Losing BMI Through Six Sigma Techniques

Batoulsadat Haerian

MGT 8823

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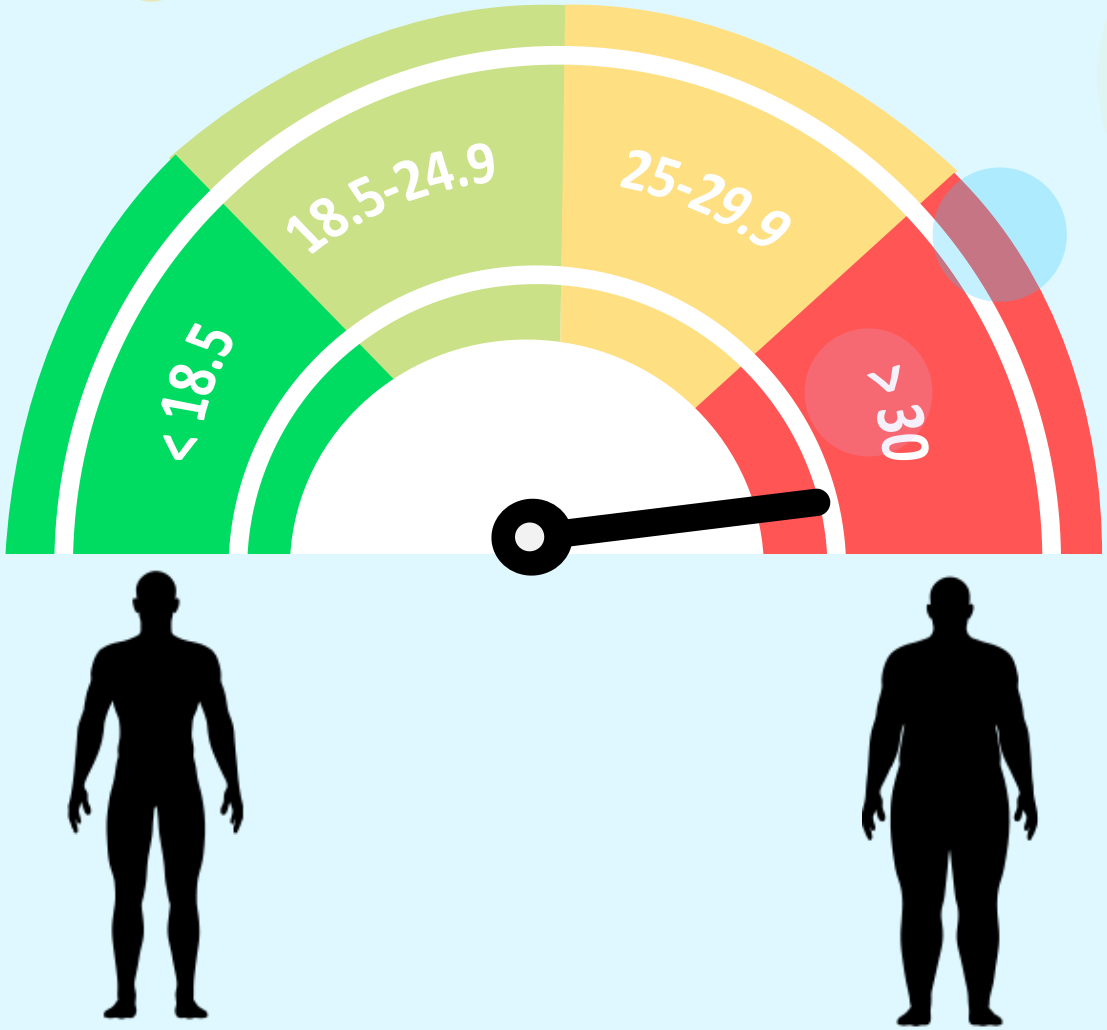

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DEFINE

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Obesity is an excessive fat accumulation that presents a risk to health (BMI > 30)

About 51% (4 billion people) of the global population (age > 5 years) is expected to be overweight and obesity within 2020-3035 if prevention, treatment and support do not improve.

Subject	2020	2025	2030	2035
Number with overweight or obesity (BMI≥25kg/m²), millions (%)	2,603 (38%)	3,041 (42%)	3,507 (46%)	4,005 (51%)
Number with overweight or obesity (BMI≥30kg/m²), millions (%)	988 (14%)	1,249 (17%)	1,556 (20%)	1,914 (24%)

Globaly, the prevalence of obesity is expected to increase from 38% to 51% during 2020-2035

This ratio is rising quickly among children and in lower-income countries.

https://www.worldobesity.org/resources/resource-library/world-obesity-atlas-2023.

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Obesity increases the risk of some diseases, such as cardiovascular, hypertension, stroke, dyslipidaemia, type 2 diabetes, osteoarthritis, and certain cancers

The healthcare costs of treating **obesity** and its consequences on economic productivity increases from 1.96 trillion to over US$4 trillion during 2020-2035.

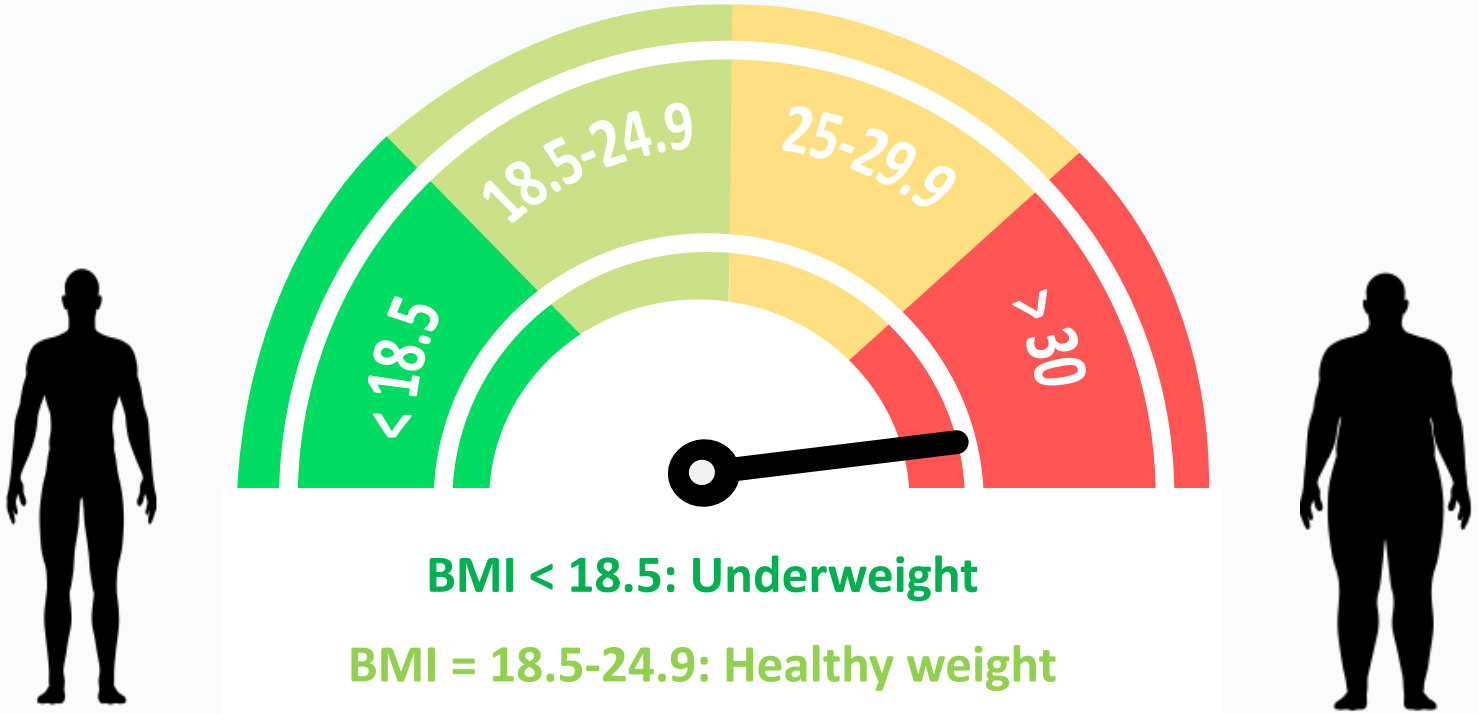
Subject	2020	2025	2030	2035
Economic impact (US$ at 2019 value) (trillions) US$	US$ 1.96	US$ 2.47	US$ 3.23	US$ 4.32
Impact as proportion of total global GDP	US$ 2.4%	US$ 2.5%	US$ 2.7%	US$ 2.9%

It also rises the global GDP from 2.4% to 2.9% during 2020-2035

Jonathan Pearson-Stuttard et al. (2023): Real-world costs of obesity-related complications over eight years: a US retrospective cohort study in 28,500 individuals. International Journal of Obesity. 47:1239–1246.
https://data.worldbank.org/indicator/NY.GDP.MKTP.CD
https://www.worldobesity.org/resources/resource-library/world-obesity-atlas-2023.

Body Mass Index (BMI) is a vital health metric for identifying obesity.

It categorizes weight based on its value into 4 groups



BMI < 18.5: Underweight

BMI = 18.5-24.9: Healthy weight

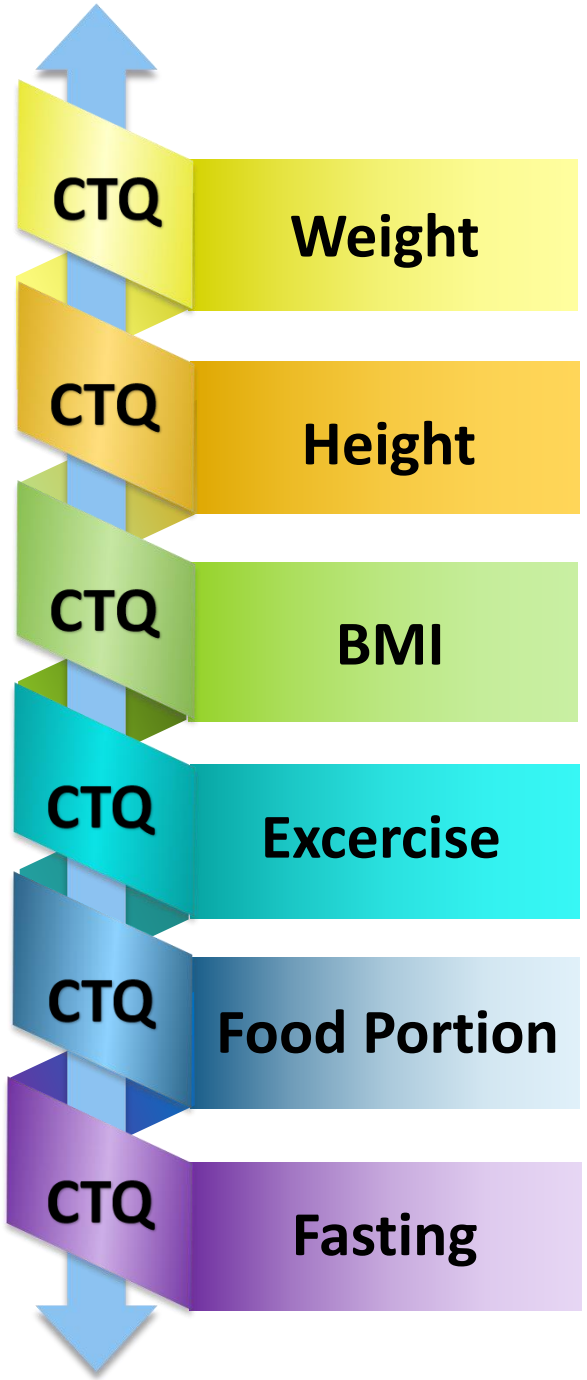
BMI = 25 - 29.9: Overweight

BMI ≥ 30: Obesity

World Health Organization. BMI. https://www.who.int/data/gho/data/themes/topics/topic-details/GHO/body-mass-index?introPage=intro_3.html. Accessed 12 Dec. 2023.

- **BMI Formula ⇒** $BMI(kg/m^2) = \frac{Weight\ in\ kilograms}{Height\ in\ meters^2}$
- **My Current BMI** is about 35 kg/m² ($\frac{84.95}{1.56^2}$) which categorizes me as obese. My BMI value raises my concerns due to the associated risk of health complications and their related treatment costs.

- **My Plan** is to reduce my BMI through weight loss within the next three months. Since obesity is a chronic but manageable condition, I am committed to undertake this weight management program to improving both my health and BMI.
- **Y Metric** is parameter weight which will measure in kg.
- **Problem** is that I currently fall into the obese category with a BMI of around 35 kg/m², determined by an average weight of about 85.5 kg and a height of 1.56 m.
- **My Goal** is to reduce my weight by 14% (each month 4.67%) over the next three months, aiming for an average of approximately 73 kg and (each month 4.17 kg) achieving a BMI of around 30 kg/m² categorized as overweight at the end of three months (April, May, and June 2023).



Weight

Precise and consistent daily weight measurements in kgs over 91 days by using a calibrated scale through standard protocols and under controlled conditions.

Height

Precise and accurate height measurements in meters, conducted with standardized protocols and equipment under controlled conditions.

BMI

Precise and consistent daily BMI calculations in kg/m^2 over 91 days, using height and wei ght values in the standard formula with accurate recording and tracking of BMI reduction.

Excercise

Precise adherence to a daily 30-minute treadmill walk with a consistent speed of 3 mph, regular completion for 91 days, and accurate recording to monitor exercise adherence.

Food Portion

Consistent reduction of daily brunch intake by half over one month, with fixed intakes of fruits and vegetables maintained during this regimen.

Fasting

Consistent cessation of brunch intake on Mondays, Wednesdays, and Fridays in December with fixed fruit and vegetable intakes maintained during fasting days.

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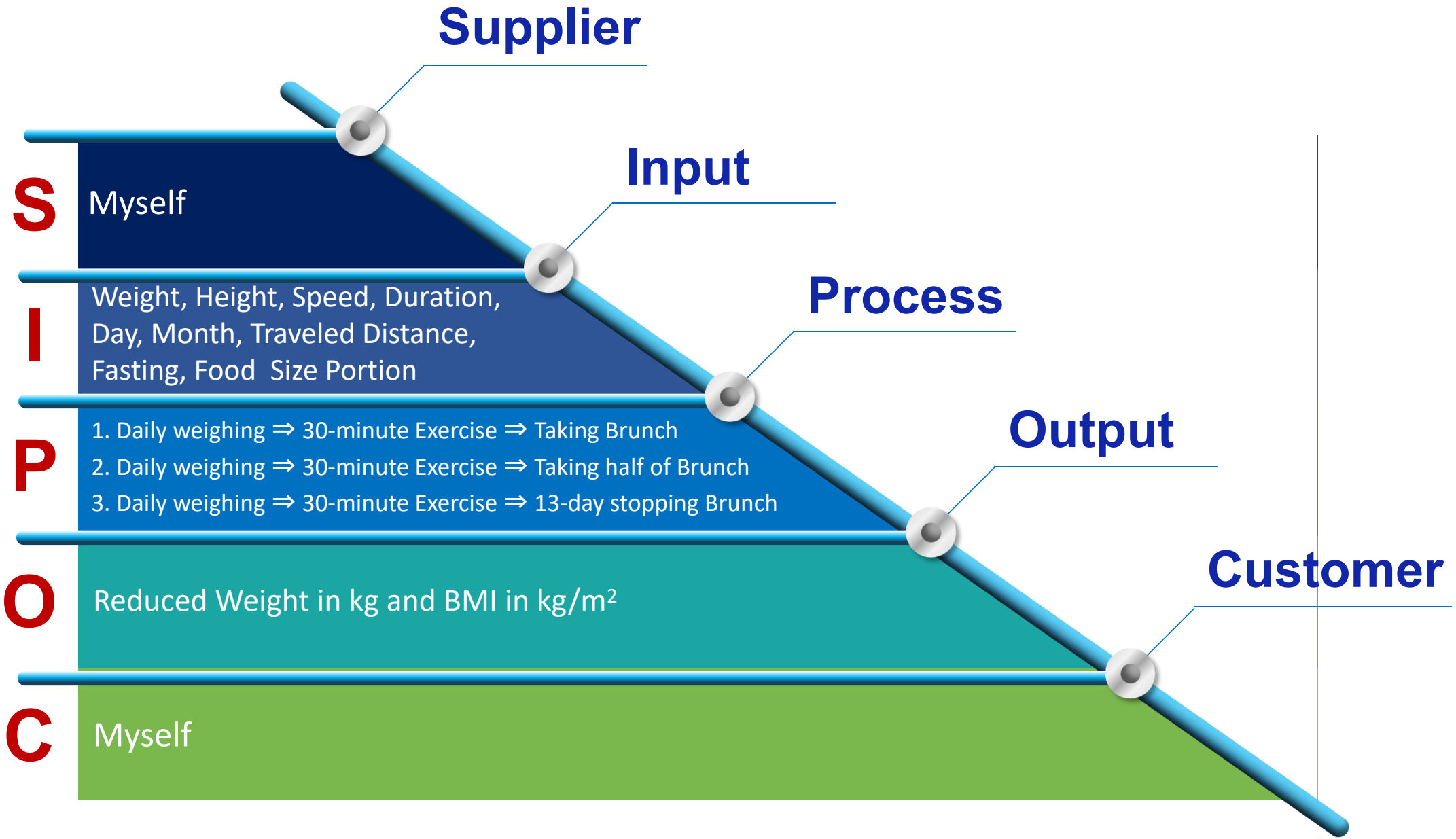

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MEASURE

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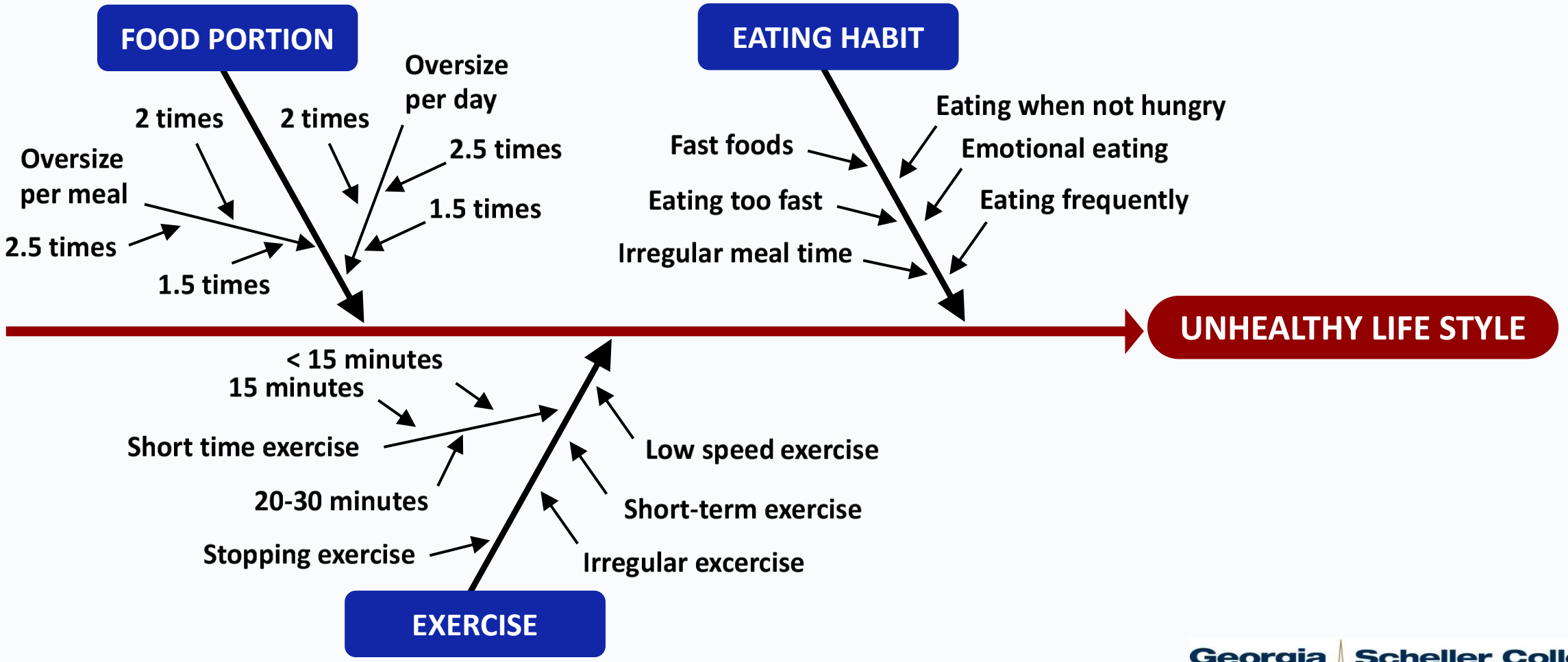
Problem: I fall into the obese category with a BMI of 35 kg/m2 and an average weight of 85 kg, attributed partly to an unhealthy lifestyle. Key contributors to this lifestyle include exercise pattern s, food portions, and eating habits, all of which require improvement.



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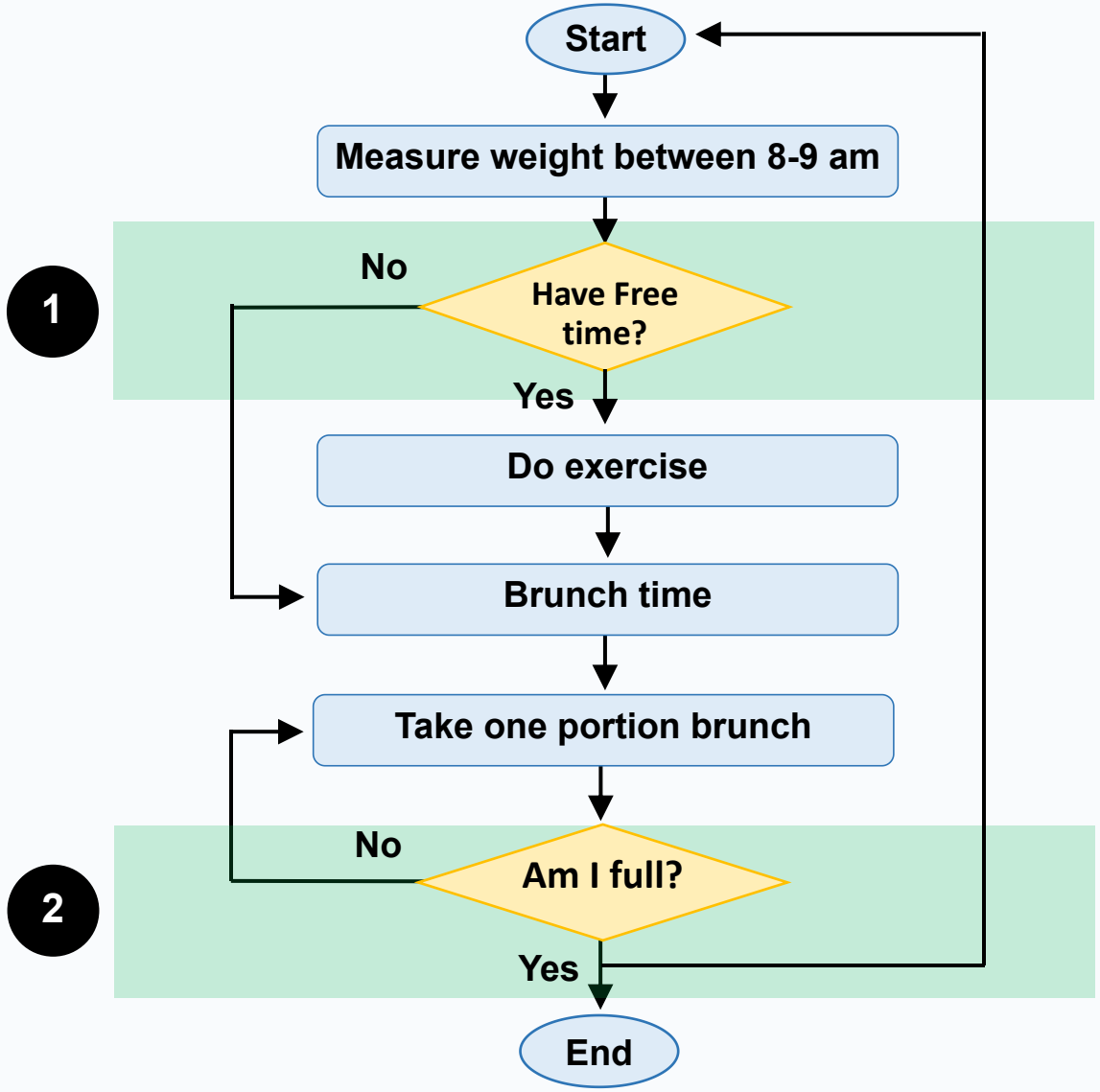
«« The prior process map for my daily lifestyle.

Steps 1 and 2 are non-value adds and should be excluded or revised.



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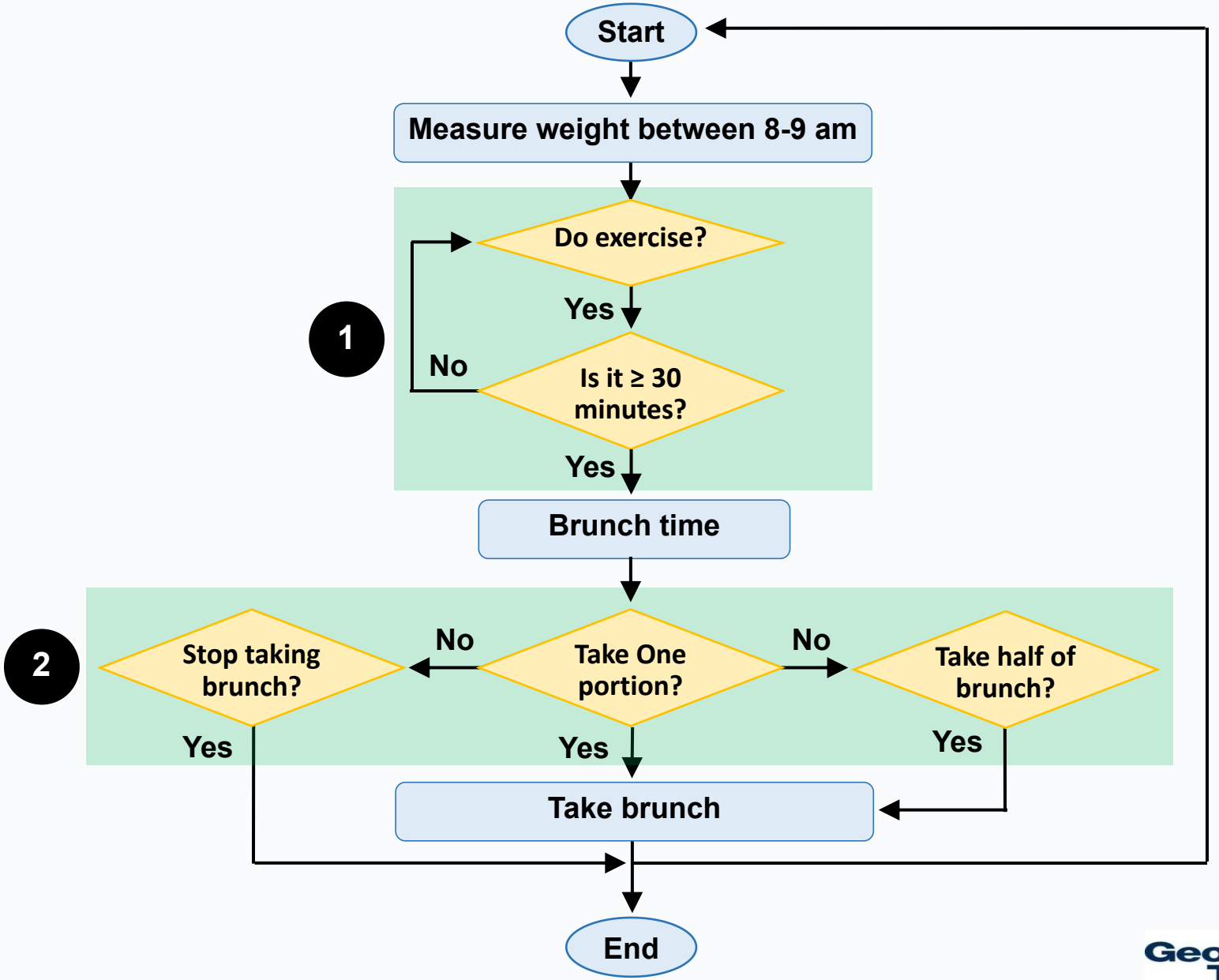
Modified process map for my daily lifestyle.

Steps 1 and 2 have been revised.



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What? Y Metric: Weight in kg

Data Type? Continous

How Measured?

- **Height:** I measure it in meters without wearing shoes in meters, rounding to the nearest centimeter. I repeat this process five times, calculating the mean height for more accuracy.
- **Weight:** I weigh myself in kilograms daily by standing at the center of a calibrated scale without wearing shoes or heavy clothing before having breakfast every morning between 8-9 and round it to the nearest gram. I consistently and regularly repeat this activity for 91 days.
- **BMI:** Height is constant and weight fluctuates daily do it calculated via $\frac{Weight}{Height^2}$ formula.
- **Weight category:** I identify category as 1 (underweight) if BMI < 18.5, 2 (healthy weight) if BMI is between 18.5-24.9, 3 (overweight) if BMI is between 25-29.9, and 4 (obesity) if BMI ≥ 30.

«« Related Conditions

Main X Metrics is Traveled Distance: walking on the treadmill at a speed of 3.0 mph with a 0 incline for about 30 minutes every morning from 10:00 to 12:00 is calculated as:

Exercise Duration in minutes x Speed in mph)/60 minutes.

Relevant metrics to X

1. Exercise without Dietary Limitation for a Duration of One Month (September)

- **Excercise Day:** A designated day of the week from Monday to Sunday for walking on the treadmill.
- **Excercise Duration:** The time spent on exercise in minutes.
- **Treadmill Speed:** The mph value during exercise.
- **Cumulattive Traveled Distance:** It is computed by summing the distance covered on the previous day with the current day's traveled distance.

2. Exercise with Dietary Restrictions for a Two Months.

- **Decreased Brunch Portion by Half Within One Month:** Taking 50% of the typical amount of brunch during mealtime as established by baseline in the first week. In the subsequent 50% of meal will be consumed for four weeks.
- **Fasting for One Month:** Stopping taking brunch and beverages during the mealtime for 13 days of one month, each week Monday, Wednesday, and Friday.

* During 91 days, I will daily take four fruits (apple, pear, orange, and grapefruits) and 500 grams of raw vegetables (mushrooms, broccoli, celery, spinach, and lettuce) and drink water and tea.

⋘ **Sampling Notes** Data collection includes weight in kg and other variables on their related scales daily for 91 days, resulting in a total of 91 weight and other values denoted.

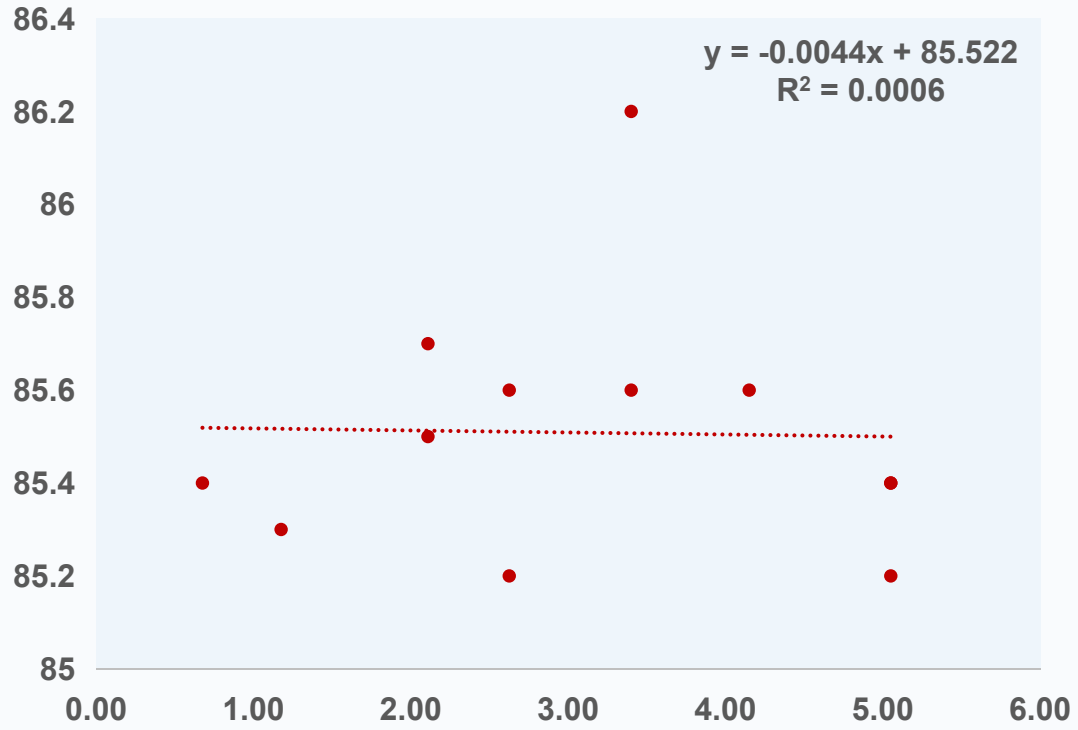
⋘ **Recording Information** will be done by myself using a scale to record my body weight in kg in the morning. Then, will calculate daily BMI and traveled distance by calculator.

Regression Analysis: Traveled Distance

As the results and scatter plot depict there is no significant correlation between the traveled distance and weight loss at the level of 0.05 (F = 0058, df = 1 and 10, p-value = 0.941).

y = 85.522 - 0.0044 * Traveled Distance

Parameter	Value
Count	12
Multiple R	0.0204
R Square	0.0006
Adjusted R Square	-0.099
Intercept	85.522
Traveled Distance	-0.0044



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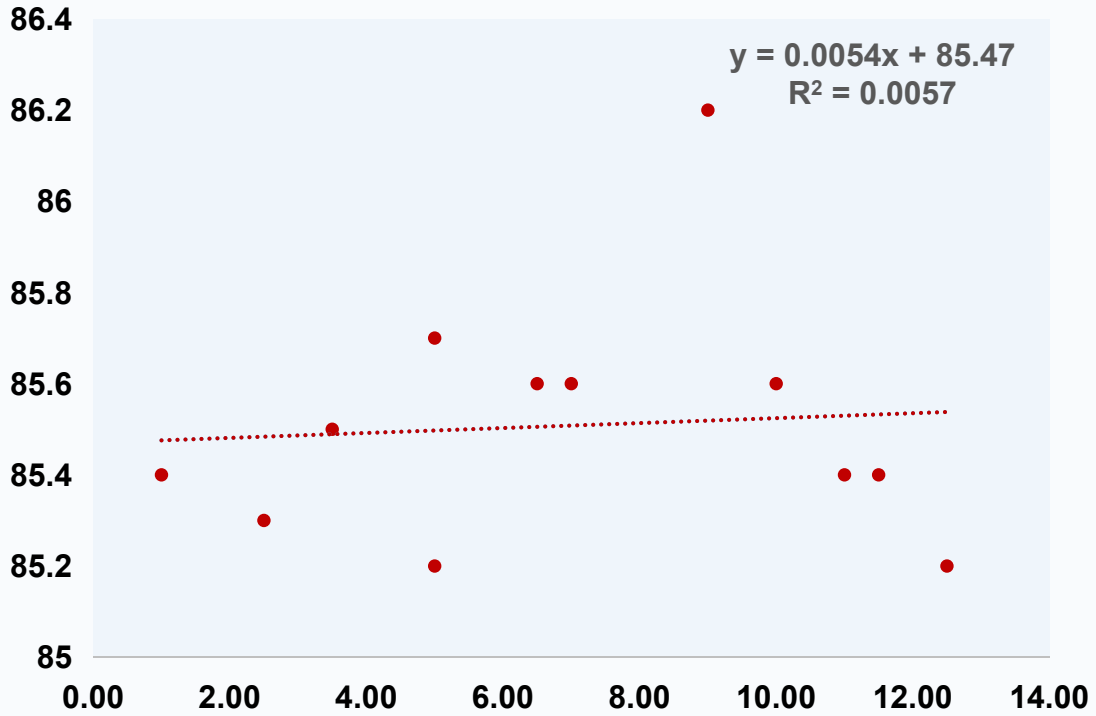
Regression Analysis: Brunch Portion Size

As the results and scatter plot demonestrate there is no significant correlation between the brunch portion size and weight loss at the level of 0.05 (F = 0.0569, df = 1 and 10, p-value = 0.82).

y = 85.47 + 0.0054 * Brunch Portion Size

Parameter	Value
Count	12
Multiple R	0.0752
R Square	0.0057
Adjusted R Square	-0.094
Intercept	85.47
Brunch Portion Size	0.0054



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Previous 12 Days DPMO Level

Considering exercise failure or consuming more than one daily brunch portion as defects, there were 5 instances of zero exercise and 5 instances of zero or more than one brunch portion within a span of 12 days. The sigma levels for both the exercise and consuming more than one daily brunch portion defects indicate a very suboptimal performance of 1.71.

Parameters	Calculation	Exercise	Brunch portion size
Total number of defects observed	D =	5	5
Total number of units processed	N =	12	12
Number of defect opportunities per unit	O =	1	1
Defects Per Opportunity	DPO =D/N*O	0.41666666667	0.41666666667
Defects per Million Opportunities	DPMO	416666.667	416666.667
Yield Rate	(1-DPO)*100	58.33%	58.33%
Sigma Level		1.71	1.71

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ANALYZE

ONE

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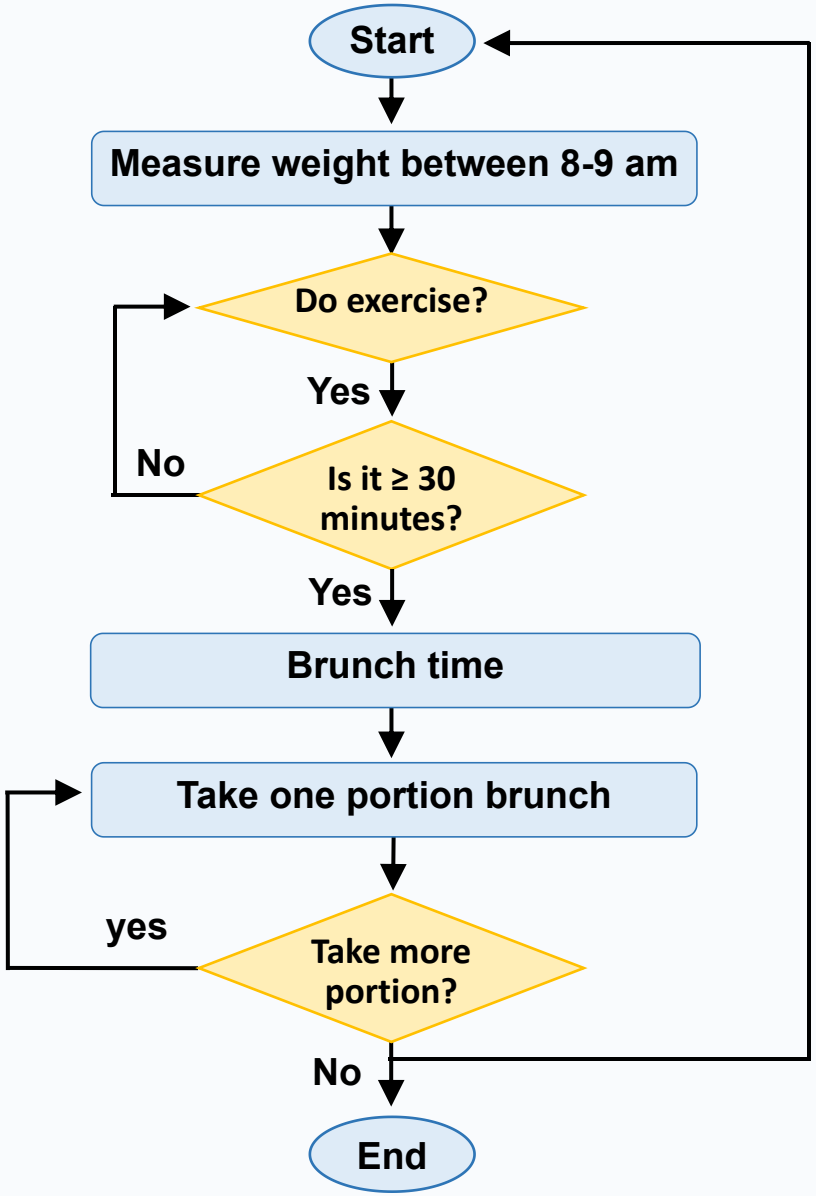
⋘ Consistent a 30-minute exercise over a regular span of 30 days.

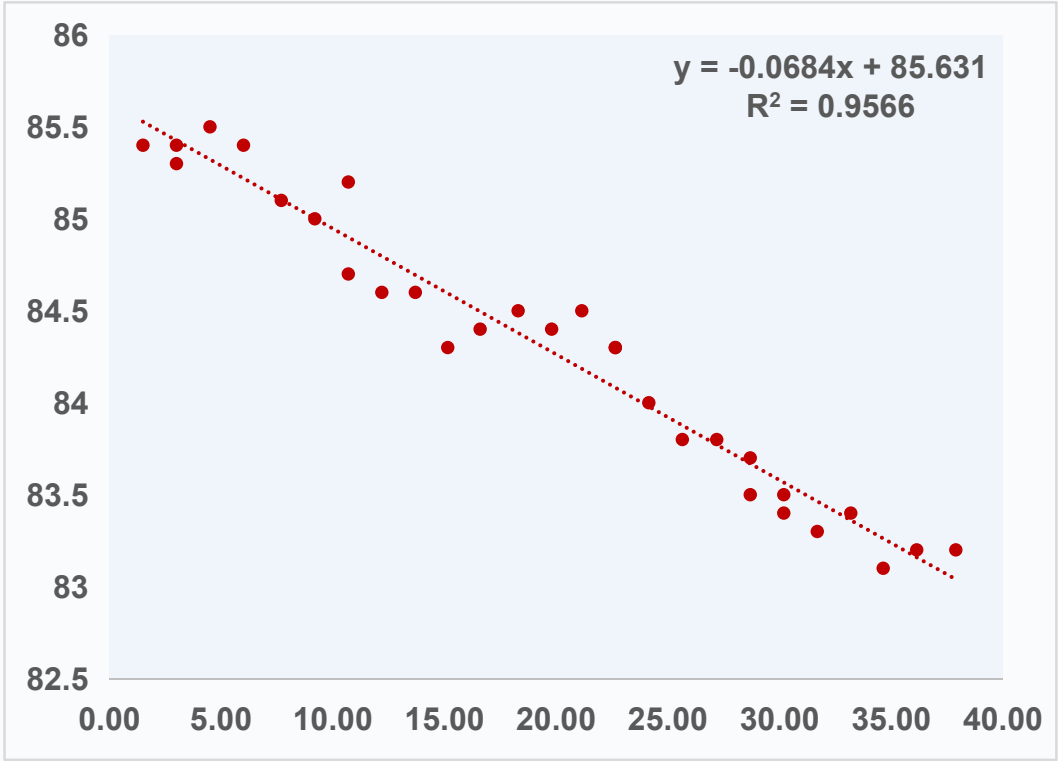


Regression Analysis: Traveled Distance

The findings and scatter plot revealed a strong negative association between the traveled distance and weight loss at a significance level of 0.05 (F = 616.76, df = 1 and 28, p-value = 1.3E-20).

y = 85.631 - 0.0684 * Traveled Distance

Parameter	Value
Count	30
Multiple R	0.978
R Square	0.9566
Adjusted R Square	0.955
Intercept	85.631
Traveled Distance	-0.0684



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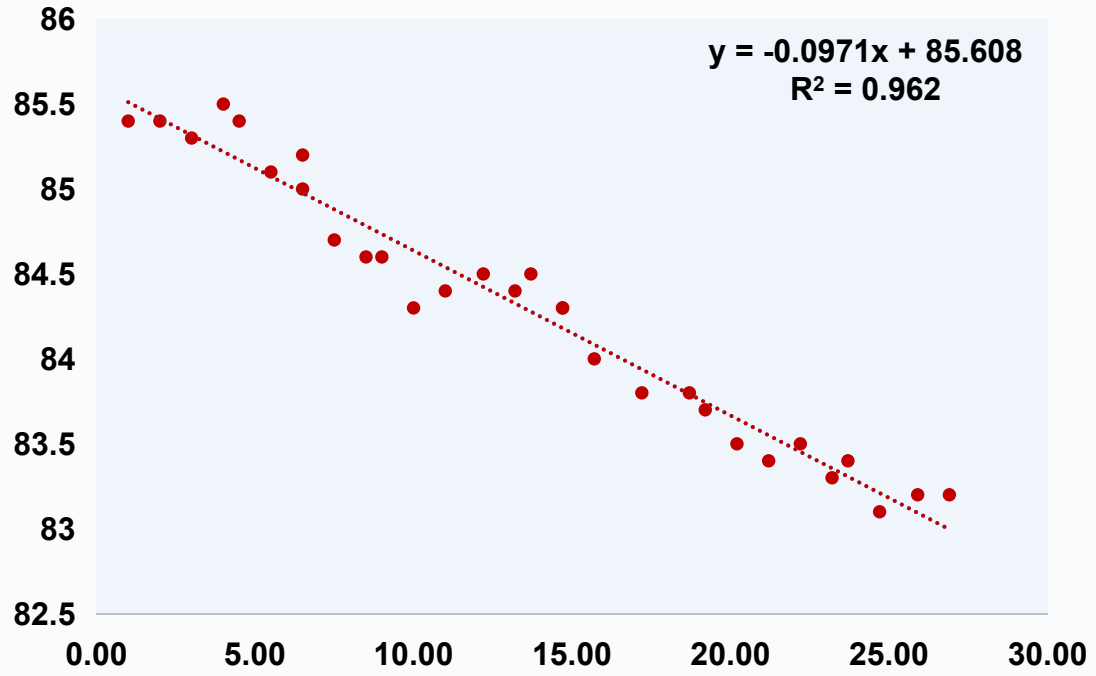
Regression Analysis: Brunch Portion Size

As the results depict there is a strong negative correlation between the brunch portion size and weight loss, at the level of 0.05 (F = 709.23, df = 1 and 28, p-value =1.98E-21).

y = 85.608 + 0.0054 * Brunch Portion Size

Parameter	Value
Count	30
Multiple R	0.9808
R Square	0.962
Adjusted R Square	0.9607
Intercept	85.608
Brunch Portion Size	-0.0971



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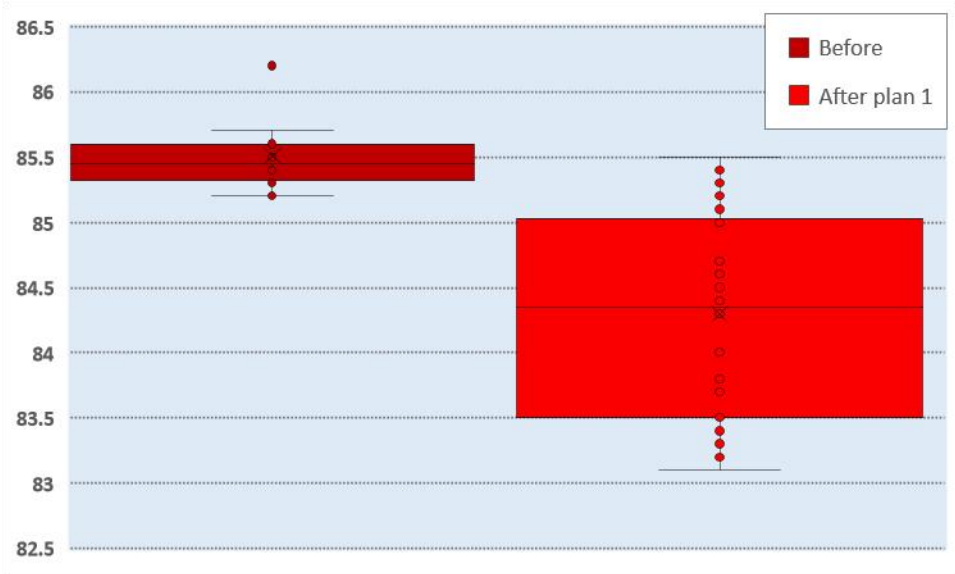
⋘ DPMO level of a 30-minute exercise consistently performed over a continuous 30-day period.

Considering exercise failure or consuming more than one daily brunch portion as defects, there were 5 instances of zero exercise and 6 instances of zero or more than one brunch portion within a span of 30 days. The sigma levels for both the exercise and consuming more than one daily brunch portion defects indicate a very suboptimal performance of 2.47 and 2.34, respectively.

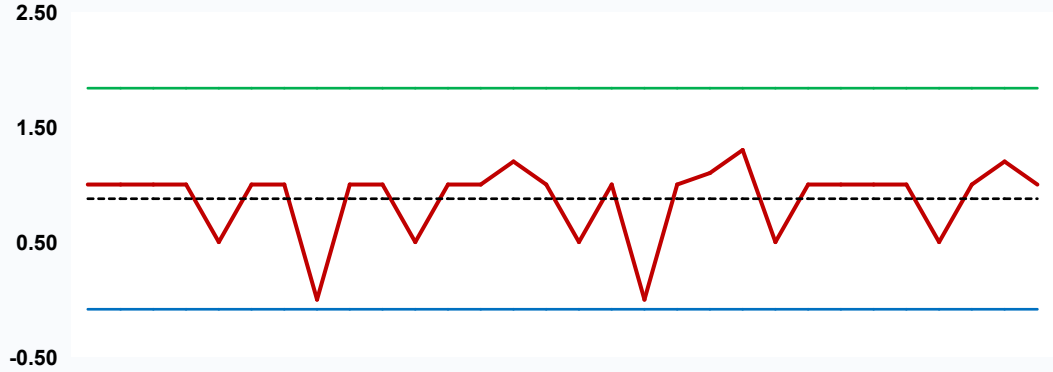
Parameters	Calculation	Exercise	Brunch portion size
Total number of defects observed	D =	5	6
Total number of units processed	N =	30	30
Number of defect opportunities per unit	O =	1	1
Defects Per Opportunity	DPO =D/N*O	0.166666667	0.2
Defects per Million Opportunities	DPMO	166666.6667	200000
Yield Rate	(1-DPO)*100	83.33%	80%
Sigma Level		2.47	2.34

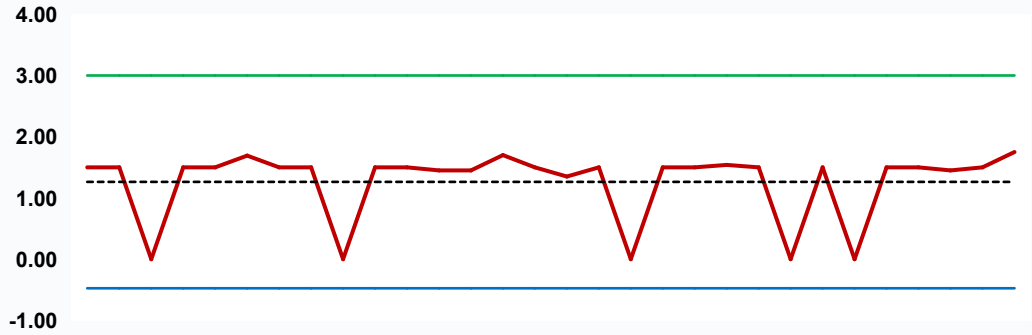
Results of t-Test (Two-Sample Assuming Unequal Variances)

A comparison of weight in kgs before and after incorporating a consistent daily 30-minute exercise over 30 days showed a substantial mean difference at a significance level of 0.05 (t = 7.557, df = 40, two-tail p-value = 3.332E-09). Consequently, the null hypothesis of zero mean difference between the two groups is rejected. Following this regimen, I achieved an average weight loss of approximately 1.215 kg, reducing from 85.508 kg to 84.293 kg.



Process Control: A 30-minute exercise consistently and consuming daily brunch portion over a continuous 30-day period.



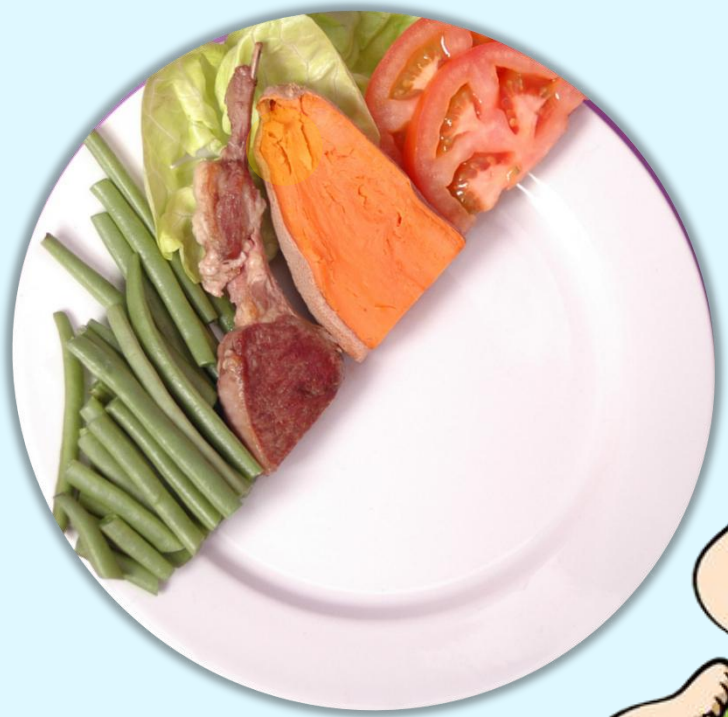


Utilizing both control charts, a 30-minute exercise (left chart) coupled with the daily consumption of one brunch portion (right chart) was executed continuously for 30 days. No outliers were identified, and all data points fall within the upper and lower control limits of -3δ to +3δ. Consequently, both charts are deemed to be in control. However, the distance between the upper and lower control limitsis is high due to size of sigma. To have a more consistent performance, it needs to a smaller tolerance.

Conclusion

Through my planned activity of **"Consistent 30-minute exercise over 30 days,"** I successfully achieved a weight loss of approximately 1.215 kg, reducing from 85.5 kg to 84.3 kg within one month. This weight loss exhibited a strong correlation with both the daily traveled distance on the treadmill and the size of the brunch portion. Control charts for both the traveled distance and brunch portion size indicated that these processes were within control over the 30-day period. To have a more consistent performance, it needs to a smaller tolerance. Overall, the first plan reached only 1.36% of the project's objective, falling short of the 4.67% weight loss goal by 3.31%.

To sustain and maintain my current weight, I have incorporated daily 30-minute exercise into my lifestyle, contributing to a reduced risk of obesity and an enhanced quality of life.



DMAIC

ANALYZE

TWO

A_2

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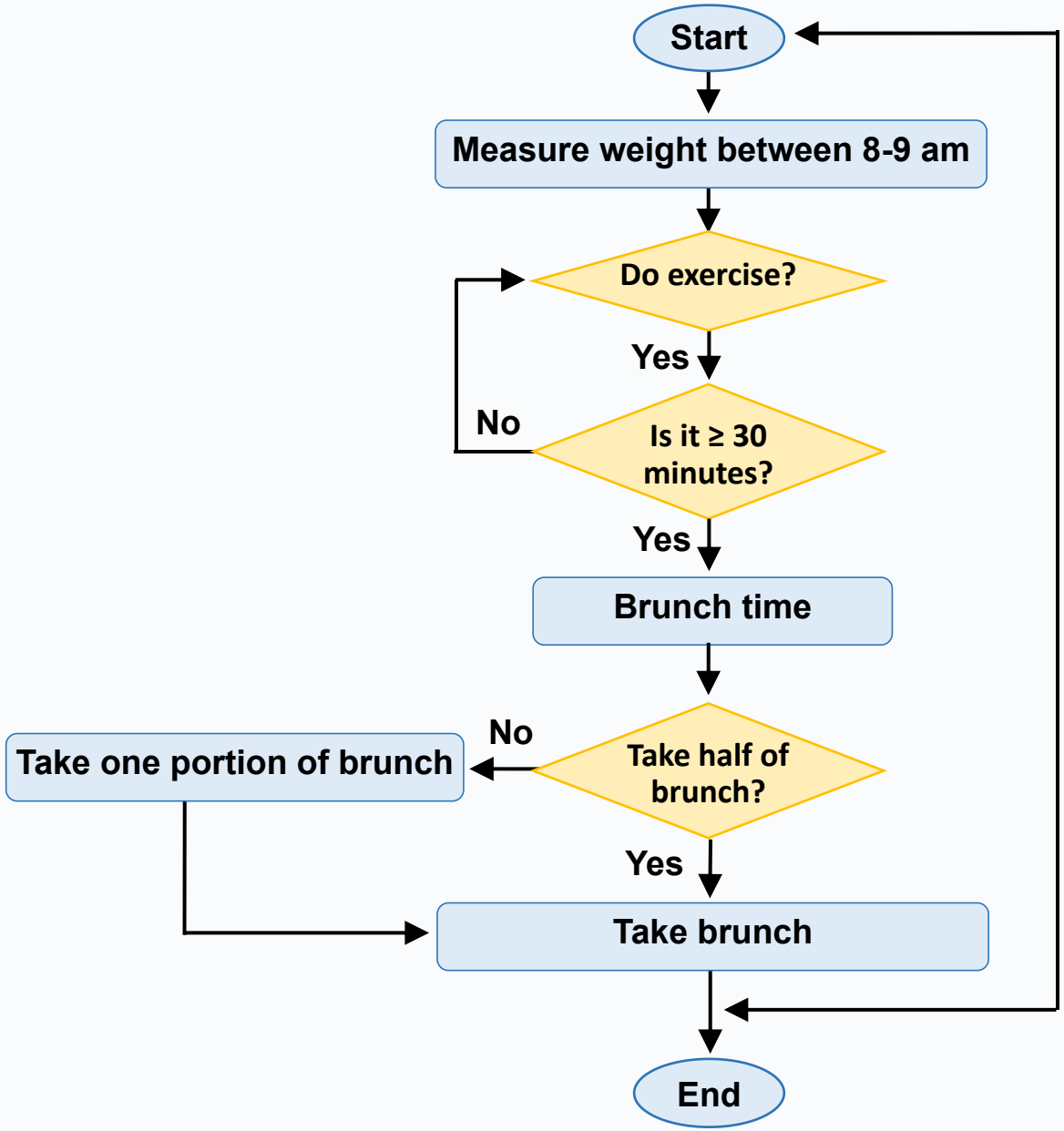
«« Consistent 30-minute exercise and reduced brunch portion to half over 31 days.

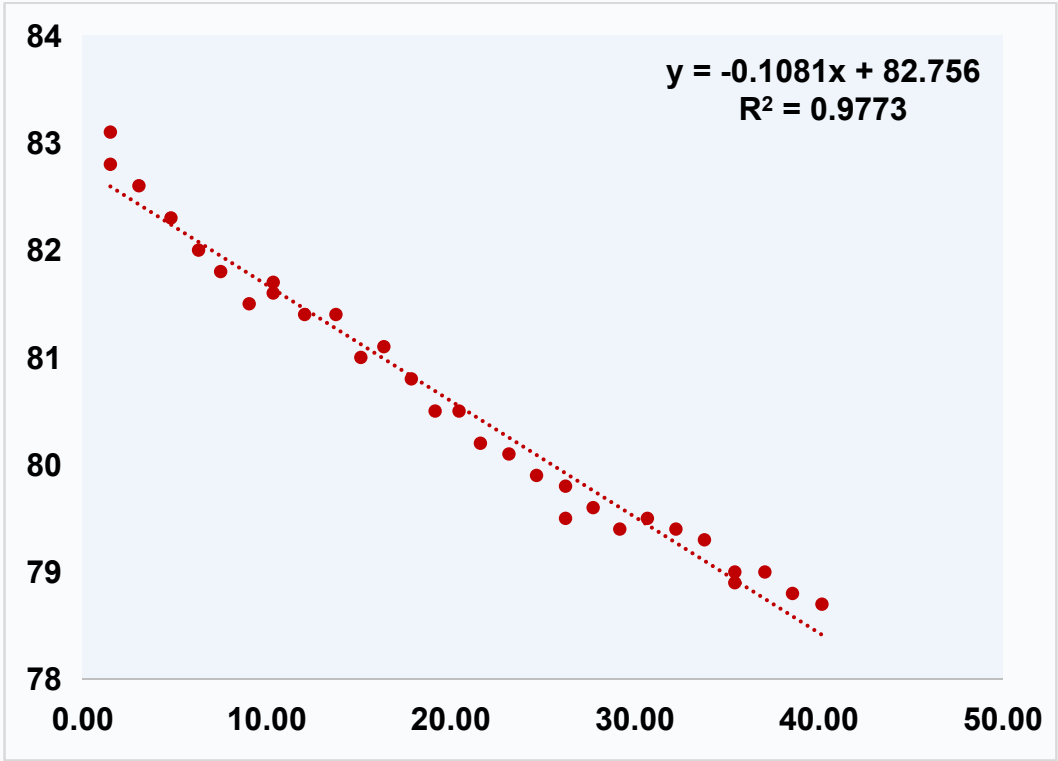


Regression Analysis: Traveled Distance

The findings and scatter plot shows a strong negative association between the traveled distance and weight loss, at a significance level of 0.05 (F = 1246.82, df = 1 and 29, p-value = 2.2E-25).

y = 82.7557 - 0.1081 * Traveled Distance

Parameter	Value
Count	31
Multiple R	0.9885
R Square	0.9773
Adjusted R Square	0.9765
Intercept	82.756
Traveled Distance	-0.1081



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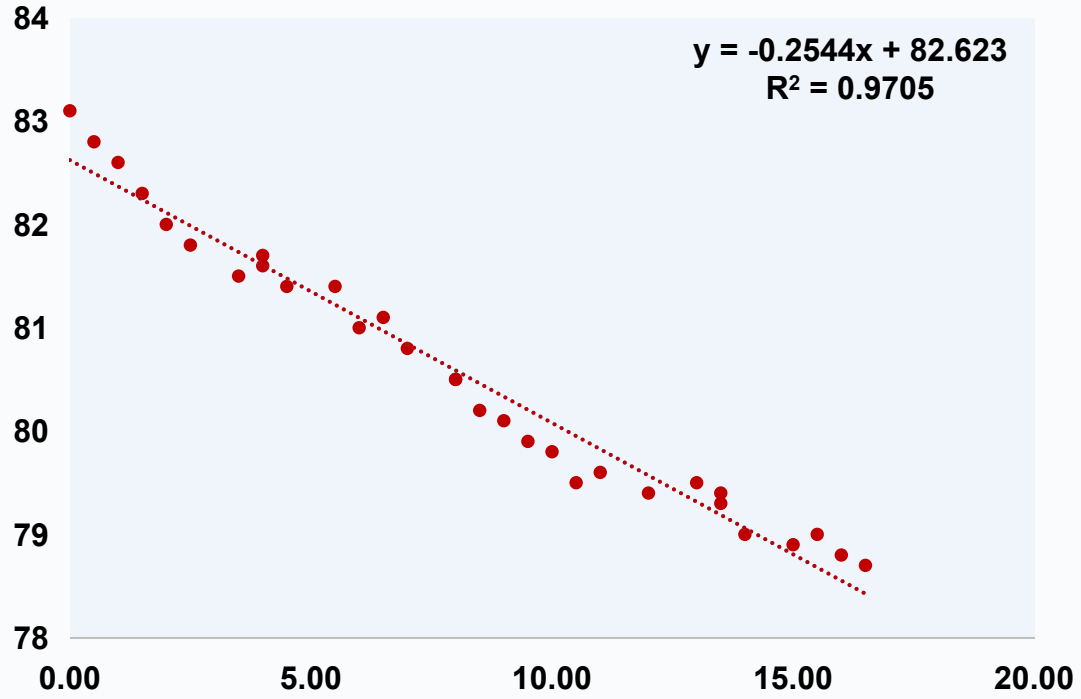
Regression Analysis: Brunch Portion Size

As the results depict there is a strong negative correlation between the brunch portion size and weight loss, at the level of 0.05 (F = 954.1, df = 1 and 29, p-value =9.7E-24).

y = 82.623 - 0.2544 * Brunch Portion Size

Parameter	Value
Count	31
Multiple R	0.9705
R Square	0.005
Adjusted R Square	0.9695
Intercept	82.623
Brunch Portion Size	-0.2544



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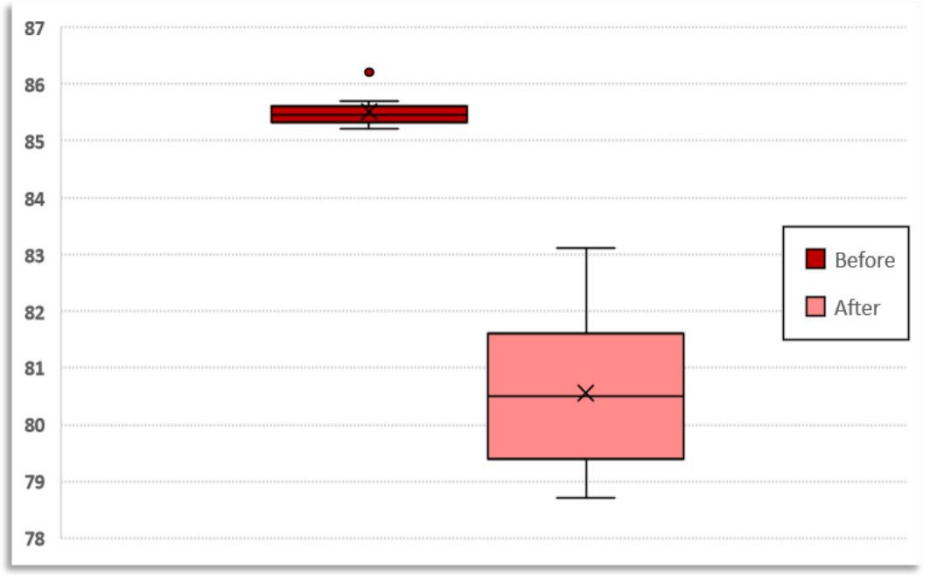
«« DPMO level of a 30-minute exercise and reduced brunch portion to half over 31 days.

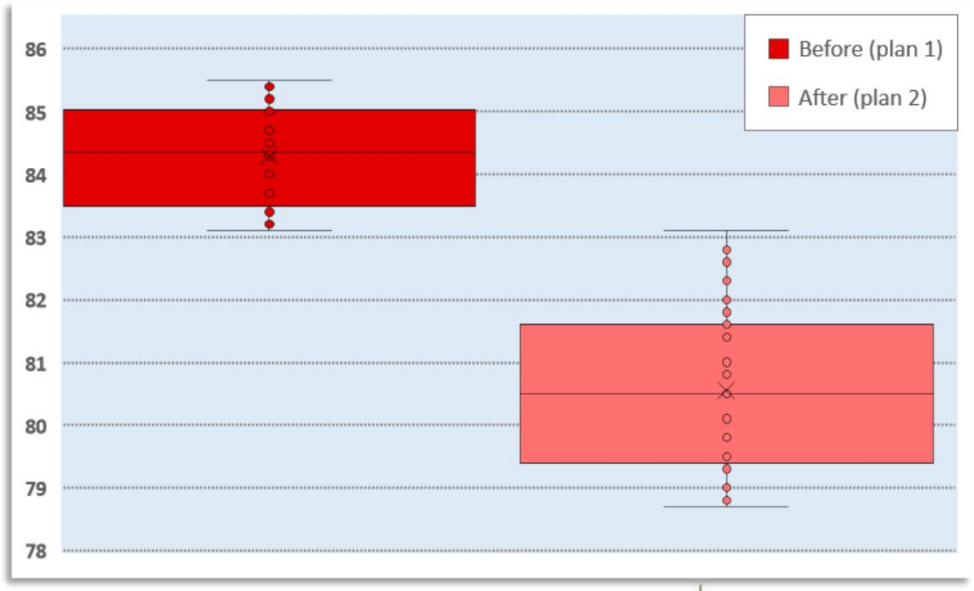
Considering exercise failure or consuming more than one daily brunch portion as defects, there were 3 instances of zero exercise and 8 instances of zero or more than one brunch portion within a span of 31 days. The sigma levels for both the exercise and consuming more than one daily brunch portion defects indicate a very suboptimal performance of 2.80 and 2.15, respectively.

Parameters	Calculation	Exercise	Brunch portion size
Total number of defects observed	D =	3	8
Total number of units processed	N =	31	31
Number of defect opportunities per unit	O =	1	1
Defects Per Opportunity	DPO =D/N*O	0.096774194	0.258064516
Defects per Million Opportunities	DPMO	96774.19355	258064.5161
Yield Rate	(1-DPO)*100	90.32%	74.19%
Sigma Level		2.80	2.15

Results of t-Test (Two-Sample Assuming Unequal Variances)

A comparison of weight in kgs before and after incorporating a consistent daily 30-minute exercise over 30 days showed a substantial mean difference at a significance level of 0.05 (t = 13.743, df = 49, two-tail p-value = 1.95834E-18). Consequently, the null hypothesis of zero mean difference between the two groups is rejected. Following this regimen, I achieved an average weight loss of approximately 3.74 kg, reducing from 84.29 kg to 80.56 kg.





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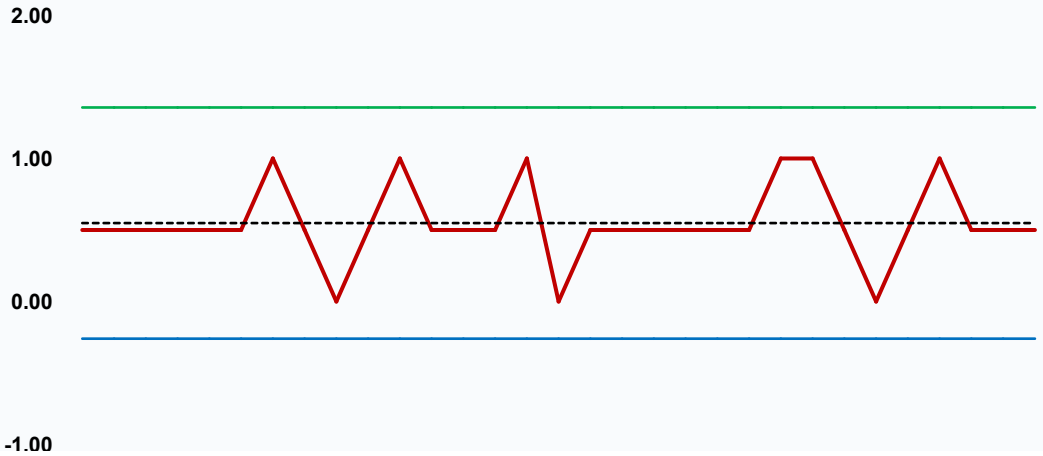
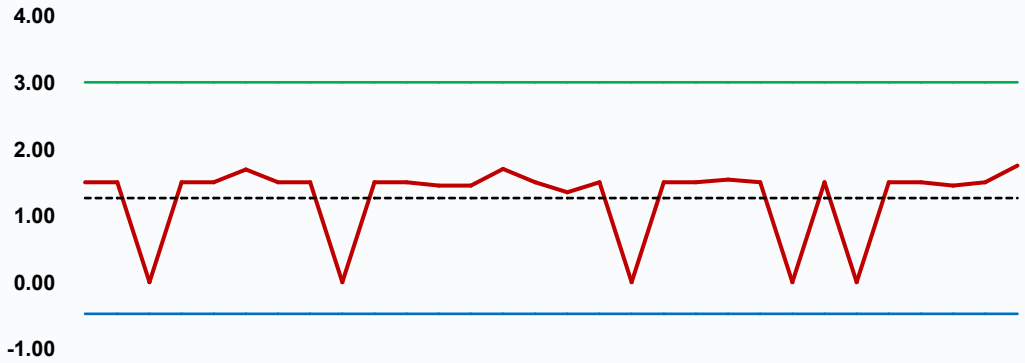
Process Control: A 30-minute exercise consistently and reduced brunch portion to half over a continuous 31-day period.





Utilizing both control charts, a 30-minute exercise (left chart) coupled with the daily consumption of reduced brunch portion to half (right chart) was executed continuously for 31 days. No outliers were identified, and all data points fall within the upper and lower control limits of -3δ to +3δ. Consequently, both charts are deemed to be in control. However, the distance between the upper and lower control limitsis is high due to size of sigma. To have a more consistent performance, it needs to a smaller tolerance.

Conclusion

Through my planned activity of **"a 30-minute exercise and reduced brunch portion to half over 31 days,"** I successfully achieved a weight loss of approximately 3.74 kg, reducing from 84.29 kg to 80.56 kg within one month. This weight loss exhibited a strong correlation with the reduced brunch portion to half. Control charts for both the traveled distance and brunch portion size indicated that these processes were within control over the 31-day period. However, the plan only reached 4.2% of the project's objective, falling short of the 4.67% (4.17 kg) weight loss goal by 0.48%.

To sustain and maintain my current weight, I have incorporated daily 30-minute exercise into my lifestyle together with reduction of my brunch portion size to half, contributing to a reduced risk of obesity and an enhanced quality of life.

13 days

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ANALYZE

A_3 THREE

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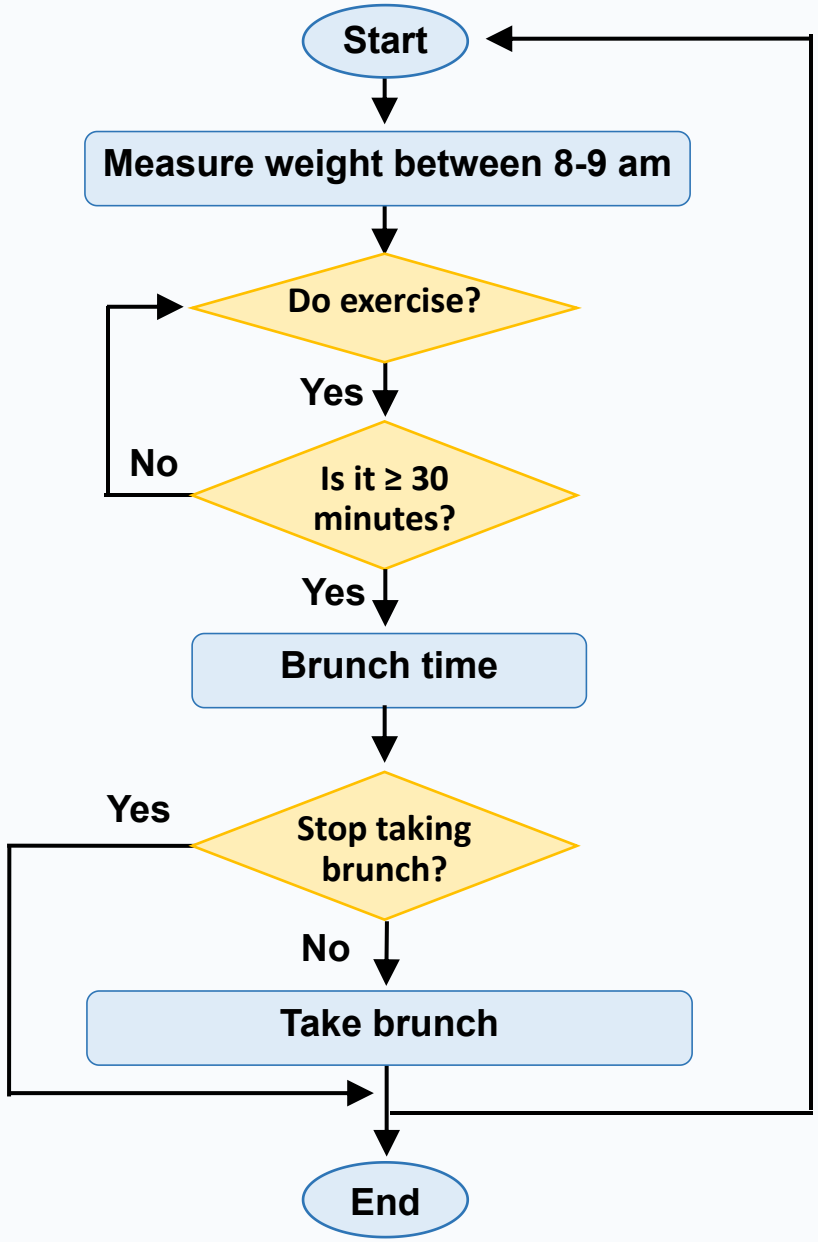
⋘ Consistent daily 30-minute exercise and 12 days fasting for brunch over a regular span of 30 days.

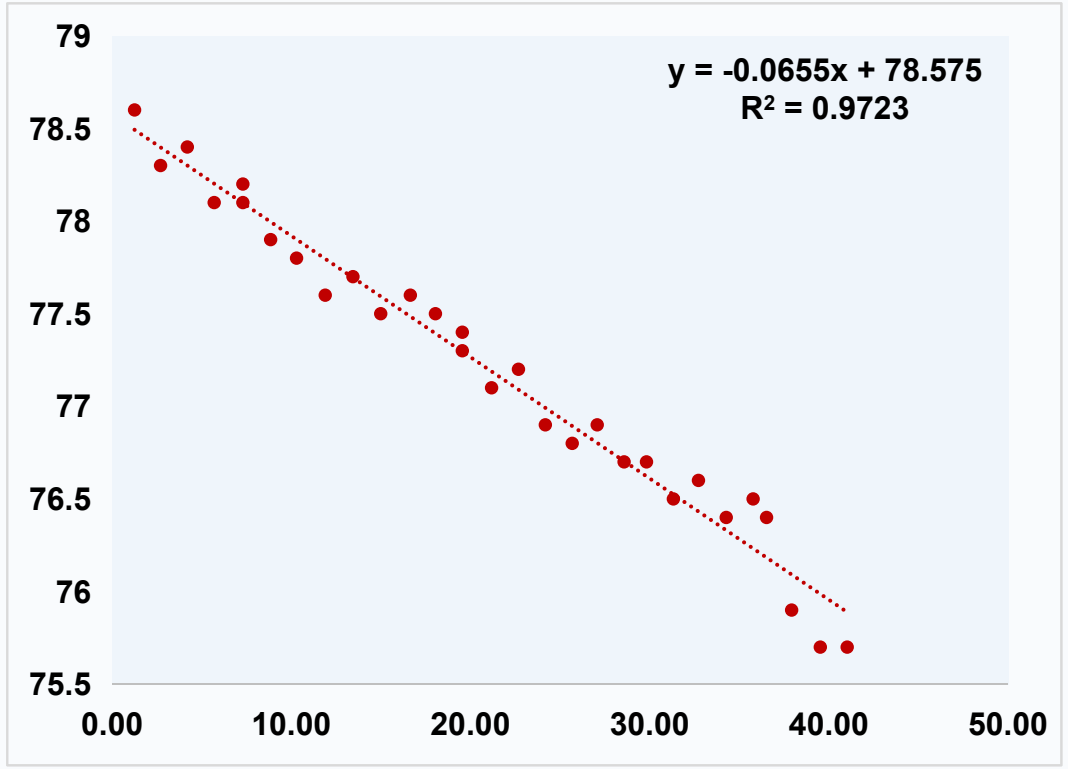


Regression Analysis: Traveled Distance

The findings and scatter plot identifies a strong negative association between the traveled distance and weight loss at a significance level of 0.05 (F = 982.9, df = 1 and 28, p-value = 2.4E-23).

y = 78.575 - 0.0655 * Traveled Distance

Parameter	Value
Count	30
Multiple R	0.9861
R Square	0.9723
Adjusted R Square	0.9713
Intercept	78.575
Traveled Distance	-0.0655



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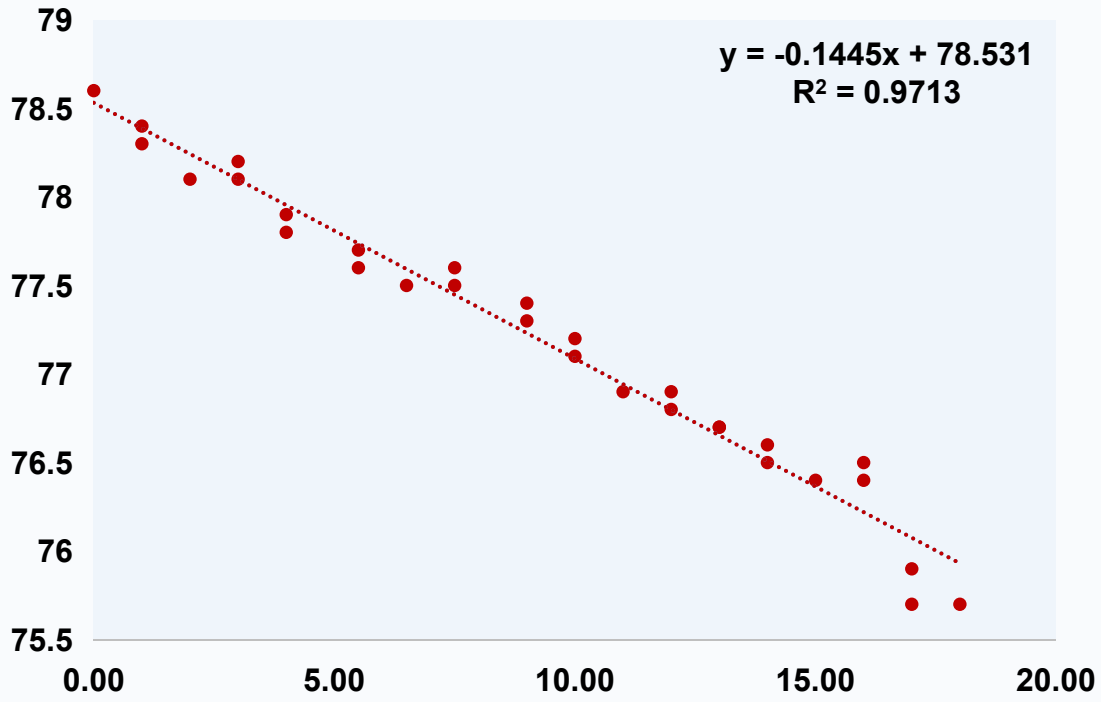
Regression Analysis: Brunch Portion Size

As the results depict there is a strong negative correlation between the brunch portion size and weight loss, at the level of 0.05 (F = 946.9, df = 1 and 28, p-value =3.9E-23).

y = 85.47 + 0.0054 * Brunch Portion Size

Parameter	Value
Count	30
Multiple R	0.9855
R Square	0.9713
Adjusted R Square	0.9703
Intercept	78.531
Brunch Portion Size	-0.1445



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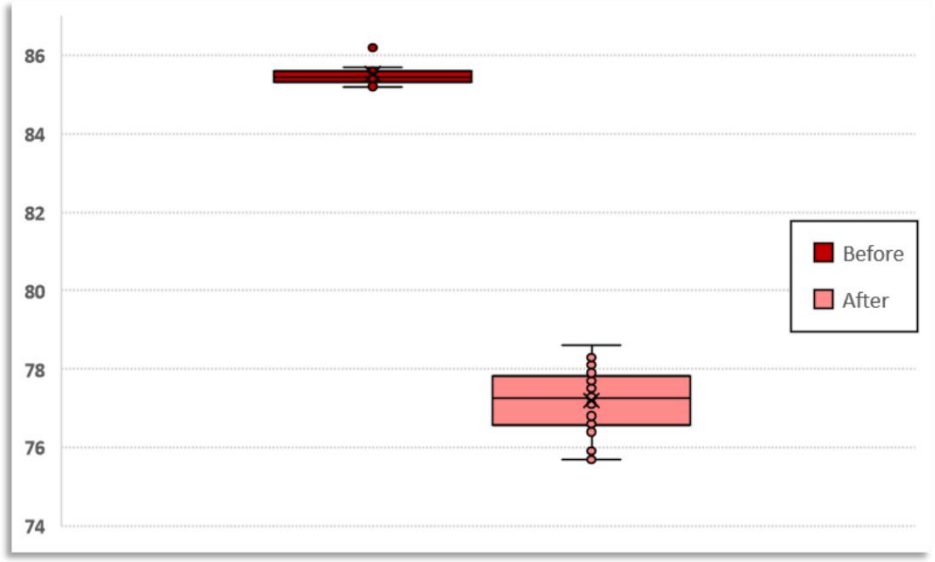
⋘ DPMO level of a 30-minute exercise and 13 days fasting for brunch over a regular span of 30 days.

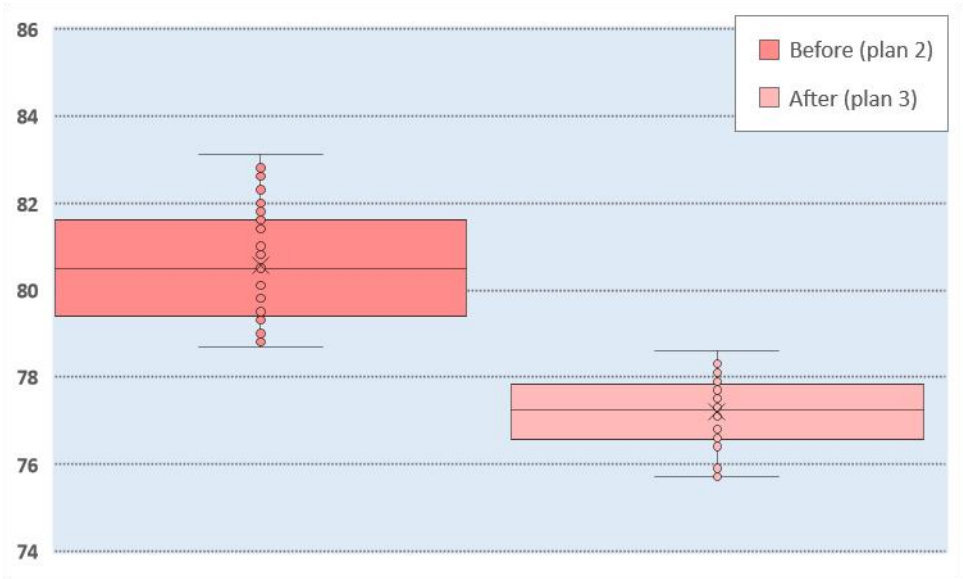
Considering exercise failure or consuming more than one daily brunch portion as defects, there were 2 instances of zero exercise and 2 instances of zero or more than one brunch portion within a span of 30 days. The sigma levels for both the exercise and consuming more than one daily brunch portion defects indicate a very suboptimal performance of 3.0 and 3.0, respectively.

Parameters	Calculation	Exercise	Brunch portion size
Total number of defects observed	D =	2	2
Total number of units processed	N =	30	30
Number of defect opportunities per unit	O =	1	1
Defects Per Opportunity	DPO =D/N*O	0.066666667	0.066666667
Defects per Million Opportunities	DPMO	66666.66667	66666.66667
Yield Rate	(1-DPO)*100	93.33%	93.33%
Sigma Level		3.00	3.00

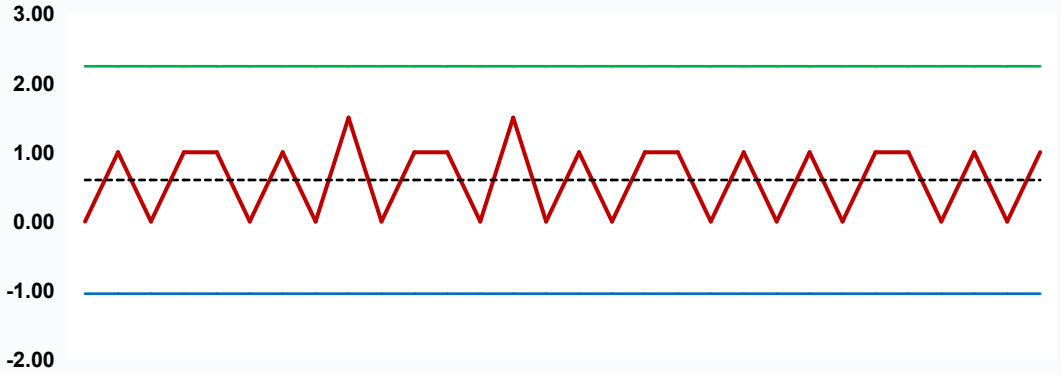
Results of t-Test (Two-Sample Assuming Unequal Variances)

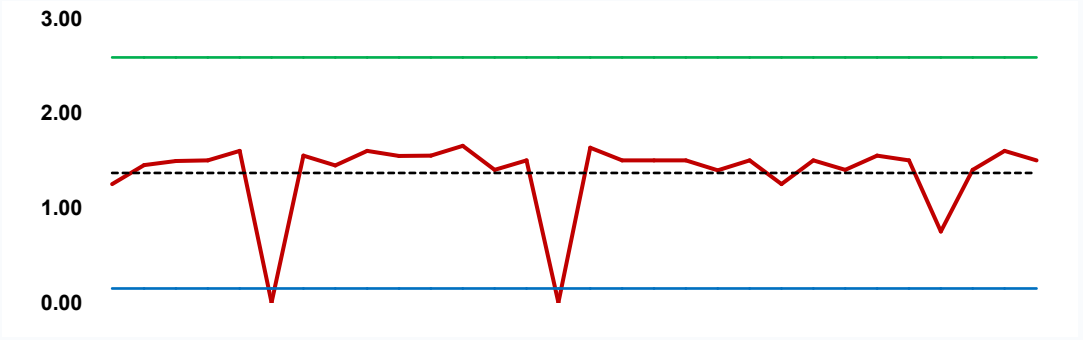
A comparison of weight in kgs before and after incorporating a consistent daily 30-minute exercise over 30 days showed a substantial mean difference at a significance level of 0.05 (t = 12.2, df = 50, two-tail p-value = 1.3E-16). Consequently, the null hypothesis of zero mean difference between the two groups is rejected. Following this regimen, I achieved an average weight loss of approximately 3.36 kg, reducing from 80.56 to 77.2 kg.





«« Process Control: A 30-minute exercise consistently and 13 days fasting for brunch over a regular span of 30 days.





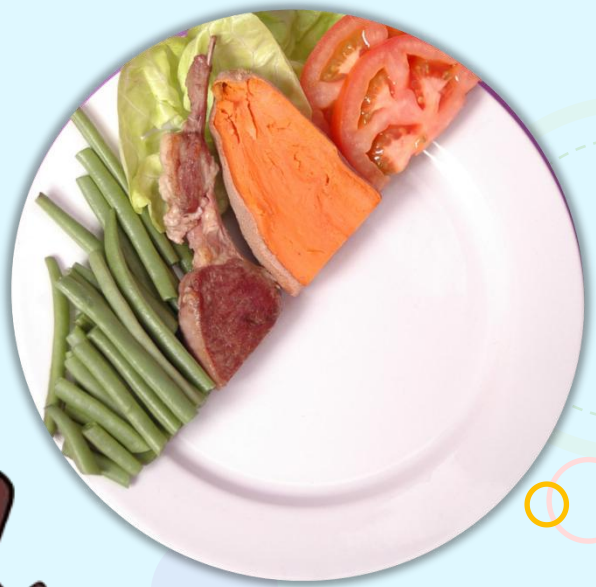
Leveraging both control charts, a 30-minute exercise (right chart) combined with the 13 days of fasting for brunch (left chart) was consistently implemented over a 30-day period. The left chart is within control; however, the presence of two outliers beyond the lower control limit of right chart requires investigation. The days exhibiting outliers need to be examined, indicating that the 30-minute exercise may not be under control, necessitating further scrutiny. Moreover,The distance between the upper and lower control limitsis is high due to size of sigma. To have a more consistent performance, it needs to a smaller tolerance.

Conclusion

Through my planned activity of **"a 30-minute exercise and and 13 days fasting for brunch over a regular span of 30 days,"** I successfully achieved a weight loss of approximately 3.36 kg, reducing from 80.56 kg to 77.2 kg within one month. This weight loss exhibited a strong correlation with the reduced brunch portion to half. Control charts for the fasting for brunch over a regular span of 30 days was within control over the 30-day period whereas the traveled distance was not due to the presence of two outliers beyond the lower control limit hence the 30-minute exerciseneeds further scrutiny. This plan only reached 3.76% of the project's objective, falling short of the 4.67% (4.17 kg) weight loss goal by 0.91%.

To sustain and maintain my current weight, I have incorporated daily 30-minute exercise into my lifestyle together with reduction of my brunch portion size to half, contributing to a reduced risk of obesity and an enhanced quality of life.

13 days



DMAIC

ANALYZE

A_T TOTAL

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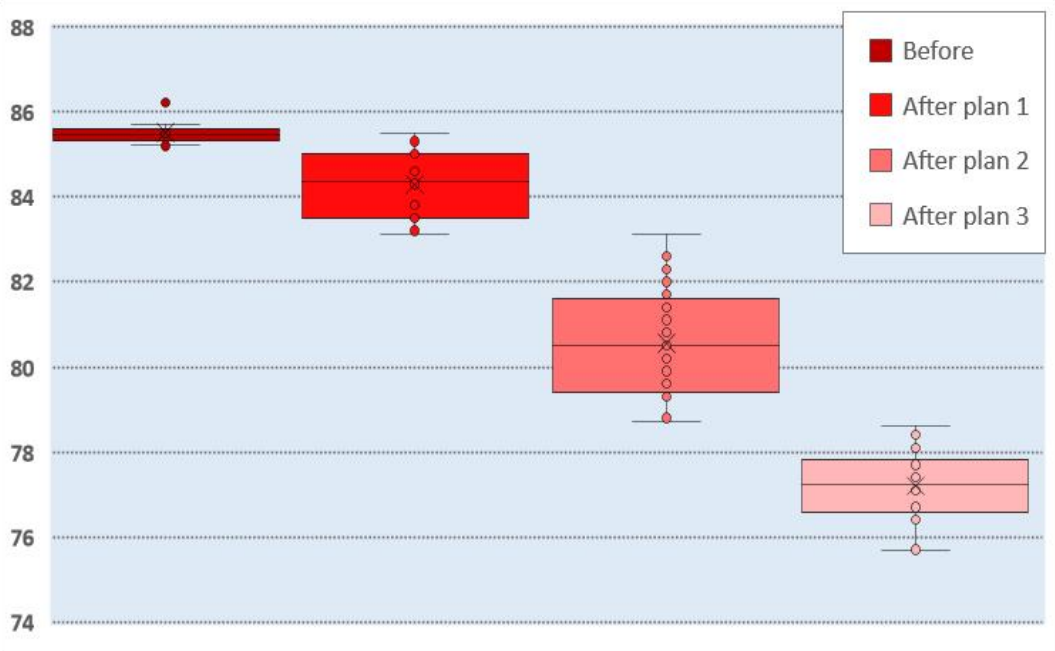
One-factor ANOVA model Results

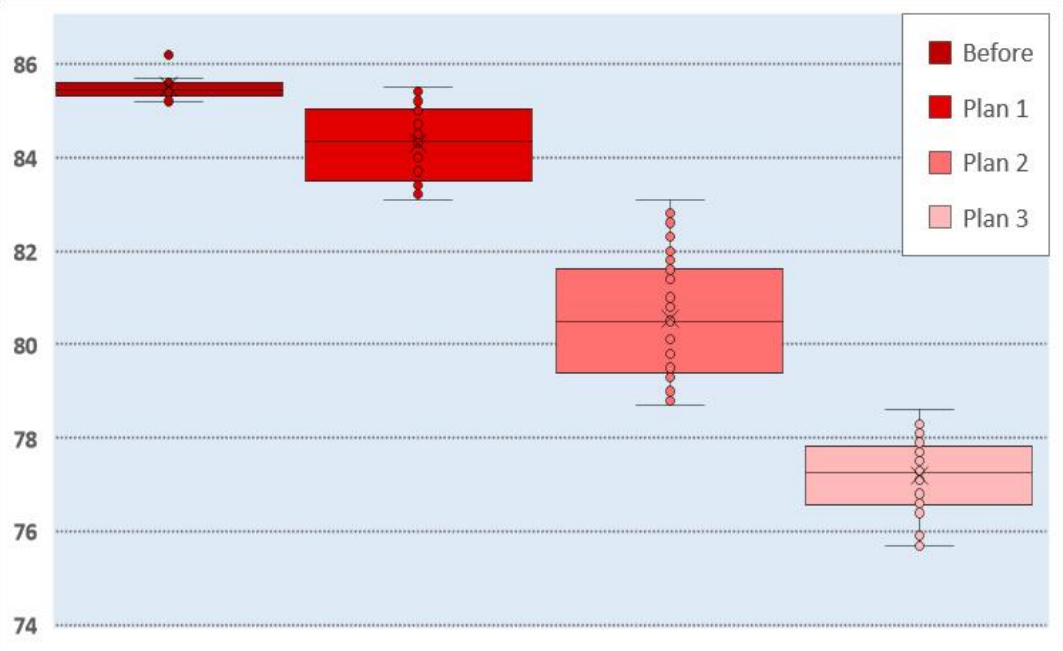
The outcomes from the comparison of mean weight loss among the Previous (n = 12, 85.51 ± 0.27), Weight1 (n = 30, 84.29 ± 0.77), Weight2 (n = 31, 80.55 ± 1.30), and Weight3 (n = 30, 77.20 ± 0.80) groups, utilizing a one-factor ANOVA model, decisively reject the null hypothesis asserting equal means across all groups (F = 380.33, df = 102, p = 3.51E-54). Consequently, it is clear that the mean of at least one group is significantly distinct from the others



Pairwise Comparison Results

A post hoc examination employing Tukey's Honest Significant Difference (HSD) method was conducted to evaluate the significance of differences between pairs of means within the four groups. The findings demonstrated a significant difference between all pairs of tested groups.

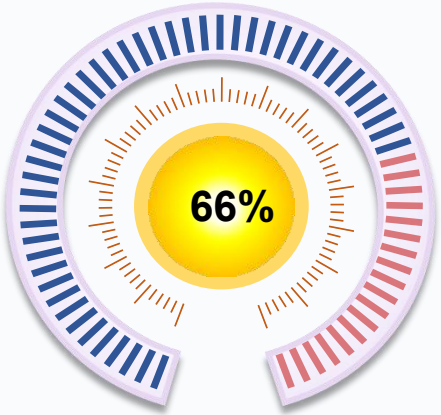
- Previous vs Weight1: p = 4.42507E-06
- Previous vs Weight2: p = 3.66778E-16
- Previous vs Weight3: p = 1.30908E-31
- Weight1 vs Weight2: p = 6.89448E-20
- Weight1 vs Weight3: p = 1.03975E-40
- Weight2 vs Weight3: p = 1.21829E-17



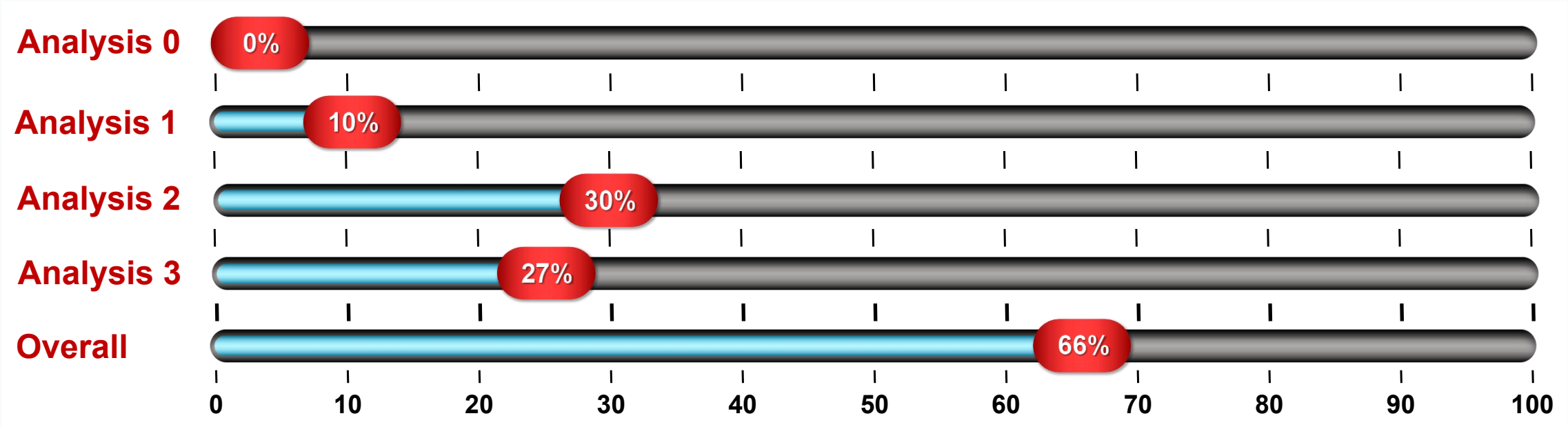
Conclusion

Through my three planned activities of **"30-minute exercise in the first month, reducing brunch portion size to half in the second month, and incorporating 13 days of fasting in the third month,"** I successfully achieved a weight loss of approximately 8.23 kg, reducing from 85.5 kg to 77.2 kg within three months. Despite this accomplishment, the three plans reached only 9.32% of the project's objective (first month: 1.36%, second month: 4.2%, and third month: 3.76%), falling short of the 14% weight loss goal by 4.7%, and my weight still is in the obesity range. The second month plan was more successful than other two month plans.

To maintain my current weight and achieve the target weight loss of 14%, I will integrate a daily 30-minute exercise, reduced brunch portion size to half, and at least three days fasting every week into my lifestyle. This lifestyle change aims to contribute to a reduced risk of obesity and an enhanced quality of life.



We accomplished 66.4% of the predicted weight loss. The effectiveness of the second plan was more than others, attributed to daily halving brunch portion sizes in 30 days along with 30-minute exercise.



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