Volume 3, Issue 3, 2025

Frontier in Medical & Health Research

ISSN: (e) 3007-1607 (p) 3007-1593

THE PREVALENCE OF OVERWEIGHT AND OBESITY AMONG TYPE 2 DIABETIC FEMALES: A CROSS-SECTIONAL ANALYSIS OF DIETARY AND NUTRIENT INTAKE PATTERNS

Sidra Naheed[1], Dr. Fazia Ghaffar[*2], Hira Ayub[3], Ayesha Sayed[4]

[1,4]*Department of Food & Nutrition Sciences,*
[*2]*College of Home Economics*
[3]*University of Peshawar, Khyber Pakhtunkhwa, Pakistan*

[*2]faziaghaffar@uop.edu.pk

DOI: https://doi.org/10.5281/zenodo.17647615

Keywords
T2DM, Obesity, Macronutrients, Insulin resistance, Body Fats

Article History
Received on 03 April 2025
Accepted on 03 May 2025
Published on 12 May 2025

Corresponding Author: *

Abstract

Background: *Obesity, which is the most modifiable risk factor, is characterized by the accumulation of body fat, particularly visceral fat, due to unhealthy dietary patterns contributing to elevated blood glucose levels and insulin resistance in the type 2 diabetic population.* ***Objectives:*** *To assess the nutritional status and its association with anthropometry in type 2 diabetic patients among females.* ***Methods:*** *Based on written consent this study was performed at Lady Reading Hospital, Endocrinology department, Peshawar, Pakistan from December 2022 to March 2023. A sample of 96 female patients were selected randomly. A detailed demographic (age), anthropometric (weight, height, BMI, MUAC, body fat percentage through BIA) and 24-hr recall method was used to analyze the nutritional status.* ***Results:*** *The mean weight (73.24 ± 12.07), BMI (26.12 ± 5.43), MUAC (23.28 ± 2.82), and percent body fat (35.29 ± 2.17) were elevated beyond the reference range. The BMI was further classified, and a large no. of females lie in the overweight classification with 37.5%. The nutritional evaluation showed that the mean calories (2388.31 ± 328.25), carbohydrates (349.10 ± 34.67) and fats (80.42 ± 8.68) had high consumption while protein (45.30 ± 9.34) and all the micronutrients were low in daily food intake. The regression analysis shows that carbohydrates appear to be the most predictive macronutrient for body composition, but the observed effects are small and should be interpreted with caution.* ***Conclusion****: It is concluded that the daily diet among female type 2 diabetic patients was unhealthy and needs dietary modifications, which is the main cause of obesity and ultimately the risk factor for developing type 2 diabetes.*

INTRODUCTION

Obesity is a long-term condition influenced by various factors, characterized by an unhealthy accumulation of body fat that poses health risks. Numerous major medical diseases, including as cardiovascular disease, type 2 diabetes, and some types of cancer, are linked to it (WHO 2020). Over one billion individuals' worldwide 650 million adults, 340 million adolescents, and 39 million children, are affected by the alarmingly high prevalence of obesity. High-income countries are not the only ones affected by this epidemic; urbanization, dietary changes, and a decline in physical activity contribute to the sharp rise in obesity rates in low- and middle-income countries (WHO, 2023).

Frontier in Medical & Health Research

ISSN: (e) 3007-1607 (p) 3007-1593

Obesity, characterized by the excessive accumulation of body fat, is a significant public health concern because it is linked to a higher risk of type 2 diabetes mellitus, dyslipidemia, hypertension, and cardiovascular disease, with its prevalence rising globally. The distribution of body fat, as well as the total amount of body fat, is closely linked to metabolic issues. Central obesity, which manifests as an increase in visceral fat, plays a crucial role in the onset of insulin resistance and related metabolic complications. Moreover, fat mass in the trunk is inversely related to insulin sensitivity; however, fat mass in the legs positively affects glucose levels and is associated with a lower probability of diabetes and cardiovascular disease. A decrease in muscle mass, referred to as sarcopenia, is linked to physical and functional limitations as well as adverse metabolic effects; as a result, sarcopenia represents a significant global health concern. Furthermore, the distribution of muscle is connected to metabolic irregularities. (Kim, H. N., & Song, S. W. 2019)

In Pakistan, obesity is becoming a more serious public health issue as a result of sedentary lifestyles, urbanization, and poor eating habits. Approximately 27.9% of Pakistani adults are overweight, according to recent surveys, while 9.5% are obese. Non-communicable diseases like diabetes, hypertension, and cardiovascular disorders are becoming more common, especially in metropolitan areas, as a result of the rising burden of obesity (Ng, M., Fleming, T., 2014).

Obesity is one of the most important modifiable risk factors contributing to the onset of diabetes, particularly type 2 diabetes mellitus (T2DM). The accumulation of excess body fat, especially around the abdomen, leads to insulin resistance, a condition where cells become less responsive to insulin, resulting in elevated blood sugar levels. As noted by Kahn et al. (2006), insulin resistance can ultimately strain the pancreas, causing it to produce insufficient insulin, which may lead to the development of type 2 diabetes. (Kahn,S., 2006).

The incidence of type 2 diabetes mellitus (T2DM) has been closely associated with the rising prevalence of obesity. Insulin resistance, a major contributing factor to the development of type 2 diabetes, is exacerbated by obesity. Overeating, especially visceral fat, causes the release of free fatty acids and pro-inflammatory cytokines that disrupt insulin signaling pathways. This disturbance leads to decreased cell absorption of glucose and increased blood glucose levels, which are hallmarks of type 2 diabetes (T2DM) (Zheng et al., 2018).

Chronic inflammation associated with obesity may disrupt vitamin D metabolism and function because inflammatory cytokines can inhibit vitamin D activation and downregulate vitamin D receptors, which are critical for the biological effects of vitamin D (Sibley,S.D. 2012). Vitamin D, obesity, and type 2 diabetes have a complicated and reciprocal interaction. Through processes including increased vitamin D storage in adipose tissue, obesity can cause vitamin D insufficiency, and low vitamin D levels can make metabolic disorders associated with obesity worse. Moreover, vitamin D insufficiency has been linked to β-cell malfunction and insulin resistance, which both contribute to the development of type 2 diabetes. On the other hand, sufficient vitamin D levels may enhance glucose metabolism and insulin sensitivity, which could lessen the negative impact of obesity on the risk of diabetes (Harahap et al., 2022).

2. METHDOLOGY:

2.1 Sampling:

This research explored the potential dietary and non-dietary risk factors associated with patients suffering from type II diabetes in Khyber Pakhtunkhwa, Pakistan, regardless of their metabolic syndrome status. After obtaining written consent, a random selection of 96 patients was made, and their nutritional health was assessed using the ABCD method. The study took place from December 2022 to March 2023 in the Endocrinology Ward of Lady Reading Hospital (LRH) in Peshawar. Ethical approval for the study was granted by the ASRB committee.

2.2 Mode of Data Collection

A self-constructed questionnaire, in conjunction with a standardized semi-quantitative Food Frequency Questionnaire (FFQ), was crafted to collect the required data.

2.3 Anthropometric measurement

2.3.1 Age

The ages of all the respondents were taken in years.

Frontier in Medical & Health Research

ISSN: (e) 3007-1607 (p) 3007-1593

2.3.2 Height

The height was measured by the height board or measuring scales. The respondent stood straight against the height board touching their heels near to the board. Height was measured without shoes and cap/ scarf.

2.3.3 Weight

The weight of all the respondents were taken in kilograms through a weight machine. The respondents were asked to remove any heavy materials from their pockets or remove any heavy item of clothing or apparel. The scale was put on a hard, even surface, no carpeting. Respondents were asked to stand still barefooted, with weight distributed evenly on both feet.

2.3.4 BMI

It is pronounced as Body Mass Index. BMI was calculated through weight and height. The formula used for BMI was:

BMI= Weight in kg/ (Height in m) ^{2}

The World Health Organization (WHO) classifies BMI in the following ways:

- BMI below 18.5 indicates that an individual is underweight.
- BMI ranging from 18.5 to 24.9 signifies that a person has a "normal" or healthy weight.
- BMI between 25 and 29.9 shows that an individual is overweight.
- BMI over 30 means that a person is classified as having obesity.

2.3.5 MUAC

It is referred to as Mid Upper Arm Circumference and was established using adult MUAC tape to measure the mid upper arm of all participants.

2.3.6 Body Fat Percentage

The body fat percentage was calculated through the biochemical impedance analyzer. The respondents were asked to remove any heavy metals from pockets. They were directed to stand straight and hold the liver with hands straight forward making a 90 angle.

2.3.7 Dietary Assessment

The dietary evaluation involved a detailed analysis of a person's food consumption over the past 24 hours; participants were requested to provide information about what they had eaten in the previous day to assess their nutrient intake. Later on, WinDiets Software 2005 was used for analysis of nutrients.

2.3.8 Statistical Analysis:

Data were analyzed by using latest Statistical Package for Social Sciences (SPSS) version 20 for entering and analysis of collected data. Descriptive statistic was used to determine frequencies, mean and standard deviation for different variables. For comparison of means one-way ANOVA, Regression was used to find out the relationship between variables.

3. Results:

3.1 Age Wise Distribution of the Sample

The age-wise distribution of Type II Daibaetic patients is given in Table 3.1. The data showed that 29.1 % of patients fell into age group of 25-35 years. About 24.9% of patients fell into age group of 36-45 years, 24.9% of patients fell into age group of 46-55 years and 20.6% of female fell into the age group of 56-60 years. It is concluded from the present study that type II diabetes mostly affect people in the middle years.

Table 1: Age-wise Distribution of the Sample

Age	No. of Patients	Percentage (%)
25-35	28	29.1
36-45	24	24.9
46-55	24	24.9
56-60	20	20.6
Total	96	99.5

Frontier in Medical & Health Research

ISSN: (e) 3007-1607 (p) 3007-1593

3.2 Anthropometric Measurements

Table 3.2 shows the anthropometric measurements of female type II diabetic patients. Female respondents had a mean weight of (73.24 ± 12.07) kg, with a range of (47-100) kg. The P-value was (0.854), indicating no statistical significance. The average height was (163.42 ± 3.83) cm, with a range of (151-169) cm and a P-value of (0.497), indicating no significance. The average BMI was 26.12 ± 5.43 kg/m², with a range of 19-40 kg/m² and a P-value of (0.0005), indicating a statistically significant difference. The average MUAC was (23.28 ± 2.82) cm, with a range of (15-35.5) cm and a P-value of (0.016), which was significant. The body fat percentage was 35.29 ± 2.17%, ranging between 29-43%, with a P-value of (0.938), indicating no significance.

According to Nyamdorj, R. 2008, the four indicators of obesity (BMI, waist circumference, waist to hip ratio and waist to statue ratio) were checked for association with diabetes and hypertension. They found a positive correlation among these factors and concluded that they were strongly positively correlated with diabetes among Asian female population. Multiple lifestyle factors are also of great importance in the development of T2DM, they include sedentary lifestyle, physical inactivity, smoking and alcohol consumption

Table 2: Anthropometric Measurements of Females

Parameters	Female		P Value	Reference Values
	Range Min – Max	Mean ± SD (P value)		
Weight	47 – 100	73.24 ± 12.07	0.854	Female = 55 - 59
Height	151 – 169	163.42 ± 3.83	0.497	Female =162.56 – 167.64
BMI	19 – 40	26.12 ± 5.43	0.0005	Female = 18.5 – 24.5
MUAC	15 – 35.5	23.28 ± 2.82	0.016	Female = >22 cm
Percent Body Fat	29 – 43	35.29 ± 2.17	0.938	Female =23% - 33%

3.3 Classification of the Sample Based on BMI

The BMI distribution table shows that the majority fall into overweight or obese categories, with only 10.3% having a normal BMI. Overweight individuals make up the largest group at 37.5%, followed by those in Obesity Class 1 (22.9%), Class 2 (11.5%), and Class 3 (6.3%). This indicates that nearly 78% of the female patients are above a healthy weight, underscoring the strong association between higher body mass and the development of Type 2 diabetes. Excess weight, particularly obesity, is a major risk factor for insulin resistance, which plays a key role in the onset and progression of the disease.

According to Yong W obesity has become a major public health problem worldwide. It is not only a major risk factor for many common diseases like type 2 diabetes, hypertension, vascular diseases, but also leads directly or indirectly to an increase in health care resources. Compared with lean counterparts, obese women show reduced amplitude, higher circulating levels of insulin, poor oocyte quality, higher miscarriage rates and offspring who are more likely to be sick.

Table 3: Classification of the sample Based on BMI

BMI Category	No	%
Normal	21	10.3
Overweight	36	37.5
Obesity class 1	22	22.9

Frontier in Medical & Health Research

ISSN: (e) 3007-1607 (p) 3007-1593

Obesity Class 2	11	11.5
Obesity Class 3	6	6.3

3.4 Macronutrient intake of the Sample

Nutrition evaluation of the dietary intakes of the female respondents is presented in Table. Among the macro-nutrients, the major source of energy was fats with a mean and SD (80.42 ± 8.68) the RDA of fat is (45 - 75 g/ day) and the mean consumption lies above the maximum value of recommended range. The intake of saturated fatty acids was (19.29 ± 5.66), that lies also above the RDA (<15 g/day). The intake of polyunsaturated and monounsaturated fatty acids were (17.06 ± 4.41) and (21.89 ± 9.99) that lies under the RDA. As the female respondents have high intake of fats and saturated fatty acids which are the causes for heart disease and stroke, but they have normal values for lipid profile as recorded due to antihyperlipidemic medications prescribed by the endocrinologist. Protein consumption was recorded with mean (45.30 ± 9.34) which shows that mean consumption is lower than the RDA (50 – 60 g/day). The third macro-nutrient is carbohydrate which was recorded with the mean consumption of (349.10 ± 34.67) and this value is larger than recommended intake of carbohydrates (225 – 325 g/day). Furthermore consumption of sugar was recorded with mean (15.48 ± 5.94) that is lower than the RDA (25 g/day), and starch mean (146.72 ± 33.54) that exceeds the RDA (130 g/ day). Consumption of water was recorded with mean (761.35 ± 211.84) that is lower than the RDA (2160 g/ day), and recorded cholesterol mean was (244.09 ± 27.06) that exceeds the RDA (200 mg/ day). In the end the mean of total calories obtained from the consumption of macro-nutrient by T2DM female respondents were (2388.31 ± 328.25) and this value exceeds the recommended calories intake of 2200 kcal/ day. Hence it is concluded after the macronutrient analysis that the female respondents were not taking the proper diet, and mostly their dietary nutrients like carbohydrates, starch and cholesterol exceed the RDA and the total calories consumption was too high that were the main cause for elevated HbA1C, FBG and RBG levels.

According to epidemiological research, dietary factors may either raise or lower the risk of diabetes. The Finnish Diabetes Prevention Study (DPS) recommended raising the diet's fiber density and lowering consumption of both total and saturated fat. Reducing overall fat and calorie intake was one of the dietary aims of the Diabetes Prevention Program (DPP). The incidence of diabetes was also significantly reduced in a diet rich in vegetables, fruit, legumes, nuts, fish, and extra virgin olive oil, which is characteristic of the Mediterranean diet.

Table 4: Macronutrient Intake of the Patients

Nutrients	Interquartile Range	Mean ± SD	P-Value (age)	RDA/ day
Calories	1715 – 3001	2388.31 ± 328.25	0.285	2200 kcal/ day
Carbohydrate	273.40 – 398.50	349.10 ± 34.67	0.476	225 – 325 g/ day
Protein	20.40 – 55.50	45.30 ± 9.34	0.212	50 – 60 g/ day
Fats	56.40 – 98.70	80.42 ± 8.68	0.382	45 - 75 g/ day
Saturated Fatty acids	10.00 - 29.90	19.29 ± 5.66	0.716	<15 g/ day
Polyunsaturated Fatty acids	10.00 - 32.70	17.06 ± 4.41	0.711	<22 g/ day
Monounsaturated Fatty acids	10.10 - 46.78	21.89 ± 9.99	0.225	<44 g/ day
Sugar	4.50 - 29.10	15.48 ± 5.94	0.364	25 g/ day
Starch	88.00 - 193.00	146.72 ± 33.54	0.316	130 g/ day
Water	382.20 - 1330.30	761.35 ± 211.84	0.981	2160 g/ day
Cholesterol	209 - 299	244.09 ± 27.06	0.047	200 mg/ day

Frontier in Medical & Health Research

ISSN: (e) 3007-1607 (p) 3007-1593

Table 5: Micronutrient's Intake of the Sample

Nutrients	Inter quartile Range	Mean ± SD	P- value (Age)	RDA/ day
Mineral intake of female respondents				
Calcium (Ca)	638 - 1395	970.50 ± 216.06	0.730	1200 mg/ day
Sodium (Na)	1004 - 1999	1543.38 ± 319.13	0.393	1900 mg/ day
Iron (Fe)	10.00 – 18.50	16.93 ± 1.99	0.967	18 mg/ day
Zinc (Zn)	8.50 – 15.80	11.10 ± 0.95	0.198	11 mg/ day
Copper (Cu)	0.69- 0.99	0.89 ± 0.05	0.910	0.9 mg/ day
Potassium (K)	2024 - 2616	2387.47 ± 141.52	0.266	2600 mg/day
Magnesium (Mg)	217 - 324	282.54 ± 30.61	0.255	310 – 320 mg/day
Fat soluble vitamins				
Nutrients	**Inter quartile Range**	**Mean ± SD**	**P- value (Age)**	**RDA/ day**
Vitamin A	459 - 718	633.86 ± 70.12	0.118	700 µg/ day
Retinol	522.- 768.00	629.44 ± 48.32	0.808	700 µg/ day
Vitamin D **(Age: 25 – 49)**	0.55 – 2.90	1.31 ± 0.44	0.068	2.5 µg/ day
Vitamin D **(Age: 50+)**	2.58 – 4.16	3.51 – 0.37	0.079	5 µg/ day
Vitamin E	3.54 - 17.17	10.08 ± 3.47	0.890	15 mg/ day

Data indicates the minerals intake of the female respondents. The average calcium consumption was 970.50 ± 216.06, which is lower than the required quantity of 1200 mg per day. The average sodium level was 1543.38 ± 319.13, which is lower than the recommended daily allowance of 1900 mg. The average iron intake was 16.93 ± 1.99 mg/day, which is less than the recommended daily intake of 18. Zinc consumption averaged 11.10 ± 0.95 mg/day, meeting the recommended daily intake of 11 mg. The average copper consumption (00.89 ± 0.05) was nearly equal to the recommended daily intake (0.9 mg). The average potassium consumption was (2387.47 ± 141.52) lower than the RDA (2600 mg/day). Magnesium was the last mineral and its mean consumption was recorded (282.54 ± 30.61) which is lower than the RDA (310 – 320 mg/day). Mineral intake of the respondent was compared with the age of the study sample in order to obtain P-values. As we know that P-value <0.05 is consider to be statistically significant, so the results of P-value(s) shows that there is no significance between any mineral(s) intake and the differences of age.

The average consumption of vitamin A was 633.86 ± 70.12, which is lower than the recommended daily intake of 700 µg. The average consumption of retinol (629.44 ± 48.32) was lower than the recommended daily allowance of 700 µg. Female respondents aged 24–49 had a vitamin D intake of (1.31 ± 0.44), which is lower than the RDA (2.5 µg/day), while the mean for those aged 50+ was (3.51 - 0.37), which is lower than the RDA (5 µg/day). Vitamin E is the last fat-soluble vitamin, with a mean of 10.08 ± 3.47, which is less than the recommended daily intake of 15 mg. Overall, female T2DM respondents were low in fat-soluble vitamins. Fat soluble vitamins intake of the female respondents were compared with the age by applying one-way ANOVA test and the results are presented in the column P-value. If we go through these data, we can see that none of the vitamin showed any significance towards comparison with age between the group and within the group

Frontier in Medical & Health Research

ISSN: (e) 3007-1607 (p) 3007-1593

As vitamin A and retinol have importance for vision, immune functions, skin and in the regulation of cell growth. For vitamin D specifically, reduced exposure to sunlight, common in individuals with limited outdoor activity or who live in areas with limited sunlight, could contribute to deficiency. These deficiencies might due to poor dietary habits, malabsorption or metabolic issues. Vitamins A, D, E, and K are soluble in organic solvents and are used to cure deficiencies in certain cases. Even in health circles, the average intake of fat-soluble vitamins, such as vitamin A, D, E, and K, is insufficient and, at worst, dangerously low. Human bodies are not able to generate vitamins. They help the body use food by causing metabolic events that allow life to continue, and they must be consumed with food or as supplements.

6.3: Regression Statistics of Dietary macro nutrients as predictors of anthropometric measurements of the sample

Table 6: Predictability of Macronutrients for Obesity among the Patients

Coefficients						
Parameters		**Unstandardized Coefficients**		**Standardized Coefficients**	**t**	**Sig.**
		B	Std. Error	Beta		
Energy						
1.	Weight	1.937	3.451	.067	.561	.007
2.	BMI	3.188	10.042	.052	.317	.052
3.	MUAC	-28.593	17.867	-.246	-1.600	.013
4.	Body fat percentage	35.115	18.695	.233	1.878	.064
Carbohydrate						
1.	Weight	.324	.355	.106	.913	.000
2.	BMI	-1.199	1.032	-.186	-1.162	.000
3.	MUAC	-2.223	1.836	-.181	-1.211	.000
4.	Body fat percentage	5.460	1.921	.343	2.842	.000
Fats						
1.	Weight	.060	.093	.079	.645	.000
2.	BMI	-.086	.271	-.053	-.319	.000
3.	MUAC	-.300	.481	-.097	-.624	.000
4.	Body fat percentage	.645	.504	.162	1.280	.000
Proteins						
1.	Weight	-.101	.100	-.123	-1.009	.000
2.	BMI	-.171	.291	-.099	-.588	.023
3.	MUAC	.077	.518	.023	.148	.083
4.	Body fat percentage	.432	.542	.101	.796	.004

The regression analysis examines at how dietary macronutrients (energy, carbohydrates, fats, and proteins) influence anthropometric parameters like weight, BMI, mid-upper arm circumference (MUAC), and body fat %. Carbohydrate intake has the strongest and most persistent relationships with body fat percentage (unstandardized B = 5.460, standardized Beta = 0.343, *p* < 0.001), indicating that more carbohydrate consumption leads to increased body fat. Significant but smaller associations are also reported between carbohydrate intake and weight, BMI, and MUAC. Energy intake had a substantial and negative relationship with MUAC (Beta = -0.246, *p* = 0.013), an unexpected finding that may necessitate further investigation for confounding variables. One significant concern is the contradiction between some t-values and p-values, such as low t-values paired with highly significant p-values, which is

Frontier in Medical & Health Research

ISSN: (e) 3007-1607 (p) 3007-1593

statistically improbable and may reveal data reporting issues. Overall, carbohydrates appear to be the most predictive macronutrient for body composition, but the observed effects are small and should be interpreted with caution.

Conclusion: The current study concludes on the high prevalence of obesity and overweight among type 2 diabetic female patients of Pathan ethnicity in Khyber Pakhtunkhwa. Differences in BMI were found to be statistically significant according to age, education level, and BMI categories. The study emphasizes the need of patient education programs, public health awareness, and training for primary care physicians on the management of overweight and obesity for the prevention of further complications. Further research is needed to understand the pathophysiological and epidemiological factors of obesity among type 2 diabetic patients and their health implications.

REFERENCES

World Health Organization. (2020). News-room fact-sheets detail obesity and overweight. *Online, URL: https://www. who. int/newsroom/fact-sheets/detail/obesity-and-overweight*.

WHO, O. (2023). overweight, Available online: https://www. who. int/en/news-room/fact-sheets/detail/obesity-and-overweight.

Kahn, S. E., Hull, R. L., & Utzschneider, K. M. (2006). Mechanisms linking obesity to insulin resistance and type 2 diabetes. *Nature*, *444*(7121), 840-846.

Zheng, Y., Ley, S. H., & Hu, F. B. (2018). Global aetiology and epidemiology of type 2 diabetes mellitus and its complications. *Nature reviews endocrinology*, *14*(2), 88-98.

Earthman, C. P., Beckman, L. M., Masodkar, K., & Sibley, S. D. (2012). The link between obesity and low circulating 25-hydroxyvitamin D concentrations: considerations and implications. *International journal of obesity*, *36*(3), 387-396.

Harahap, I. A., Landrier, J. F., & Suliburska, J. (2022). Interrelationship between vitamin D and calcium in obesity and its comorbid conditions. *Nutrients*, *14*(15), 3187.

Ng, M., Fleming, T., Robinson, M., Thomson, B., Graetz, N., Margono, C., ... & Gakidou, E. (2014). Global, regional, and national prevalence of overweight and obesity in children and adults during 1980–2013: a systematic analysis for the Global Burden of Disease Study 2013. *The lancet*, *384*(9945), 766-781.

Kim, H. N., & Song, S. W. (2019). Association between carbohydrate intake and body composition: the Korean National Health and Nutrition Examination Survey. *Nutrition*, *61*, 187-193.

Nyamdorj R, Qiao Q, Söderberg S, Pitkäniemi J, Zimmet P, Shaw J, Alberti G, Nan H, Uusitalo U, Pauvaday V, Chitson P. Comparison of body mass index with waist circumference, waist-to-hip ratio, and waist-to-stature ratio as a predictor of hypertension incidence in Mauritius. Journal of hypertension. 2008 May 1;26(5):866-70.

Yong W, Wang J, Leng Y, Li L, Wang H. Role of obesity in female reproduction. International Journal of Medical Sciences. 2023 Jan 31;20(3):366.

Wu Y, Ding Y, Tanaka Y, Zhang W. Risk factors contributing to type 2 diabetes and recent advances in the treatment and prevention. International journal of medical sciences. 2014 Sep 6;11(11):1185.

Ravisankar P, Reddy AA, Nagalakshmi B, Koushik OS, Kumar BV, Anvith PS. The comprehensive review on fat soluble vitamins. IOSR Journal of Pharmacy. 2015 Nov;5(11):12-28.