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Prevalence of overweight and obesity and its risk factors in adults Type 1 Diabetic patients among Saudi general population

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ABSTRACT

Background: Diabetes mellitus, a prevalent endocrine disorder worldwide, has seen an increasing global incidence in recent years, establishing it as a significant public health issue. Notably, individuals with Type 1 Diabetes often have a higher Body Mass Index (BMI) compared to the general population. *Objective:* The study aims to evaluate the prevalence and risk factors of overweight and obesity in adults with Type 1 Diabetes in Saudi Arabia. *Methods:* A descriptive, cross-sectional web-based study was conducted, collecting data through an online questionnaire. This tool, designed based on literature reviews and expert consultations, gathered information on demographics, medical history, BMI, diabetes details, dietary habits and lifestyle. *Results:* Out of 250 type 1 diabetic patients aged between 18 and 45 years (mean age 26.0 ± 11.8 years) who completed the survey, 187 (74.8%) were females. The study found that 29.2% were overweight and 19.6% were obese. Overweight/obesity was observed in 66.7% of smokers and the same percentage of those who exercised at the gym. Moreover, overweight and obesity rates were significantly higher among patients who did not adhere to a high-fiber diet compared to those who did (66.7% vs. 46.4%, respectively; P=.049). *Conclusion:* The study highlighted that nearly half of the patients with diabetes were overweight or obese. Factors such as age, smoking and unhealthy diet correlated significantly with the obesity rate among individuals with Type 1 Diabetes.

Keywords: Obesity, Overweight, Type 1 Diabetes Mellitus, Prevalence, Risk Factors, Diabetes Management, Saudi Arabia.

1. INTRODUCTION

Diabetes mellitus is a pervasive endocrine disorder globally. Over recent years, the disease's incidence has escalated, positioning diabetes as a considerable public health challenge (Lin et al., 2020; Harding et al., 2019).

The World Health Organization (WHO) indicates that more than 170 million people globally are diagnosed with diabetes, with projections expecting this figure to rise to 370 million by 2030 (Al-Lawati, 2017).

Diabetes, hypertension and obesity have been recently ranked by the WHO as the top three ongoing risk factors contributing to worldwide cardiovascular mortality. Notably, Saudi Arabia ranks second in the Middle East and seventh globally in terms of diabetes prevalence. Around 7 million individuals in the country are diabetic, with an additional 3 million categorized as pre-diabetic. Remarkably, the incidence of diabetes in Saudi Arabia has surged tenfold over the past three years (Al-Dawish et al., 2016).

The prevalence of obesity has been rising noticeably worldwide, affecting both developed and developing nations. Changes in dietary habits and activity levels primarily drive this trend (Arroyo-Johnson and Mincey, 2016; Chooi et al., 2019; Gallus et al., 2015; Alrashid et al., 2022). Obesity, a global epidemic, contributes to numerous chronic diseases, adversely affecting patients' quality of life and causing early mortality (Alrasheed et al., 2021; Vassilopoulou et al., 2017; Aronne, 2002; Fontaine and Barofsky, 2001). Research indicates that obesity is prevalent among 60-90% of all diabetic patients, especially those with type 2 diabetes (Halpern and Mancini, 2005; Stumvoll et al., 2005).

The substantial rise in overweight and obesity rates affects patients with Type 1 Diabetes (T1D), making them particularly susceptible to excess weight. Increased Body Mass Index (BMI) in T1D patients is linked with higher cardiometabolic risk and rapid chronic complication progression compared to their lean counterparts (Corbin et al., 2018). Obesity-induced insulin resistance leads to high insulin requirements, complicating glycemic control and weight management. A sedentary lifestyle and evolving food habits could be the principal reasons for the escalating incidence of obesity and diabetes in both urban and rural areas of Saudi Arabia (Al-Nuaim et al., 2012; De-Nicola et al., 2015). This study aims to evaluate the prevalence of overweight and obesity and its associated risk factors among adults with Type 1 Diabetes in Saudi Arabia.

2. METHODOLOGY

A descriptive cross-sectional study was conducted to assess overweight and obesity among type 1 diabetic patients in Saudi Arabia. The study included all patients who were 18 years or older, residing in Saudi Arabia and diagnosed with Type 1 Diabetes mellitus for at least six months. The study excluded individuals who declined consent, were younger than 18 years, diagnosed with type 2 Diabetes or spoke a language other than Arabic. We developed an online questionnaire following an intensive literature review and consultation with experts. A panel of three experts independently evaluated the questionnaire's validity, clarity and applicability, with all suggested modifications applied until the final version was established.

The questionnaire was published on social media platforms from November 5th, 2022, to March 15th, 2023. Participants were encouraged to participate by emphasizing data confidentiality and the study's significance to the community. The questionnaire collected participant demographic data (age, gender, medical history, diabetes data, body mass index and habits). The second part assessed participants' obesity risk factors, including personal exercise and dietary habits. The final section addressed the effect of patients' weight on their daily life activities and diabetes complications. The researchers and their friends and relatives shared the questionnaire online until no new responses were received.

Ethical Consideration

Prior to the study's commencement, we obtained approval from the Aseer Institutional Review Board (IRB), with the assigned approval log number of REC-17-06-2022.

Data Analysis

We collected and reviewed data, which was then inputted into the Statistical Package for Social Sciences version 21 (SPSS: An IBM Company). All statistical methods used were two-tailed with an alpha level of 0.05, considering significance if P value was less than or equal to 0.05. Descriptive analysis was done by prescribing frequency distribution and percentage for study variables, including patients' personal data, diabetes data, lifestyle and various obesity risk factors. The overall prevalence of overweight and obesity among diabetic patients were graphed. Cross tabulation showed the distribution of patient's body mass index by different demographic factors, diabetes data and other risk factors for obesity, as well as the effect of their body weight. We conducted the Pearson chi-square test for significance and the exact probability test for small frequency distributions.

3. RESULTS

A total of 250 type 1 diabetic patients completed the study survey. Patients' ages ranged from 18 to 45 years, with a mean age of 26.0 ± 11.8 years. Of these, 187 (74.8%) were females and 227 (90.8%) were Saudi nationals. A total of 214 (85.6%) resided in urban areas,

and 196 (78.4%) were single. Regarding educational level, 139 (55.6%) were university graduates. A total of 122 (48.8%) were students and 53 (21.2%) were employed. A monthly income of less than 5000 SR was reported by 157 (62.8%) respondents and 215 (86%) lived with their families. In terms of obesity and overweight among type 1 diabetic patients, a total of 73 (29.2%) were overweight and 49 (19.6%) were obese (Table 1).

Table 1 Distribution of Type 1 Diabetic patients' obesity by their socio-demographic data

Socio-demographic data	Total		Body mass index						p-value
			Normal weight		Overweight		Obese		
	No	%	No	%	No	%	No	%	
Age in years									
< 20	76	30.4%	42	55.3%	23	30.3%	11	14.5%	.001*
20-29	113	45.2%	71	62.8%	32	28.3%	10	8.8%	
30+	61	24.4%	15	24.6%	18	29.5%	28	45.9%	
Gender									
Male	63	25.2%	27	42.9%	21	33.3%	15	23.8%	.301
Female	187	74.8%	101	54.0%	52	27.8%	34	18.2%	
Nationality									
Saudi	227	90.8%	115	50.7%	68	30.0%	44	19.4%	.711
Non-Saudi	23	9.2%	13	56.5%	5	21.7%	5	21.7%	
Residence area									
Urban	214	85.6%	106	49.5%	62	29.0%	46	21.5%	.169
Rural	36	14.4%	22	61.1%	11	30.6%	3	8.3%	
Marital status									
Single	196	78.4%	114	58.2%	51	26.0%	31	15.8%	.001*$
Married	49	19.6%	14	28.6%	19	38.8%	16	32.7%	
Divorced/widow	5	2.0%	0	0.0%	3	60.0%	2	40.0%	
Educational level									
Below university	101	40.4%	53	52.5%	28	27.7%	20	19.8%	.542
University	139	55.6%	71	51.1%	43	30.9%	25	18.0%	
Post-graduate	10	4.0%	4	40.0%	2	20.0%	4	40.0%	
Employment									
Unemployed	75	30.0%	33	44.0%	17	22.7%	25	33.3%	.001*
Student	122	48.8%	73	59.8%	38	31.1%	11	9.0%	
Employed	53	21.2%	22	41.5%	18	34.0%	13	24.5%	
Monthly income									
< 5000 SR	157	62.8%	86	54.8%	50	31.8%	21	13.4%	.001*
5000-10000 SR	56	22.4%	34	60.7%	9	16.1%	13	23.2%	
> 10000 SR	37	14.8%	8	21.6%	14	37.8%	15	40.5%	
Living with									
With partner	23	9.2%	6	26.1%	13	56.5%	4	17.4%	.001*$
With family	215	86.0%	116	54.0%	60	27.9%	39	18.1%	
Alone	12	4.8%	6	50.0%	0	0.0%	6	50.0%	

P: Pearson X^2 test *$: Exact probability test* ** P < 0.05 (significant)*

Table 2 presents the distribution of obesity among Type 1 diabetic patients based on their clinical data. Patients aged more than 30 years, 75.4% were overweight/obese, compared to 44.7% of those aged less than 20 years, showing statistical significance (P=.001). All divorced/widowed patients were overweight or obese, compared to 41.8% of single patients (P=.001). Similarly, 58.5%

of employed patients were overweight or obese, compared to 40.2% of students (P=.001). Of high-income patients, 78.4% were obese, versus 45.2% of those with low income (P=.001).

Overweight and obesity were significantly higher among patients living with a partner (73.9%) compared to those living alone (50%) (P=.001). Overweight/obesity was detected in 66.7% of patients on OHDs/combined with insulin, versus 46.4% of those on insulin only (P=.001). Furthermore, 80% of patients who never assess their blood glucose level were obese, versus 43.5% who did regularly (P=.020). Also, 60.4% of patients with diabetic complications were obese, versus 45.7% of those without (P=.049). Overweight/obesity was detected in 58.1% of patients with other co-morbidities, versus 44.9% of others (P=.004).

Table 2 Distribution of Type 1 Diabetic patients' obesity by their diabetes clinical data

Diabetes data	Total		Body mass index						p-value
			Normal weight		Overweight		Obese		
	No	%	No	%	No	%	No	%	
Duration of DM									
< 5 years	71	28.4%	40	56.3%	20	28.2%	11	15.5%	.612
5-10 years	59	23.6%	32	54.2%	17	28.8%	10	16.9%	
> 10 years	120	48.0%	56	46.7%	36	30.0%	28	23.3%	
Treatment received									
OHDs	12	4.8%	4	33.3%	1	8.3%	7	58.3%	.001*$
Insulin injection	220	88.0%	118	53.6%	69	31.4%	33	15.0%	
Both of them	18	7.2%	6	33.3%	3	16.7%	9	50.0%	
Blood glucose level assessment									
No assessed at all	10	4.0%	2	20.0%	5	50.0%	3	30.0%	.020*
Irregularly	79	31.6%	35	44.3%	21	26.6%	23	29.1%	
Regularly	161	64.4%	91	56.5%	47	29.2%	23	14.3%	
Blood glucose level control									
Not controlled	24	9.6%	11	45.8%	6	25.0%	7	29.2%	.518
Partially controlled	159	63.6%	81	50.9%	45	28.3%	33	20.8%	
Totally controlled	67	26.8%	36	53.7%	22	32.8%	9	13.4%	
HbA1c									
< 6.5	42	16.8%	25	59.5%	9	21.4%	8	19.0%	.694
6.5-7.5	93	37.2%	45	48.4%	31	33.3%	17	18.3%	
7.5-9.5	85	34.0%	42	49.4%	23	27.1%	20	23.5%	
> 9.5	30	12.0%	16	53.3%	10	33.3%	4	13.3%	
Had other chronic disease									
Yes	74	29.6%	31	41.9%	19	25.7%	24	32.4%	.004*
No	176	70.4%	97	55.1%	54	30.7%	25	14.2%	

P: Pearson X^2 test *$: Exact probability test* ** P < 0.05 (significant)*

Overweight/obesity was detected in 66.7% of smokers, versus 47.4% of non-smokers (P=.022). Also, 66.7% of patients who exercise at a gym were obese, compared to 33.3% of others who walk (P=.027). Around 60% of patients who received advice regarding weight control from a PHCC physician were obese, compared to 41.9% of those who did not (P=.001). Overweight and obesity were significantly higher among patients who did not follow a high fiber diet than others who did (66.7% vs. 46.4%, respectively; P=.049) (Table 3).

Figure 1 illustrates the distribution of BMI categories among Type 1 diabetic patients, comparing those who follow a high-fiber diet to those who do not. The majority of patients adhering to a high-fiber diet fall within the 'Normal' BMI category (51.3%), while those not following a high-fiber diet are most frequently categorized as 'Overweight' (43.3%). This suggests a potential association between a high-fiber diet and healthier BMI among Type 1 diabetic patients.

Of obese patients, 18.4% reported a significant effect on their daily life activities, compared to 1.4% of overweight and 2.3% of those with normal weight (P=.001). Also, 32.7% of obese patients had diabetic complications, in comparison to 21.9% of overweight and 16.4% of normal weight patients (P=.049).

Table 3 Risk factors for overweight and obesity among Type 1 Diabetic patients, Saudi Arabia

Risk factors	Total		Body mass index						p-value
			Normal		Overweight		Obese		
	No	%	No	%	No	%	No	%	
Smoking									
Yes	18	7.2%	6	33.3%	4	22.2%	8	44.4%	.022*
No	232	92.8%	122	52.6%	69	29.7%	41	17.7%	
Exercises and physical activity									
Yes	65	26.0%	37	56.9%	17	26.2%	11	16.9%	.559
No	185	74.0%	91	49.2%	56	30.3%	38	20.5%	
Type of exercises									
Gym	18	27.7%	6	33.3%	6	33.3%	6	33.3%	.027*$
Walking	42	64.6%	28	66.7%	11	26.2%	3	7.1%	
Running	5	7.7%	3	60.0%	0	0.0%	2	40.0%	
Frequency of exercising per week									
Daily	34	56.7%	19	55.9%	10	29.4%	5	14.7%	
3 times/week	19	31.7%	11	57.9%	2	10.5%	6	31.6%	.403$
2 times/week	2	3.3%	1	50.0%	1	50.0%	0	0.0%	
1 time/week	5	8.3%	3	60.0%	2	40.0%	0	0.0%	
Did you have advices regarding weight control from PHCC physician									
Yes	95	38.0%	38	40.0%	26	27.4%	31	32.6%	.001*
No	155	62.0%	90	58.1%	47	30.3%	18	11.6%	
Follow a diet									
Yes	55	22.0%	33	60.0%	11	20.0%	11	20.0%	.211
No	195	78.0%	95	48.7%	62	31.8%	38	19.5%	
Number of daily meals									
2 meals	100	40.0%	52	52.0%	31	31.0%	17	17.0%	.454
3 meals	117	46.8%	55	47.0%	35	29.9%	27	23.1%	
4 meals	33	13.2%	21	63.6%	7	21.2%	5	15.2%	
Snack between meals									
Yes	178	71.2%	95	53.4%	47	26.4%	36	20.2%	.309
No	72	28.8%	33	45.8%	26	36.1%	13	18.1%	
Eating meals late at night									
Yes	147	58.8%	72	49.0%	44	29.9%	31	21.1%	.666
No	103	41.2%	56	54.4%	29	28.2%	18	17.5%	
Drink coffee									
Yes	178	71.2%	93	52.2%	50	28.1%	35	19.7%	.821
No	72	28.8%	35	48.6%	23	31.9%	14	19.4%	
Soft drinks									
Yes	110	44.0%	60	54.5%	34	30.9%	16	14.5%	.203
No	140	56.0%	68	48.6%	39	27.9%	33	23.6%	
Cheese, butter, cream									
Yes	188	75.2%	94	50.0%	56	29.8%	38	20.2%	.799
No	62	24.8%	34	54.8%	17	27.4%	11	17.7%	
Yolk									
Yes	162	64.8%	82	50.6%	45	27.8%	35	21.6%	.524
No	88	35.2%	46	52.3%	28	31.8%	14	15.9%	

High-fiber foods									
Yes	220	88.0%	118	53.6%	60	27.3%	42	19.1%	.049*
No	30	12.0%	10	33.3%	13	43.3%	7	23.3%	

P: Pearson X^2 test *$: Exact probability test* * P < 0.05 (significant)*

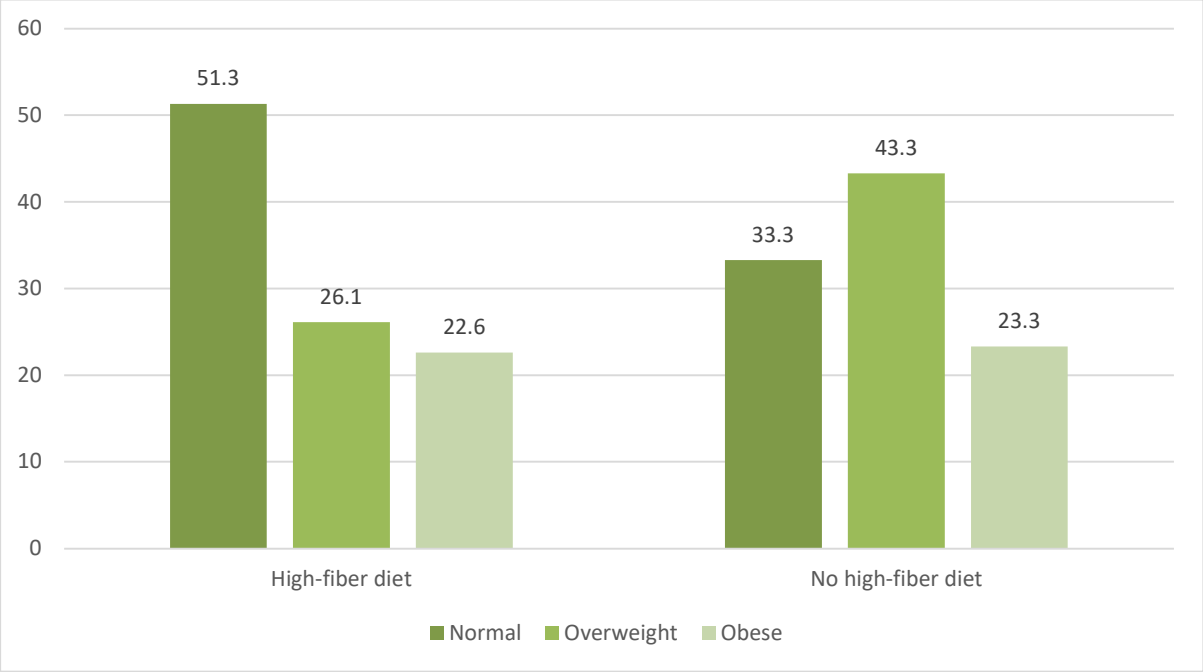

Figure 1 Dietary Habits (High-fiber diet vs. No high-fiber diet) vs. BMI categories among Type 1 diabetic patients

Table 4 Effect of overweight and obesity on Type 1 Diabetic patients, Saudi Arabia

Effect	Body mass index						p-value
	Normal weight		Overweight		Obese		
	No	%	No	%	No	%	
Does your weight affect your daily life activities							
No effect at all	107	83.6%	42	57.5%	14	28.6%	.001*$
Mild to moderate effect	18	14.1%	30	41.1%	26	53.1%	
High effect	3	2.3%	1	1.4%	9	18.4%	
Had diabetes complications							
Yes	21	16.4%	16	21.9%	16	32.7%	.049*
No	107	83.6%	57	78.1%	33	67.3%	

P: Pearson X^2 test *$: Exact probability test* * P < 0.05 (significant)*

4. DISCUSSION

Despite the increased risk of adverse health outcomes and a detrimental impact on quality of life, only half of individuals with diabetes and other chronic conditions receive dietary or exercise guidance from their primary healthcare providers. Over the past two decades, obesity rates in Saudi Arabia and other Gulf countries have notably escalated (Alhyas et al., 2011; Aljaadi and Alharbi, 2020; Gezawa et al., 2019). Recent research in Saudi Arabia identified obesity and being overweight as prevalent risk factors for diabetes (Al-Mansour, 2019).

This study's objective was to evaluate the prevalence of overweight and obesity, as well as associated risk factors, in adults with Type 1 Diabetes in the general population of Saudi Arabia. The findings revealed that nearly half of the individuals with Type 1 Diabetes were overweight or obese, with the majority being overweight, affecting less than one-third of the patients. These findings align with those reported by Schueren et al., (2021), who noted that 37% of patients with Type 1 Diabetes were obese. Current literature suggests that a significant number of patients with Type 1 Diabetes experience obesity at some point, with an increasing prevalence in recent years, ranging from 2.8% to 37.1% (Polsky and Ellis, 2015).

An examination of trends displayed an increase in the obesity rate among adults with Type 1 Diabetes, rising from 3.4% during the baseline period (1986 to 1988) to 22.7% between 2004 and 2007 (Conway et al., 2010). In Saudi Arabia, Khalid et al., (2018) reported that 56.6% of type 1 diabetic patients had a BMI > 30. Another study by Albishi et al., (2017) revealed that one-third of the newly diagnosed type 1 diabetic patients were overweight (35.5%). However, variations in these results are primarily due to the definition of obesity, the age of the studied population and the country. When obesity is defined as a body mass index (BMI) at or above the 95th percentile, the estimated prevalence ranges from 5.2% for the age group of 5 to 30 years (Pinhas-Hamiel et al., 2015) to 13.5% in adolescents (average age 15.4 years) according to the T1D Exchange Registry (T1DX) study (Minges et al., 2017).

However, when applying stricter criteria (BMI > 97th percentile), a large study from a German and Austrian database reported a lower obesity prevalence of just 2.8% among patients aged under 20 years old (Fröhlich-Reiterer et al., 2014). In terms of risk factors, the current study indicated that overweight and obesity were significantly higher among older patients (> 30 years), employed patients and those with a high monthly income, suggesting an unhealthy lifestyle, including frequent outdoor meals. Patients living alone, who may rely more on outdoor meals and fast food, also showed an increased risk for obesity.

As for lifestyle and dietary habits, the study demonstrated that a higher rate of obesity was detected among smokers and those who do not maintain a high fiber diet. Various risk factors including lack of physical activity (Cameron et al., 2003; Bhupathiraju and Hu, 2016), dietary habits (Sandouk and Lansang, 2017; Fraser et al., 2012; Jeffery et al., 2006; Currie et al., 2010) and others (Wing et al., 2001; Flegal et al., 2010; Parekh et al., 1998) are assessed in numerous studies.

5. CONCLUSIONS AND RECOMMENDATIONS

In conclusion, the current study showed that nearly half of the diabetic patients had overweight and obesity. Old age, smoking and unhealthy diet was significantly associated with rate of obesity among type 1 diabetics. The study revealed that T1DM patients need special attention. Health education in the primary health care and diabetes centers should be promoted with more efforts to screen for weight changes among diabetic patients.

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Author Contributions

Lujain Bin Othman, Ali Alamri, Yara Assiri and Faris Alzahrani all contributed significantly to this research. Bin Othman was responsible for data collection, analysis, interpretation and manuscript drafting. Alzahrani was involved in the study's conceptualization, design and data analysis and manuscript preparation. Assiri contributed by assisting with data collection, analysis, literature review and manuscript preparation. As the principal investigator, Alamri provided oversight and guidance across the project's diverse aspects. Together, their combined efforts ensured the successful completion of this research.

Informed Consent

Written informed consent was procured from all individual participants included in the study.

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Conflict of interest

The authors declare that there is no conflict of interests.

Data and materials availability

All data sets collected during this study are available upon reasonable request from the corresponding author.

REFERENCES AND NOTES

1. Albishi LA, Altoonisi MM, Alblewi SM, Osman RH, Ahmed NA, Fararjeh M. Clinical demographic patterns of Type 1 Diabetes in Saudi children in Tabuk City, 2000-2010. J Diabetes Mellit 2017; 7(7):41-54.

2. Al-Dawish MA, Robert AA, Braham R, Al-Hayek AA, Al-Saeed A, Ahmed RA, Al-Sabaan FS. Diabetes mellitus in Saudi Arabia: A review of the recent literature. Curr Diabetes Rev 2016; 12(4):359-68.
3. Alhyas L, Mckay A, Balasanthiran A, Majeed A. Prevalences of overweight, obesity, hyperglycaemia, hypertension and dyslipidaemia in the Gulf: Systematic review. JRSM Short Rep 2011; 2(7):55.
4. Aljaadi A, Alharbi M. Overweight and Obesity among Saudi Children: Prevalence, Lifestyle Factors and Health Impacts. Handbook of Healthcare in the Arab World 2020; 1–25.
5. Al-Lawati JA. Diabetes mellitus: A local and global public health emergency! Oman Med J 2017; 32(3):177-179.
6. Al-Mansour M. The prevalence and risk factors of type 2 diabetes mellitus (DMT2) in a semi-urban Saudi population. Int J Environ Res Public Health 2019; 17(1):7.
7. Al-Nuaim AA, Al-Nakeeb Y, Lyons M, Al-Hazzaa HM, Nevill A, Collins P, Duncan MJ. The prevalence of physical activity and sedentary behaviours relative to obesity among adolescents from Al-Ahsa, Saudi Arabia: Rural versus urban variations. J Nutr Metab 2012; 2012:417589.
8. Alrasheed AA, Alammar AM, Alrasheed AA, Aljurayyan AN, Aljufayr MA, Alghaihb SG, Alelaiwi AA, Al-Sahli NA. The prevalence of hypertension among patients with Type 1 diabetes and its associated factors in Saudi Arabia. Medical Science 2021; 25(117):2748-2756
9. Alrashid FF, Idris SA, Alshammari HA, Altamimi AD, Alsalwah HS. Current status of bariatric surgery perceptions in Hail region, Saudi Arabia. Medical Science 2022; 26:ms455e2486. doi: 10.54905/disssi/v26i129/ms455e2486
10. Aronne LJ. Classification of obesity and assessment of obesity-related health risks. Obes Res 2002; 10 Suppl 2:105S-15S.
11. Arroyo-Johnson C, Mincey KD. Obesity epidemiology worldwide. Gastroenterol Clin North Am 2016; 45(4):571-57 9.
12. Bhupathiraju SN, Hu FB. Epidemiology of obesity and diabetes and their cardiovascular complications. Circ Res 2016; 118(11):1723-35.
13. Cameron AJ, Zimmet PZ, Dunstan DW, Dalton M, Shaw JE, Welborn TA, Owen N, Salmon J, Jolley D, Shaw JE. Overweight and obesity in Australia: The 1999–2000 Australian diabetes, obesity and lifestyle study (AusDiab). Med J Aust 2003; 178(9):427-32.
14. Chooi YC, Ding C, Magkos F. The epidemiology of obesity. Metabolism 2019; 92:6-10.
15. Conway B, Miller RG, Costacou T, Fried L, Kelsey S, Evans RW, Orchard TJ. Temporal patterns in overweight and obesity in Type 1 Diabetes. Diabet Med 2010; 27(4):398-404.
16. Corbin KD, Driscoll KA, Pratley RE, Smith SR, Maahs DM, Mayer-Davis EJ; Advancing Care for Type 1 Diabetes and Obesity Network (ACT1ON). Obesity in Type 1 Diabetes: Pathophysiology, clinical impact and mechanisms. Endocr Rev 2018; 39(5):629-663.
17. Currie J, Della-Vigna S, Moretti E, Pathania V. The effect of fast-food restaurants on obesity and weight gain. Am Econ J Econ Policy 2010; 2(3):32-63.
18. De-Nicola E, Aburizaiza OS, Siddique A, Khwaja H, Carpenter DO. Obesity and public health in the Kingdom of Saudi Arabia. Rev Environ Health 2015; 30(3):191-205.
19. Flegal KM, Carroll MD, Ogden CL, Curtin LR. Prevalence and trends in obesity among US adults, 1999-2008. JAMA 2010; 303(3):235-41.
20. Fontaine KR, Barofsky I. Obesity and health-related quality of life. Obes Rev 2001; 2(3):173-82.
21. Fraser LK, Clarke GP, Cade JE, Edwards KL. Fast food and obesity: A spatial analysis in a large United Kingdom population of children aged 13–15. Am J Prev Med 2012; 42 (5): e77-85.
22. Fröhlich-Reiterer EE, Rosenbauer J, Pozza SB, Hofer SE, Schober E, Holl RW; DPV-Wiss Study Group, German BMBF Competence Networks Diabetes mellitus and Obesity. Predictors of increasing BMI during the course of diabetes in children and adolescents with Type 1 Diabetes: Data from the German/Austrian DPV multicentre survey. Arch Dis Child 2014; 99(8):738-43.
23. Gallus S, Lugo A, Murisic B, Bosetti C, Boffetta P, La-Vecchia C. Overweight and obesity in 16 European countries. Eur J Nutr 2015; 54(5):679-89.
24. Gezawa ID, Uloko AE, Gwaram BA, Ibrahim DA, Ugwu ET, Mohammed IY. Pattern of obesity among patients with type 2 diabetes at a tertiary healthcare center in Northern Nigeria. Diabetes Metab Syndr Obes 2019; 12:2785–90.
25. Halpern A, Mancini MC. Diabesity: Are weight loss medications effective? Treat Endocrinol 2005; 4(2):65–74.
26. Harding JL, Pavkov ME, Magliano DJ, Shaw JE, Gregg EW. Global trends in diabetes complications: A review of current evidence. Diabetologia 2019; 62(1):3-16.
27. Jeffery RW, Baxter J, Mc-Guire M, Linde J. Are fast food restaurants an environmental risk factor for obesity? Int J Behav Nutr Phys Act 2006; 3:2.
28. Khalid SA, Samia AB, Muneera AA, Patan MK, Bandari KA. Overweight and Obesity in Saudi Adults with Type 1 Diabetes Mellitus. Arch Diabetes Obes 2018; 1(3).
29. Lin X, Xu Y, Pan X, Xu J, Ding Y, Sun X, Song X, Ren Y, Shan PF. Global, regional and national burden and trend of diabetes in 195 countries and territories: An analysis from 1990 to 2025. Sci Rep 2020; 10(1):14790.

30. Minges KE, Whittemore R, Weinzimer SA, Irwin ML, Redeker NS, Grey M. Correlates of overweight and obesity in 5529 adolescents with Type 1 Diabetes: The T1D Exchange Clinic Registry. Diabetes Res Clin Pract 2017; 126: 68-78.
31. Parekh PI, Petro AE, Tiller JM, Feinglos MN, Surwit RS. Reversal of diet-induced obesity and diabetes in C57BL/6J mice. Metabolism 1998; 47(9):1089-96.
32. Pinhas-Hamiel O, Levek-Motola N, Kaidar K, Boyko V, Tisch E, Mazor-Aronovitch K, Graf-Barel C, Landau Z, Lerner-Geva L, Ben-David RF. Prevalence of overweight, obesity and metabolic syndrome components in children, adolescents and young adults with Type 1 Diabetes mellitus. Diabetes Metab Res Rev 2015; 31(1):76-84.
33. Polsky S, Ellis SL. Obesity, insulin resistance and Type 1 Diabetes mellitus. Curr Opin Endocrinol Diabetes Obes 2015; 22(4):277-82.
34. Sandouk Z, Lansang MC. Diabetes with obesity-Is there an ideal diet. Cleve Clin J Med 2017; 84(7 Suppl 1):S4-14.
35. Schueren BV, Ellis D, Faradji RN, Al-Ozairi E, Rosen J, Mathieu C. Obesity in people living with Type 1 Diabetes. Lancet Diabetes Endocrinol 2021; 9(11):776-85.
36. Stumvoll M, Goldstein BJ, Haeften TW. Type 2 diabetes: Principles of pathogenesis and therapy. Lancet 2005; 365 (9467):1333–1346.
37. Vassilopoulou L, Psycharakis C, Petrakis D, Tsiaoussis J, Tsatsakis AM. Obesity, persistent organic pollutants and related health problems. Adv Exp Med Biol 2017; 960:81-110.
38. Wing RR, Goldstein MG, Acton KJ, Birch LL, Jakicic JM, Sallis JF Jr, Smith-West D, Jeffery RW, Surwit RS. Behavioral science research in diabetes: Lifestyle changes related to obesity, eating behavior and physical activity. Diabetes Care 2001; 24(1):117-23.