Are individuals with higher BMI more prone to Type-2 diabetes compared to those with normal BMI?

Background and Research question: Global diabetes cases have quadrupled since 1990, now affecting over 800 million adults, with obesity significantly contributing to the rise in Type II Diabetes Mellitus (T2DM) [1]. Most respondents said that controlling their weight is a priority for them, and they seem to be actively working toward this objective [2]. This background effectively justifies the study's importance due to the increasing prevalence of obesity and diabetes worldwide. This study design aims to determine whether individuals with high BMI are more prone to T2DM through statistical analysis of a diverse population.

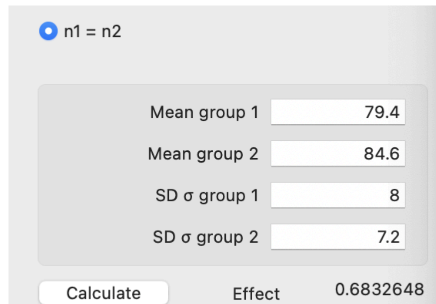
Study Design: This observational study involves no external manipulation and will recruit participants aged 18–35 years without Type 1 or Type 2 diabetes or severe comorbidities (e.g., liver, kidney, or cancer-related conditions). Participants will be prescreened to ensure a balanced sample based on demographics and lifestyle. Fasting glucose levels will be monitored using Continuous Glucose Monitoring (CGM) devices over 10 days and standardized fasting blood glucose (FBG) tests after an 8-hour overnight fast, with blood samples collected at a testing center. The study includes participants with a normal BMI (22.6 ± 1.7 kg/m²) and pre-meal glucose levels of 79.4 ± 8.0 mg/dL, as well as overweight participants (BMI 27.3 ± 4.7 kg/m²) with fasting glucose levels of 84.6 ± 7.2 mg/dL. Participants will consume both standardized and self-selected meals during the study.

Groups	Variables
1. Normal (22.6 ± 1.7 kg/m2)	**Independent Variable**: BMI group (Normal BMI and Higher BMI/Overweight).
2. Overweight (27.3 ± 4.7 kg/m2)	**Dependent Variable:** Fasting Glucose level (Mean value for 10 days observation of each participant)

Null and Alternative Hypotheses

- **Null Hypothesis (H0)**: The mean for fasting glucose level of Normal BMI individuals is the same as for higher BMI individuals ($\mu1 = \mu2$).
- **Alternative Hypothesis (Ha)**: The mean for fasting glucose level of Normal BMI individuals is different from that for higher BMI individuals ($\mu1 \neq \mu2$), indicating a higher risk of Type-2 diabetes.

Appropriate Test: The **independent t-test** will compare glucose levels between two groups: individuals with **normal BMI** and individuals with **higher BMI (Overweight)**. The goal is to determine if the groups have a statistically significant difference in glucose levels.



Power Analysis: The power analysis, based on the given means and standard deviations, indicates that with an effect size of 0.6832, a total of 114 participants (57 per group) is needed to achieve 95% power at a 0.05 significance level for a two-tailed test. This medium-to-large effect size, calculated using Cohen's D, reflects a significant difference in fasting glucose levels between normal and high BMI groups. The findings emphasize the biological and clinical importance of the relationship between BMI and glucose levels, reinforcing the need for this study and the importance of interventions targeting BMI to regulate glucose levels.

Data Simulation: The data for both groups were generated using a random number generator, with 57 participants in each group. For the normal BMI group, the mean fasting glucose level was 79.4 with a standard deviation of 8, while for the overweight BMI group, the mean and standard deviation were 84.6 and 7.2, respectively. These values for the means and standard deviations were sourced from prior research.

Statistical Analysis: The assumptions for conducting an independent t-test are verified. Both groups' data, measured at the interval level, are tested for normality using the Kolmogorov-Smirnov (K-S) test, yielding p-values of 0.200 and 0.166 for the normal and overweight groups, respectively, both exceeding the 0.05 significance level at a confidence interval of 95%. This confirms normality. Levene's test for homogeneity of variances has produced a p-value of 0.213, also above 0.05, indicating equal variances. With all assumptions satisfied, an independent t-test is deemed appropriate.

Results and Discussion: From the independent t-test we get a p-value <0.01, which is less than the significance level of 0.05 indicating that we should **reject the null hypothesis**. The results of this study demonstrate a statistically significant difference in fasting glucose levels between individuals with normal BMI and those with Overweight (Higher BMI). These findings align with existing literature suggesting that higher BMI is associated with impaired glucose regulation and increased risk of Type-II diabetes. This study underscores the importance of maintaining a healthy BMI to regulate fasting glucose levels, as BMI is strongly linked to blood sugar. Weight management and lifestyle changes are critical for preventing type II diabetes and related complications.

Appendix:

Data Simulation:

To simulate data for this observational study, we created a synthetic dataset reflecting the study's design, with participants aged 18–35 years and grouped based on BMI categories. The data was simulated for 57 participants for each group followed by using a random number generator (https://www.random.org/gaussian-distributions/), where the mean and standard deviation values were attained from a similar research study [3]. SPSS software has been used to do the rest of the statistical analysis **(Group 0- Normal. Group 1- Overweight).**

	Participant	FastingGlucoseLevel	Group
8	38.00	70.10	.00
9	39.00	90.40	.00
0	40.00	78.50	.00
1	41.00	71.60	.00
2	42.00	77.90	.00
3	43.00	82.80	.00
4	44.00	87.90	.00
5	45.00	74.70	.00
6	46.00	74.70	.00
7	47.00	66.70	.00
8	48.00	73.20	.00
9	49.00	76.10	.00
0	50.00	88.40	.00
1	51.00	83.80	.00
2	52.00	87.90	.00
3	53.00	75.80	.00
4	54.00	62.20	.00
5	55.00	77.20	.00
6	56.00	79.00	.00
7	57.00	75.40	.00
8	58.00	79.70	1.00
9	59.00	87.30	1.00
0	60.00	89.00	1.00
1	61.00	83.60	1.00
2	62.00	78.00	1.00
3	63.00	80.60	1.00
4	64.00	96.80	1.00
5	65.00	87.90	1.00

Gaussian Random Number Generator

This form allows you to generate random numbers from a Gaussian distribution (also known as a normal distribution). The randomness comes from atmospheric noise, which for many purposes is better than the pseudo-random number algorithms typically used in computer programs. The form uses a Box-Muller Transform to generate the Gaussian distribution from uniformly distributed numbers.

Step 1: The Numbers

Generate 57 random numbers (maximum 10,000) from a Gaussian distribution.

The distribution's mean should be 79.4 (limits ±1,000,000) and its standard deviation 8 (limits ±1,000,000).

The numbers should have 3 significant digits (minimum 2, maximum 20).

Note that this generator does not guarantee your numbers to have the exact mean and standard deviation of the distribution from which they are taken. To approximate the distribution better, generate more numbers.

Step 2: Display Options

Format the numbers in 2 column(s).

You can choose the notation that will be used for your numbers:

- Scientific (E) notation [explain this]
- Standard decimal notation [to appear]

Step 3: Go!

Be patient! It may take a little while to generate your numbers...

Get Numbers Reset Form Switch to Advanced Mode

Figure: A screenshot of the SPSS interface of input data where Group-0 means Normal Participants and Group-1 means Overweight individuals. The other screenshot is from the random number generator.

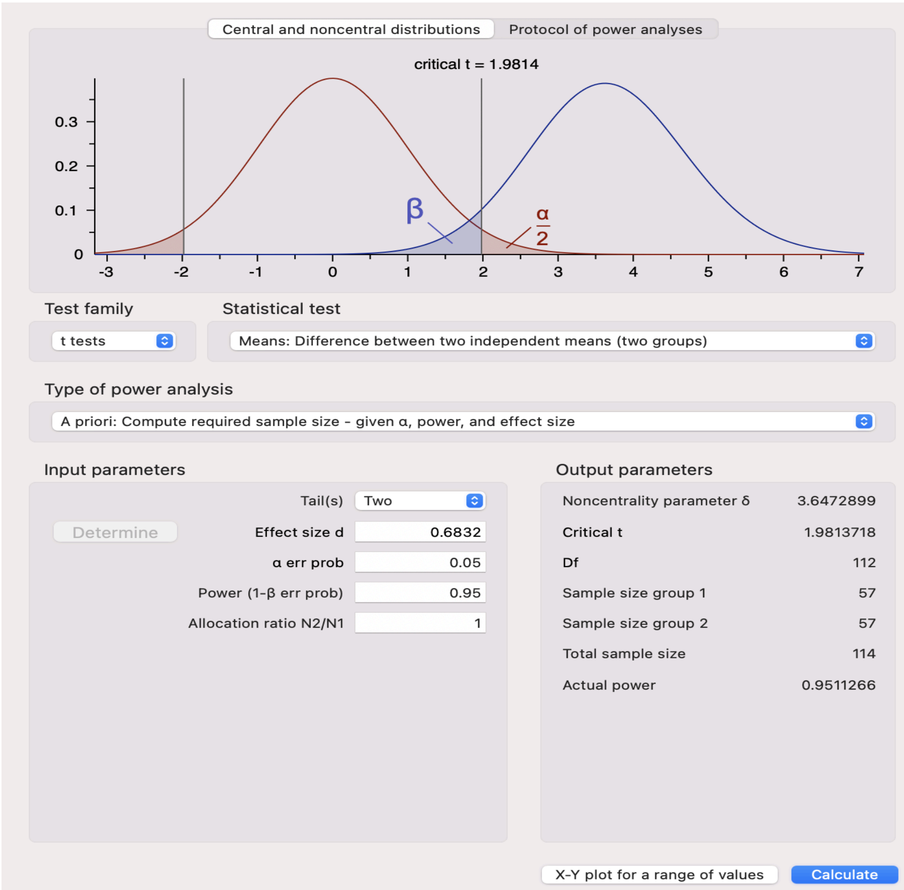


Figure: The power analysis screenshot from G*power to determine the appropriate sample size.

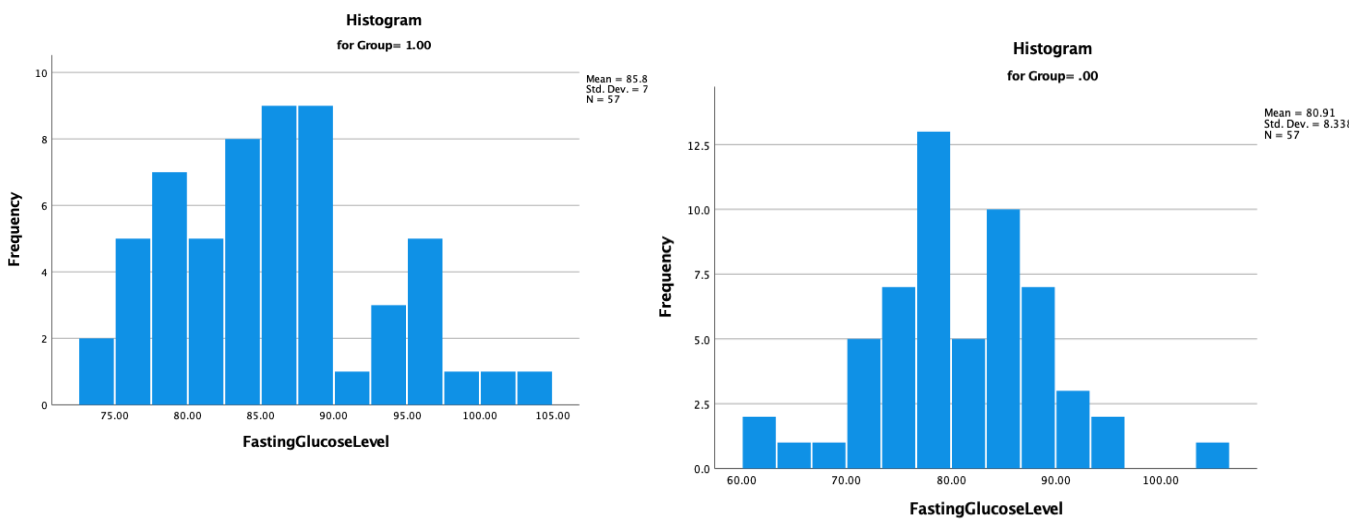


Figure: Data visualization from SPSS to show the mean and standard deviations for the simulated data in the histograms

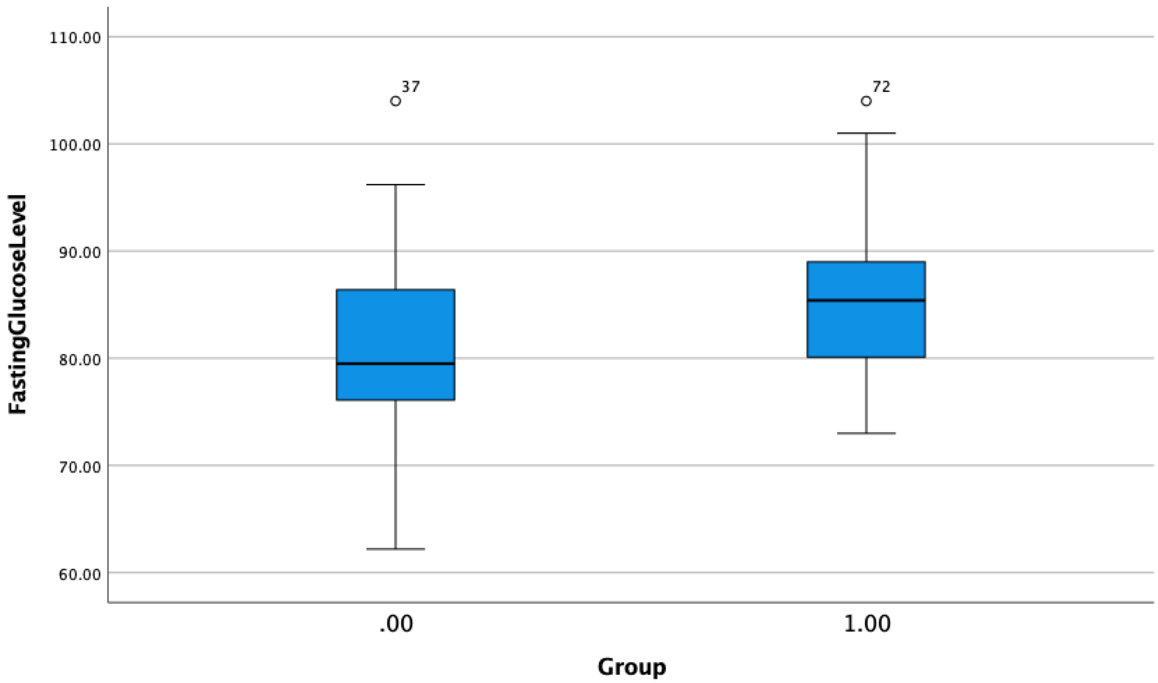


Figure: Box plot of two groups to visualize the distribution of a continuous variable (e.g., fasting glucose levels) across groups (e.g., BMI categories). In this figure, the central line represents the median, while the box indicates the interquartile range. The dots signify outliers. For the Normal BMI group, Participant 37, and for the Overweight group, Participant 72, both have a fasting glucose level of 104 mg/L, which is identified as an outlier.

Checking the Normality of the data for both groups and Homogeneity of Variance:

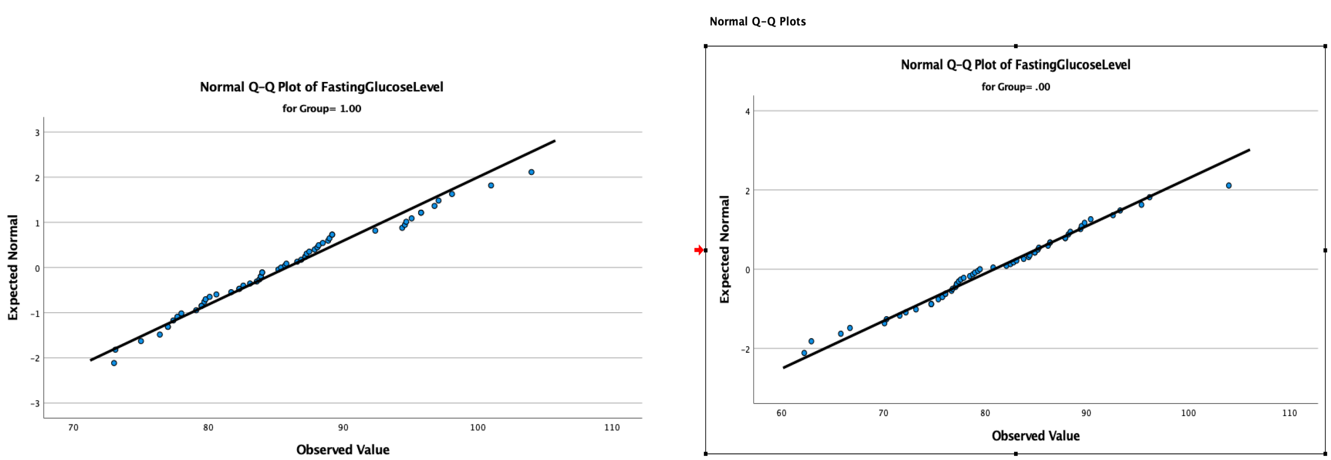


Figure: Q-Q plots for both of the groups' data.

The points align closely with the diagonal reference line of the Q-Q plots, indicating the data is likely normally distributed.

Tests of Normality

	Group	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
FastingGlucoseLevel	.00	.076	57	.200*	.988	57	.863
	1.00	.106	57	.166	.973	57	.241

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Test of Homogeneity of Variance

		Levene Statistic	df1	df2	Sig.
FastingGlucoseLevel	Based on Mean	1.568	1	112	.213
	Based on Median	1.429	1	112	.234
	Based on Median and with adjusted df	1.429	1	108.750	.235
	Based on trimmed mean	1.582	1	112	.211

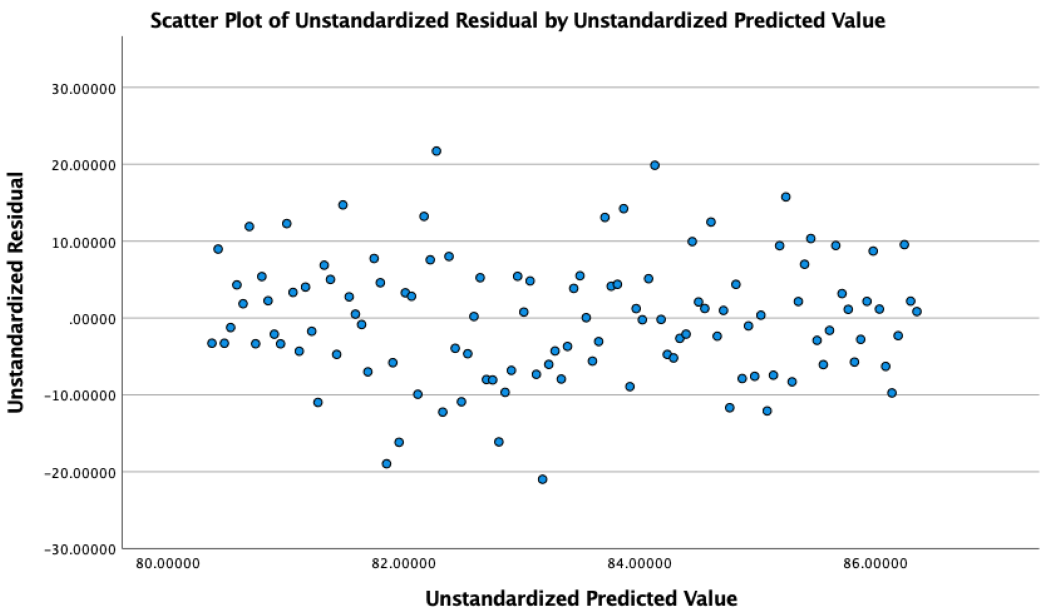


Figure: Scatter plot for residuals and predicted value to check homogeneity of variance

As the residuals scattered randomly around 0 on the y-axis, with no discernible pattern or trend it shows the homogeneity of variance too. Also the previously given screen shot of Leven's test vouches for this as having a p-value greater than the significance level.

Independent t-test Results:

T-Test

Group Statistics

	Group	N	Mean	Std. Deviation	Std. Error Mean
FastingGlucoseLevel	.00	57	80.9053	8.33785	1.10438
	1.00	57	85.8193	7.09687	.94000

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means							
						Significance				95% Confidence Interval of the Difference	
		F	Sig.	t	df	One-Sided p	Two-Sided p	Mean Difference	Std. Error Difference	Lower	Upper
FastingGlucoseLevel	Equal variances assumed	1.568	.213	-3.388	112	<.001	<.001	-4.91404	1.45026	-7.78754	-2.04053
	Equal variances not assumed			-3.388	109.212	<.001	<.001	-4.91404	1.45026	-7.78834	-2.03973

Independent Samples Effect Sizes

		Standardizer[a]	Point Estimate	95% Confidence Interval Lower	95% Confidence Interval Upper
FastingGlucoseLevel	Cohen's d	7.74226	-.635	-1.010	-.257
	Hedges' correction	7.79460	-.630	-1.003	-.255
	Glass's delta	7.09687	-.692	-1.078	-.301

a. The denominator used in estimating the effect sizes.
Cohen's d uses the pooled standard deviation.
Hedges' correction uses the pooled standard deviation, plus a correction factor.
Glass's delta uses the sample standard deviation of the control group.

References:

1. *Hu, F. B. (2011). Globalization of diabetes: the role of diet, lifestyle, and genes. Diabetes care, 34(6), 1249-1257.*
2. *Huxley, R., Barzi, F., & Woodward, M. (2006). Excess risk of fatal coronary heart disease associated with diabetes in men and women: Meta-analysis of 37 prospective cohort studies. BMJ, 332(7533), 73–78.*
3. *Casey Means, M. C. R. (2024, October 9). What should your glucose levels be? The 2024 Levels Guide to Healthy Blood Sugar Ranges. Levels. https://www.levels.com/blog/what-should-my-glucose-levels-be-ultimate-guide?utm_source=chatgpt.com*