DOI: 10.66069/ojspub.27451014

Analysis of Risk Factors: The Association Between Obesity and Diabetes

Sandhya Rani[1], Kattula Shyamala[2]

[1]Research Scholar, Department of Economics, Sir. M. V. P. G. Centre, Tubinakere, Mandya – 571 402
sandhya@gmail.com

[2]Professor, Department of Economics, Sir. M. V. P. G. Centre, Tubinakere, Mandya – 571 402
kattula30shy@gmail.com

Abstract: ***The prevalence of obesity and diabetes has emerged as a significant public health concern in world, with a strong correlation between these two conditions. As the world undergoes rapid urbanization and lifestyle changes, the incidence of obesity has markedly increased, particularly in urban areas. This increase in obesity rates has been accompanied by a concomitant increase in diabetes cases, predominantly type 2 diabetes. The study aims to analyze the relationship between obesity and type 2 diabetes, mainly concentrate on Body Mass Index (BMI) and to understand the difference in the severity of obesity between men and women in India. The research methodology likely involved a combination of descriptive statistics, correlation analysis, linear regression, and ANOVA to elucidate the differences in obesity prevalence. The findings of the study are expected to provide valuable insights into the obesity-diabetes relationship and gender-based differences in obesity, which can inform public health initiatives in India.***

Keywords: obesity, BMI, type 2 diabetes, risk factor, gender differences

1. Introduction

The prevalence of obesity and diabetes has emerged as a significant public health concern in world with a strong correlation between these two conditions. As the world undergoes rapid urbanization and lifestyle changes, the incidence of obesity has markedly increased, particularly in urban areas. This increase in obesity rates has been accompanied by a concomitant increase in diabetes cases, predominantly type 2 diabetes. Rapid urbanization and lifestyle changes are common in developing countries like India, which have led to an increase in obesity. Along with this, shifts in dietary patterns have also contributed to a significant increase in obesity rates. Research has demonstrated that obese individuals exhibit a higher propensity for developing insulin resistance, a critical factor in the pathogenesis of type 2 diabetes. The accumulation of visceral adipose tissue, a characteristic feature of obesity, contributes to chronic inflammation and metabolic dysregulation, further exacerbating the risk of diabetes. Moreover, genetic predisposition and dietary factors specific to the Indian population may amplify the obesity-diabetes relationship.

2. Review of Literature

The association between obesity and type 2 diabetes mellitus (T2DM) is a well-recognized global health concern (Ruze et al., 2023). Obesity is a major risk factor for T2DM, and the increasing prevalence of obesity worldwide has contributed significantly to the rise in T2DM cases (Ruze et al., 2023). This close relationship has even led to the term "diabesity" (Leitner et al., 2017). Both obesity and T2DM have reached pandemic levels, affecting people of all ages and in nearly all countries (Chandrasekaran & Weiskirchen, 2024; Ruze et al., 2023). Obesity is considered a significant risk factor for the development and progression of T2DM (Chandrasekaran & Weiskirchen, 2024). Obesity contributes to insulin resistance, pancreatic β cell dysfunction, and impaired fat metabolism, all of which are key factors in the development of T2DM (Feng, 2014; Pan et al., 2023; Sa, 2014).

The burden of diabetes in India is high and increasing, largely fueled by the rising prevalence of overweight/obesity and unhealthy lifestyles (Pradeepa & Mohan, 2021). the prevalence of overweight/obesity and hypertension was higher in the Southern region of India, while diabetes was more prevalent in both Southern and Western regions (Meshram et al., 2016). Contradictory to expectations, the risk of obesity and related diseases is increasing not only among higher socio-economic groups but also in lower income groups where undernutrition remains a concern (Mohan et al., 2016). In 2019, an estimated 77 million individuals had diabetes in India, expected to rise to over 134 million by 2045 (Pradeepa & Mohan, 2021).

2.1 Research Gap

In recent years, obesity and diabetes have emerged as significant public health concerns in India. Obesity is recognized as a risk factor for diabetes and numerous studies have demonstrated that obesity contributes to the rising incidence of diabetes. However, there is a paucity of research examining the association between type 2 diabetes and obesity within the Indian context. Therefore, this study endeavors to investigate the correlation between obesity and type 2 diabetes and to analyze the causal relationship between these two conditions. Additionally, this study aims to identify the differences in obesity prevalence between men and women in India through BMI measurement.

2.2 Methods and Source

This study analyzed the association between obesity and type 2 diabetes mellitus using WHO data on BMI $\leq$ 18.5 (underweight), BMI $\geq$ 25 (overweight), and BMI > 30 (obese) and diabetes mellitus cases among adults aged 18+ years. To achieve the research objectives, this study likely employed a

combination of descriptive statistics, correlation analysis, linear regression, Independent sample t test, and graphical visualization to elucidate the differences in obesity prevalence between males and females in India.

2.3 Objectives

1) To analyze the relationship between obesity and type 2 diabetes.
2) To understand the difference in the severity of obesity between women and men.

2.4 Hypotheses

1) Obesity prevalence and type 2 diabetes are strongly correlated.
2) There is no difference between men and women in the prevalence of obesity

2.5 Overweight and Obesity

Overweight and obesity are defined by an abnormal or excessive accumulation of fat that poses a health risk. A Body Mass Index (BMI) over 25 is classified as overweight, while a BMI exceeding 30 is considered obese. In 2019, it was estimated that 5 million deaths from non-communicable diseases (NCDs) were linked to a BMI above optimal levels. The prevalence of overweight and obesity continues to rise among both adults and children. From 1990 to 2022, the global percentage of children and adolescents aged 5–19 years with obesity increased fourfold, from 2% to 8%, while the percentage of adults aged 18 years and older with obesity more than doubled, from 7% to 16%. Obesity is one aspect of the double burden of malnutrition, and currently, more individuals are obese than underweight in all regions except the South-East Asia Region. Although once seen as an issue confined to high-income countries, some middle-income countries now exhibit among the highest prevalence rates of overweight and obesity worldwide (WHO).

3. Body Mass Index (BMI)

Body Mass Index (BMI) is a simple index of weight-for-height that is commonly used to classify underweight, overweight and obesity in adults. It is defined as the weight in kilograms divided by the square of the height in meters (kg/m^2). For example, an adult who weighs 70kg and whose height is 1.75m will have a BMI of 22.9. Body Mass Index is a calculation that uses your height and weight to estimate body fat and categorize weight status (Markowitz, 2018). It's a common tool for screening weight categories that may lead to health problems (Markowitz, 2018).

3.1 How to calculate BMI

BMI is calculated using the following formula:
$$BMI = \frac{weight (kg)}{height (m)^2}$$
BMI = 70 kg / $(1.75 m)^2$ = 70 / 3,0625 = 22.9

3.2 BMI Categories

Table 1: The International Classification of adult underweight, overweight and obesity according to BMI

Classification	BMI (kg/m)	
	Principal cut-off points	Additional cut-off points
Underweight	<18.50	<18.50
Severe thinness	<16.00	<16.00
Moderate thinness	16.00 - 16.99	16.00 - 16.99
Mild thinness	17.00 - 18.49	17.00 - 18.49
Normal	18.50	18.50 - 22.99
Range	24.99	23.00 - 24.99
Overweight	25.00	> 25.00
Pre-obese		25.00 - 27.49
	25.00 - 29.99	27.50 - 29.99
Obese	30.00	>30.00
Obese class I	34-99	30.00 - 32.49
	30.00	32.50 - 34.99
Obese class II	35.00 39.99	35.00 - 37.49
		37.50 - 39.99
Obese class III	>40.00	>40.00

Source: Adapted from WHO, 1995, WHO, 2000 and WHO 2004

BMI values are age-independent and the same for both sexes. However, BMI may not correspond to the same degree of fatness in different populations due, in part, to different body proportions. The health risks associated with increasing BMI are continuous and the interpretation of BMI grading in relation to risk may differ for different populations.

Table 2: WHO data on Obese 30 or higher in India

Underweight below 18.5 BMI				Overweight			Obese ≥ 30 BMI		
Year	Male	Female	Both	Male	Female	Both	Male	Female	Both
2010	23.9	25.2	24.5	15.8	20.7	18.2	2.5	4.9	3.7
2011	22.9	24.2	23.6	16.6	21.5	19	2.6	5.2	3.9
2012	22.0	23.3	22.6	17.5	22.4	19.9	2.8	5.5	4.1
2013	21.0	22.3	21.6	18.3	23.2	20.7	3.0	5.8	4.4
2014	20.0	21.4	20.7	19.2	24.1	21.6	3.2	6.1	4.6
2015	19.1	20.5	19.8	20.2	25.0	22.6	3.4	6.5	4.9
2016	18.2	19.6	18.9	21.2	26.0	23.5	3.6	6.9	5.2
2017	17.3	18.7	18.0	22.2	26.9	24.5	3.8	7.3	5.5
2018	16.5	17.8	17.1	23.2	27.8	25.5	4.1	7.7	5.8
2019	15.6	17.0	16.3	24.2	28.8	26.5	4.4	8.1	6.2
2020	14.8	16.2	15.4	25.3	29.7	27.5	4.6	8.5	6.5
2021	14.0	15.4	14.6	26.4	30.6	28.5	4.9	8.9	6.9

Obesity has been on the rise in India in recent times. World Health Organization survey data (Table 2) makes this clear, and it can be seen that this obesity problem is more prevalent among women than men.

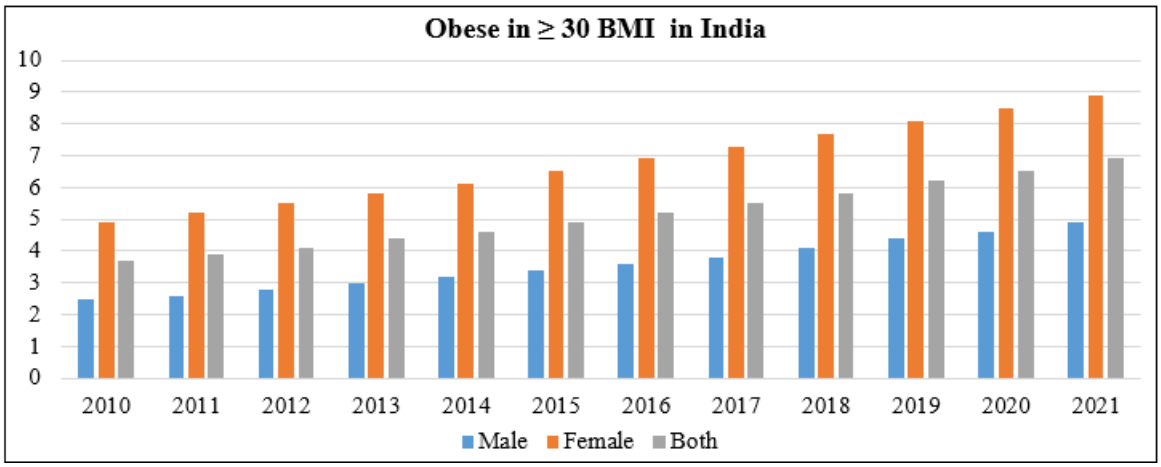


Figure 1: Obese in BMI ≥ 30

4. Type 2 Diabetes Mellitus (T2DM)

Type 2 diabetes is a long-term metabolic condition marked by high blood sugar levels, which occurs due to either the body's resistance to insulin or inadequate insulin production. Although it usually appears in adults, it is being increasingly identified in younger people. Factors that increase risk include being overweight, leading a sedentary lifestyle, having a family history of the disease, and belonging to certain ethnic groups. If not properly managed, type 2 diabetes can result in complications such as heart disease, kidney damage, and nerve issues. Management typically involves lifestyle changes such as adopting a healthier diet and increasing physical activity, along with medication or insulin therapy when needed. Consistent monitoring of blood sugar levels and continuous medical care are crucial for effectively controlling the condition and avoiding long-term health issues.

Diabetes is another health concern in India. India ranks second among the major countries with the highest prevalence of diabetes in the world, and the rise in type 2 diabetes is having a negative impact on India's economy and productivity. This has also led to an increase in the cost of living for the country's people, which has led to the need to identify the risk factors for diabetes. The prevalence of T2DM (type 2 diabetes mellitus) in India, as per the World Health Organization,

Table 3: Diabetes Mellitus 2 (T2DM)

Diabetes Mellitus 2 (%)			
Year	Male	Female	Both
2010	16.76	16.63	16.72
2011	16.98	16.87	16.95
2012	17.20	17.13	17.19
2013	17.44	17.44	17.46
2014	17.71	17.83	17.79
2015	18.04	18.33	18.20
2016	18.43	18.94	18.70
2017	18.86	19.61	19.25
2018	19.32	20.35	19.85
2019	19.81	21.14	20.48
2020	20.32	21.98	21.15
2021	20.85	22.85	21.85

Table 3 illustrates the temporal trends in the prevalence of type 2 diabetes mellitus in India. The data indicate a rapid increase in the incidence of type 2 diabetes mellitus within the country. Notably, the prevalence among women has recently surpassed that of men. The subsequent figures further demonstrate that the incidence of type 2 diabetes mellitus is rising more significantly among women compared to men.

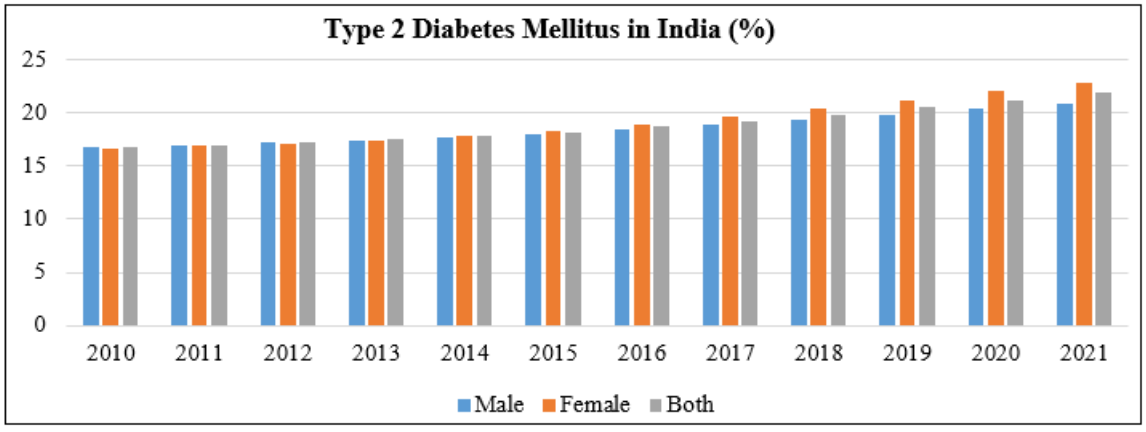


Figure 2: Diabetes Mellitus 2 (T2DM)

5. Results

5.1 Hypotheses Testing 1

Obesity prevalence and type 2 diabetes are strongly correlated.

H_0: There is no association between obesity and diabetes 2

To test the association between obesity and diabetes mellitus 2 in India correlation analysis is used. The results are presented in Table :2

Correlations					
		BMI > 30 (obese)	T2DM	BMI ≤ 18.5 (underweight)	BMI ≥ 25 (overweight)
BMI > 30 (obese)	Pearson Correlation	1	.995**	-.993**	.998**
	Sig. (2-tailed)		.000	.000	.000
	N	12	12	12	12
T2DM	Pearson Correlation	.995**	1	-.979**	.989**
	Sig. (2-tailed)	.000		.000	.000
	N	12	12	12	12
BMI ≤ 18.5 (underweight)	Pearson Correlation	-.993**	-.979**	1	-.998**
	Sig. (2-tailed)	.000	.000		.000
	N	12	12	12	12
BMI ≥ 25 (overweight)	Pearson Correlation	.998**	.989**	-.998**	1
	Sig. (2-tailed)	.000	.000	.000	
	N	12	12	12	12
**. Correlation is significant at the 0.01 level (2-tailed).					

In the above table, the correlation between obesity and diabetes is analyzed using Pearson's correlation coefficient. In this, the coefficients between obesity and overweight and diabetes are 0.995 and 0.998 respectively, indicating a direct relationship between them. Further, the correlation coefficient between underweight and diabetes is -0.99, indicating a negative relationship. Thus, the correlation is statistically significant at 0.01 (2-tailed) percent level. Thus the hypothesis-1 There is no association between obesity and diabetes is rejected. Hence, there is a strong association between obesity and diabetes 2.

5.2 Hypotheses 2

There is no difference between men and women in the prevalence of obesity

To show the difference between men and women in the prevalence of obesity Independent sample test used. The results are presented in Table :3

Independent Samples Test										
		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	T	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Obesity	Equal variances assumed	4.363	.049	-7.158	22	.000	-3.20833	.44822	-4.13789	-2.27878
	Equal variances not assumed			-7.158	18.014	.000	-3.20833	.44822	-4.14996	-2.26671

In the table above, an independent samples t-test was employed to examine the difference in obesity prevalence between men and women. The results of the t-test indicate t (22) = -7.158, p = 0.000, with a significance level of 0.05. Levene's test for equality of variances was not significant (p > 0.05). Consequently, we can conclude that there is a statistically significant difference in the prevalence of obesity between men and women. Therefore, the null hypothesis (Hypothesis 2), which posits no difference in obesity prevalence between men and women, is rejected. This confirms a statistically significant difference in obesity prevalence between the genders.

6. Findings

1) This study proves the strong correlation between diabetes and obesity, especially the fact that obesity is a contributing factor to the increase in type 2 diabetes.
2) The problem of obesity has been on the rise in recent years, and type 2 diabetes has also been on the rise.
3) This study shows that obesity is more common in women than in men, and that type 2 diabetes is also more common in women, which seems to prove that obesity is directly responsible for the increase in diabetes.

7. Suggestions

Based on the study, here are some key suggestions

1) Given the strong correlation between obesity and diabetes, efforts should be made to promote healthy lifestyles, including proper diet and regular exercise, to address the rising prevalence of both conditions.
2) Further research is needed to better understand the differences in obesity prevalence between men and women in the Indian context, in order to develop targeted interventions.

8. Conclusion

The study established a robust association between obesity and type 2 diabetes mellitus (T2DM) in India. The correlation analysis indicated a direct and statistically significant relationship between obesity, characterized by a body mass index (BMI) exceeding 30, and T2DM. Furthermore, the analysis uncovered a significant disparity in obesity prevalence between men and women in India, with a higher incidence observed among women. Targeted interventions that address both obesity and gender-based disparities can contribute to alleviating the escalating burden of these interrelated conditions. Further research is warranted to attain a more comprehensive understanding of the intricate relationship between obesity, diabetes, and other contributing factors.

References

[1] Expert Panel on the Identification, Evaluation, and Treatment of Overweight and Obesity in Adults (U.S.). Clinical Guidelines on the identification, evaluation, and treatment of overweight and obesity in adults—The evidence report. *Obes. Res.* **1998**, (Suppl. S2), 51S–209S.

[2] Hossain, P and et.el.(2007) Obesity and diabetes in the developing world—A growing challenge. *N. Engl. J. Med. 356*, 213–215.

[3] Deepa, M. et al. (2009) Prevalence and significance of generalized and central body obesity in an urban Asian Indian population in Chennai, India (CURES: 47). *Eur. J. Clin. Nutr.* 63(2), 259–267.

[4] Sharma, K. M. et al. (2011) Indian diabetes risk score helps to distinguish type 2 from Non-type 2 diabetes Mellitus (GDRC-3). *J. Diabetes Sci. Technol.* 5(2), 419–425

[5] Kearney J. (2010) Food consumption trends and drivers. *Philos Trans R Soc Lond B Biol Sci.*;365(1554):2793–2807.

[6] Rao Kondapally Seshasai S, Kaptoge S, Thompson A, et al. (2011) Diabetes mellitus, fasting glucose, and risk of cause-specific death. *N Engl J Med*.;364(9):829–841.

[7] Popkin BM, Adair .LS, Ng SW. (2012) Global nutrition transition and the pandemic of obesity in developing countries. *Nutr Rev*.;70(1):3–21.

[8] Viguiliouk E, Kendall CWC, Blanco Mejia S, et al. (2014) Effect of tree nuts on glycemic control in diabetes: a systematic review and meta-analysis of randomized controlled dietary trials. *PLoS One.*;9(7):e103376.

[9] Afshin A, Micha R, Khatibzadeh S, et al. (2015) The impact of dietary habits and metabolic risk factors on cardiovascular and diabetes mortality in countries of the Middle East and North Africa in 2010: a comparative risk assessment analysis. *BMJ Open*.;5(5):e006385.

[10] Pradeepa R, Anjana RM, Joshi SR, et al. (2015) Prevalence of generalized & abdominal obesity in urban & rural India – the ICMR-INDIAB Study (Phase-I) [ICMR-NDIAB-3] *Indian J Med Res.*;142(2):139–150.

[11] Ranjit Mohan Anjana and et.al (2015) "Incidence of Diabetes and Prediabetes and Predictors of Progression Among Asian Indians: 10-Year Follow-up of the Chennai Urban Rural Epidemiology Study (CURES)" *Diabetes Care* Volume 38,1441-1448.

[12] GBD 2016 DALYs and HALE Collaborators Global, regional, and national disability-adjusted life-years (DALYs) for 333 diseases and injuries and healthy life expectancy (HALE) for 195 countries and territories, 1990–2016: a systematic analysis for the Global Burden of Disease Study 2016. *Lancet.* 2017;390(10100):1260–1344.

[13] GBD 2016 Causes of Death Collaborators Global, regional, and national age-sex specific mortality for 264 causes of death, 1980–2016: a systematic analysis for the Global Burden of Disease Study 2016. *Lancet*. 2017;390(10100):1151–1210.

[14] Little, M. et al. (2016) Factors associated with BMI, underweight, overweight, and obesity among adults in a population of rural south India: A cross-sectional study. *BMC Obes*. 3(1), 12.

[15] Anjana RM, Deepa M, Pradeepa R, et al. (2017) Prevalence of diabetes and prediabetes in 15 states of India: results from the ICMR–INDIAB population-based cross-sectional study. *Lancet Diabetes Endocrinol*.;5(8):585–596.

[16] Duncan BB, Schmidt MI, Cousin E, et al. (2017) The burden of diabetes and hyperglycemia in Brazil-past and present: findings from the Global Burden of Disease Study 2015. *Diabetol Metab Syndr.*;9(1):18.

[17] Moradi-Lakeh M, Forouzanfar MH, El Bcheraoui C, et al. (2017) High fasting plasma glucose, diabetes, and its risk factors in the Eastern Mediterranean Region, 1990–2013: findings from the Global Burden of Disease Study 2013. *Diabetes Care*.;40(1):22–29

[18] Tripathy JP, Thakur JS, Jeet G, et al. (2017) Prevalence and risk factors of diabetes in a large community-based study in North India: results from a STEPS survey in Punjab, India. *Diabetol Metab Syndr.*;9(1):8.

[19] American Diabetes Association Professional Practice Committee (2021) 2. Classification and diagnosis of diabetes: Standards of medical care in diabetes (2022). *Diabetes Care*, *45* (Suppl. S1), S17–S38.

[20] Verma, M. et al. (2021) Epidemiology of overweight and obesity in Indian adults—A secondary data analysis of the National Family Health surveys. *Diabetes Metab. Syndr*. 15(4), 102166.

[21] Klein, S and et.el (2022) Why does obesity cause diabetes? *Cell Metab.*, *34*, 11–20

[22] Krishnan, A. et al. (2022) Estimates of major non-communicable disease risk factors for India, 2010 & 2015: A summary of evidence. *Indian J. Med. Res*. 156(1), 56–63.

[23] Pengpid, S. & Peltzer, K. (2022) Prevalence and associated factors of physical inactivity among middle-aged and older adults in India: Results of a national cross-sectional community survey. *BMJ Open* 12(8), e058156.

[24] Deepa, M. et al. (2023) Evaluation of Madras Diabetes Research Foundation-Indian Diabetes Risk score in detecting undiagnosed diabetes in the Indian population: Results from the Indian Council of Medical Research-INdia DIABetes population-based

study (INDIAB-15). *Indian J. Med. Res*. 157(4), 239–249

[25] Halder, P., Jeer, G. & Nongkynrih, B. (2023). Risk assessment of type 2 diabetes mellitus using Indian diabetes risk score among females aged 30 years and above in urban Delhi. *Indian J. Med. Sci.*

[26] Maiti, S. et al. (2023) Socioeconomic inequality in awareness, treatment and control of diabetes among adults in India: Evidence from National Family Health Survey of India (NFHS), 2019–2021. *Sci. Rep.* 13(1), 2971.

[27] Shri, N., Singh, S. & Singh, A. (2023) Prevalence and predictors of combined body Mass Index and Waist circumference among Indian adults. *Int. J. Public. Health* 68, 1605595.

[28] Chandrasekaran, K., & Weiskirchen, R. (2024) "The Role of Obesity in Type 2 Diabetes Mellitus-An Overview" *International Journal of Molecular Sciences,* 25, 1882 (1-25)

[29] https://www.who.int/news-room/fact-sheets/detail/diabetes