. Kwatra, D., Dandawate, P., Padhye, S., & Anant, S. (2016). Bitter Melon as a Therapy for Diabetes, Inflammation, and Cancer: a Panacea?. Current Pharmacology Reports, 2(1), 34-44.
18. Yin, R. V., Lee, N. C., Hirpara, H., & Phung, O. J. (2014). The effect of bitter melon (Mormordica charantia) in patients with diabetes mellitus: a systematic review and meta-analysis. Nutrition & diabetes, 4(12), e145.
19. Dahlquist, A., Jandali, D., Nauman, M. C., & Johnson, J. J. (2023). Clinical application of Momordica char-antia (Bitter Melon) for reducing blood sugar in type 2 diabetes melli-tus. *International Journal of Nutrition-7 (4)*, 8-26.
20. Hung, W. T., Sutopo, C. C. Y., Mahatmanto, T., Wu, M. L., & Hsu, J. L. (2024). Exploring the Antidiabetic and Antihypertensive Potential of Peptides Derived from Bitter Melon Seed Hydrolysate. *Biomedicines*, *12*(11), 2452.
21. National Family Health Survey 2015-2016, Ministry of Health and Family Welfare (MoHFW)GovernmentofIndia.Availableat:http://rchiips.org/NFHS/pdf/NFHS4/India.pdf
22. Singh A, Masuku M. Sampling Techniques & Determination of Sample Size in Applied Statistics Research: an Overview. IjecmCoUk [Internet]. 2014;II(11):1–22. Available from: <http://ijecm.co.uk/wp-content/uploads/2014/11/21131.pdf>
23. Garrow, J.S. and Webster, J. 1985. Quetelets index (W/H2) as a measure of fatness. International Journal of Obesity 9: 147-53.
24. Who, E. C. (2004). Appropriate body-mass index for Asian populations and its implications for policy and intervention strategies. Lancet (London, England), 363(9403), 157.
25. Indian Consensus Group. (1996). Indian consensus for prevention of hypertension and coronary heart disease. A joint scientific statement of Indian Society of Hypertension and International College of Nutrition. J Nutr Environ Med, 6, 309-318.
26. Longvah, T., Ananthan, R., Bhaskarachary, K., & Venkaiah, K. (2017). Indian Food Composition Tables. (T. Longvah, Ed.). Hyderabad, India: National Institute of Nutrition, Indian Council of Medical Research, Ministry of Health and Family Welfare, Government of India.
27. Kaur G. (2017). Diet cal: A tool for dietary assessment and planning; software version 8.: Profound Tech Solutions. Department of Dietetics, AIIMS, New Delhi, India.
28. ICMR (2018). Guidelines for Management of Type 2 Diabetes. Indian Council of Medical Research, New Delhi.
29. Definition, W. H. O. (2006). Diagnosis of diabetes mellitus and intermediate hyperglycemia: report of a WHO/IDF consultation. Geneva: World Health Organization, 3.
30. American Diabetes Association. (2017). 2. Classification and diagnosis of diabetes. Diabetes care, 40(Supplement 1), S11-S24.
31. Paul A. James, MD; Suzanne Oparil, MD; Barry L. Carter, PharmD; William C. Cushman, MD; Cheryl Dennison-Himmelfarb, RN, ANP, PhD; Joel Handler, MD;Daniel T. Lackland, DrPH; Michael L. LeFevre, MD, MSPH; ThomasD. MacKenzie, MD, MSPH; Olugbenga Ogedegbe, MD, M. (2014). 2014 Evidence-Based Guideline for the Management of High Blood Pressure in Adults Report From the Panel Members Appointed to the Eighth Joint National Committee (JNC 8), 1097(5), 507–520. https://doi.org/10.1001/jama.2013.284427
32. Patel, M., Patel, I. M., Patel, Y. M., & Rathi, S. K. (2013). A hospital-based observational study of type 2 diabetic subjects from India. Indian J Clin Pract, 24, 141-148.
33. Nair, A., Jayakumari, C., Jabbar, P. K., Jayakumar, R. V., Raizada, N., Gopi, A., ... & Seena, T. P. (2018). Prevalence and Associations of Hypothyroidism in Indian Patients with Type 2 Diabetes Mellitus. Journal of thyroid research, 2018.
34. Maniarasu, K., & Muthunarayanan, L. (2017). Prevalence of certain chronic complications of diabetes among type 2 diabetic patients in rural population of Kancheepuram District, Tamil Nadu-a cross sectional study. International Journal of Medicine and Public Health, 7(1).
35. Opeodu, O. I., & Adeyemi, B. F. (2015). Prevalence of coexisting diabetes mellitus and hypertension among dental patients in a tertiary care hospital. Journal of the West African College of Surgeons, 5(3), 16.
36. Unadike, B. C., Eregie, A., & Ohwovoriole, A. E. (2011). Prevalence of hypertension amongst persons with diabetes mellitus in Benin City, Nigeria. Nigerian journal of clinical practice, 14(3), 300-302.
37. Yamakawa, T., Sakamoto, R., Takahashi, K., Suzuki, J., Matuura‐Shinoda, M., Takahashi, M., ... & Kawata, T. (2019). Dietary survey in Japanese patients with type 2 diabetes and the influence of dietary carbohydrate on glycated hemoglobin: The Sleep and Food Registry in Kanagawa study. Journal of diabetes investigation, 10(2), 309-317.
38. Berraho, M., El Achhab, Y., Benslimane, A., Rhazi, K. E., Chikri, M., & Nejjari, C. (2012). Hypertension and type 2 diabetes: a cross-sectional study in Morocco (EPIDIAM Study). Pan African Medical Journal, 11(1).
39. Hashemizadeh, H., & Sarvelayati, D. (2013). Hypertension and type 2 diabetes: a cross-sectional study in hospitalized patients in Quchan, Iran. Iranian Journal of Diabetes and Obesity, 5(1), 21-26.
40. Abejew, A. A., Belay, A. Z., & Kerie, M. W. (2015). Diabetic complications among adult diabetic patients of a tertiary hospital in Northeast Ethiopia. Advances in Public Health, 2015.