

INTRODUCTION AND PURPOSE OF THE EXPERIMENT

Our friend Adam is 45 years old, in good physical shape, and has no health problems. His primary activity is cycling – about 150 minutes a week at a moderate pace. At 185 cm tall, he weighed 87 kg, which is considered overweight, so Adam decided to lose weight. During a visit to a dietitian, he learned that reducing his calorie intake would be crucial. Reducing his daily intake by 400 kcal should result in an average weight loss of about 0.5 kg per week.

The aim of the experiment was to test whether additional factors often considered to aid weight loss could actually accelerate Adam's weight loss. The factors to be tested are presented in the prediction table below.

Factor	Level -1	Level +1	Theory/predictions
A: Calorie source	Standard diet: Protein 10-15%, Carbohydrates 40-45%, other: vegetable fat	High protein diet: Protein 35-40%, Carbohydrates 30-35%, other: vegetable fat	There are many theories and experts who claim, that higher protein intake leads to better regulation of hunger and that the body needs more energy to burn protein compared to carbohydrates.
B: Number of meals	2	5	There are theories that frequent meals increase metabolism.
C: Physical activity time [min/week]	150	300	150 minutes per week is the minimum recommended amount of physical activity Adam strives to maintain. We expect that doubling this amount should significantly accelerate his weight loss.
D: Type of physical activity	running	cycling	Adam prefers cycling, but he is willing to switch to running if he reaches his desired body weight faster.
E: Protein source	100% unprocessed food	50-60 % wysoko przetworzone źródła białka	Currently, there are many high-protein fitness products available, we want to check whether they fulfill their functions in the weight loss process.
F: Breakfast	Yes - up to an hour after waking up	No	Adam doesn't like breakfast and only feels hungry around noon. If this is the cause of his weight problems, we should see the effect of this factor.
G: Water with vinegar on an empty stomach	Yes	No	Many people claim that it improves blood sugar control, reduces appetite, and facilitates digestion, so we want to see if it's worth the hassle of drinking this mixture.
H: Supplementation	None	L carnitine	In theory, it helps transport fat for burning, we'll see if it makes a difference to Adam's progress

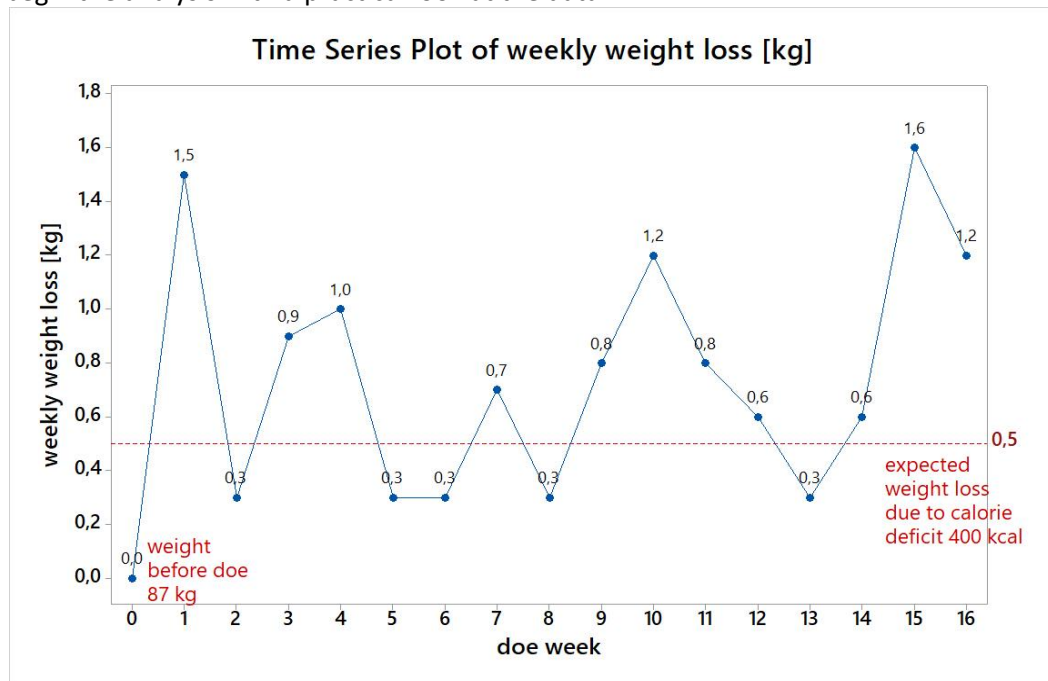
To test eight factors at two levels, we used a fractional experiment ($2_{IV}^{8-4}=16$ runs). The entire experiment lasted 16 weeks – each week was one run.

Adam always weighed himself on Monday mornings, and the main outcome measured during this DOE was weight loss in kilograms compared to the previous week. Throughout the entire experiment, Adam maintained a calorie deficit (–400 kcal per day) and drank approximately 3 liters of water each day. A detailed experimental design is presented in the DOE matrix below.

Week	A: Source of calories	B: Number of meals	C: Exercise time [min/week]	D: Type of activity	E: Protein source	F: Breakfast	G: Water with vinegar on an empty stomach	H: Supplementation	weekly weight loss [kg]	weight (kg)
1	High Protein Diet	4	300	Running	Unprocessed	Yes	No	None	1,5	85,5
2	Standard	2	150	Cycling	Highly processed	No	Yes	L Carnitine	0,4	85,1
3	Standard	4	300	Running	Unprocessed	No	Yes	L Carnitine	1	84,1
4	Standard	2	300	Cycling	Unprocessed	Yes	No	L Carnitine	1	83,1
5	Standard	2	150	Running	Unprocessed	Yes	Yes	None	0,3	82,8
6	Standard	4	150	Running	Highly processed	Yes	No	L Carnitine	0,3	82,5
7	High Protein Diet	2	150	Running	Unprocessed	No	No	L Carnitine	0,7	81,8
8	High Protein Diet	2	150	Cycling	Highly processed	Yes	No	None	0,4	81,4
9	Standard	2	300	Running	Highly processed	No	No	None	0,8	80,6
10	High Protein Diet	2	300	Running	Highly processed	Yes	Yes	L Carnitine	1,3	79,3
11	Standard	4	300	Cycling	Highly processed	Yes	Yes	None	0,8	78,5
12	Standard	4	150	Cycling	Unprocessed	No	No	None	0,6	77,9
13	High Protein Diet	4	150	Running	Highly processed	No	Yes	None	0,3	77,6
14	High Protein Diet	4	150	Cycling	Unprocessed	Yes	Yes	L Carnitine	0,6	77
15	High Protein Diet	2	300	Cycling	Unprocessed	No	Yes	None	1,6	75,4
16	High Protein Diet	4	300	Cycling	Highly processed	No	No	L Carnitine	1,2	74,2

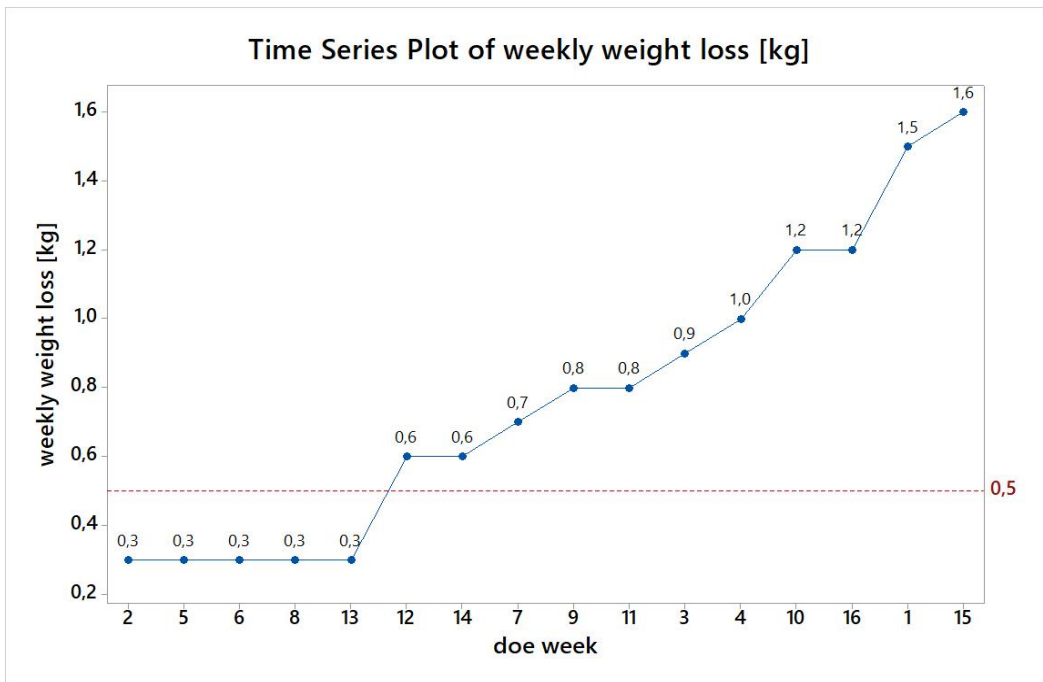
EXPERIMENT ANALYSIS

We will begin the analysis with a practical look at the data.

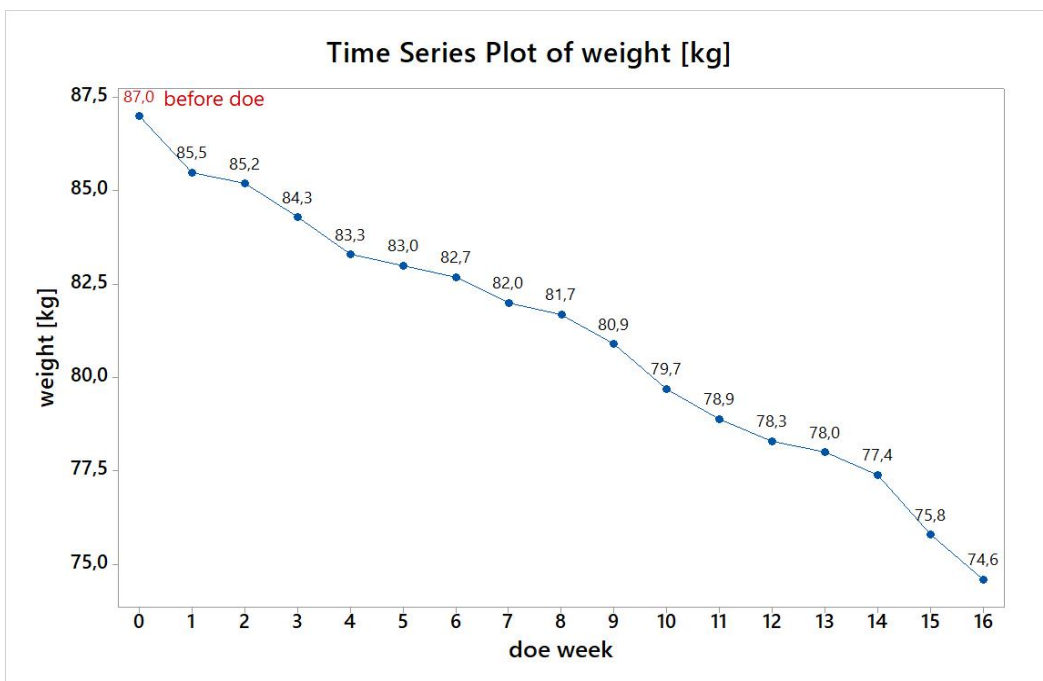


During the experiment, Adam lost between 0.3 and 1.6 kg (1.7 to 3.3 lbs) per week. The projected weight loss, thanks to maintaining a calorie deficit, was approximately 0.5 kg (1.1 lbs) per week. The significant variation in the results, sometimes significantly exceeding the predicted weight loss, indicates that the tested factors influenced the rate of weight loss.

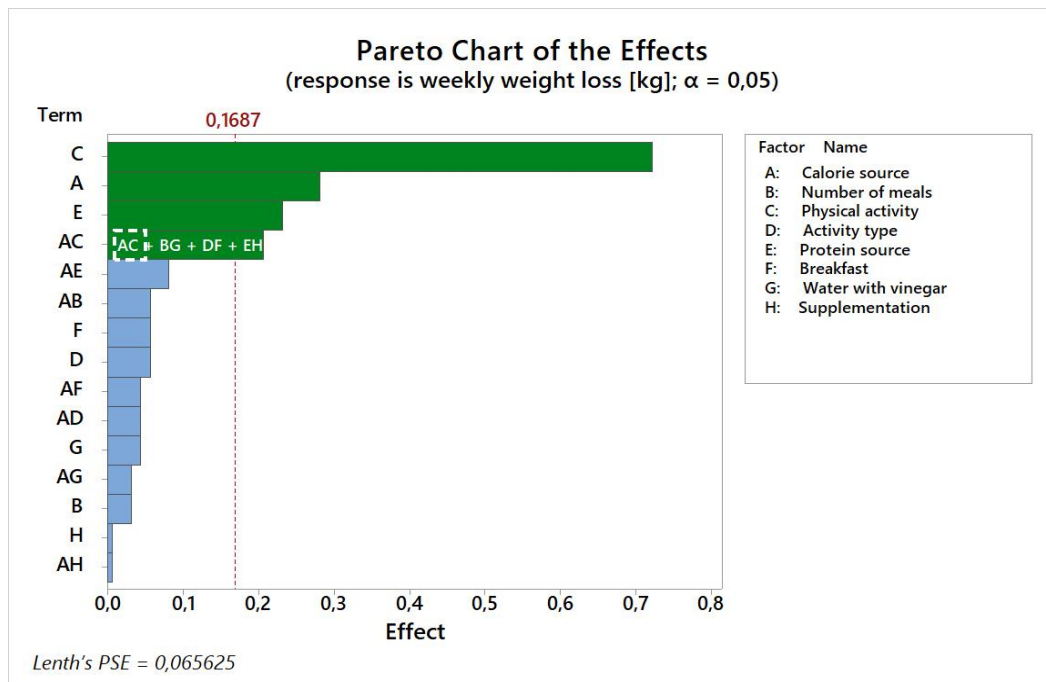
There is no apparent relationship between the passage of time and Adam's weight loss – weeks with large and small weight loss occurred randomly. This indicates that the variation in this DOE was caused by the tested factors and not by anything that changed over the 16 weeks of the experiment.



Plotting the DOE results sorted from minimum to maximum, we observe a steady decline in Adam's weight. The lack of points with significant positive or negative deviations indicates that the variation in this experiment was created by the factors tested at the given levels – no special cause variation occurred during the DOE.



Adam, who weighed 87 kg before the experiment, reached 74.6 kg after 16 weeks. This weight loss was achieved both by reducing his calorie intake and by using some of the factors tested in this DOE. So let's see which of these factors helped Adam lose weight.

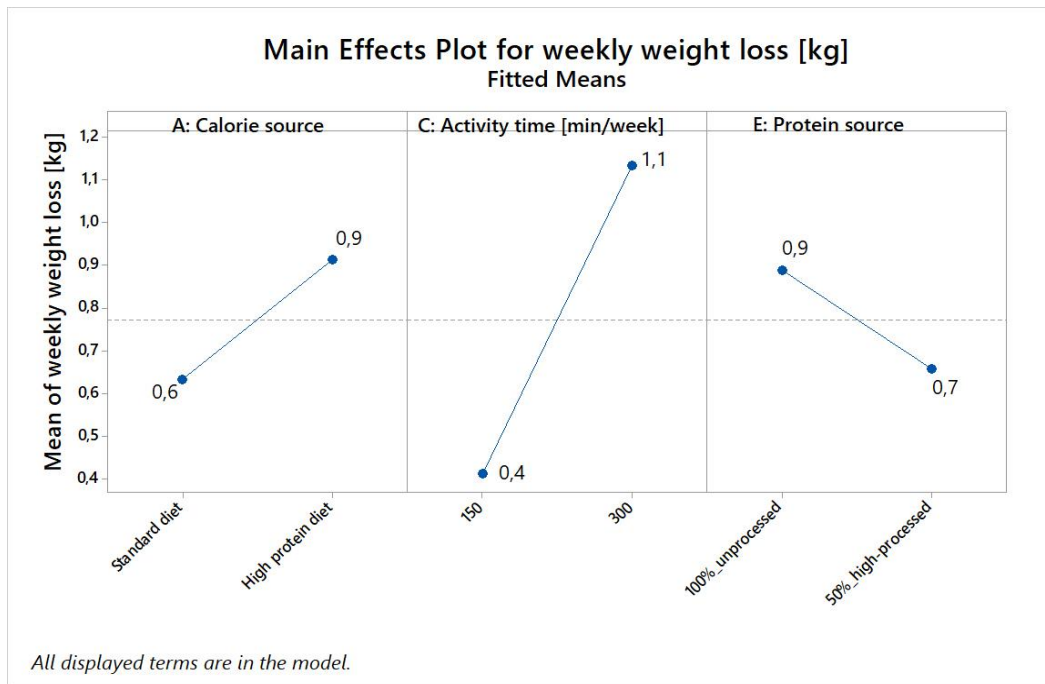


From a practical perspective, considering the structure of the alias structure, the active effect is effect C: Exercise time. The other effects have a small, even negligible, impact on weight loss. Because C interacts with A: Calorie Source, we ultimately consider effects A, E, and C, as well as the AC interaction, to be the active effects.

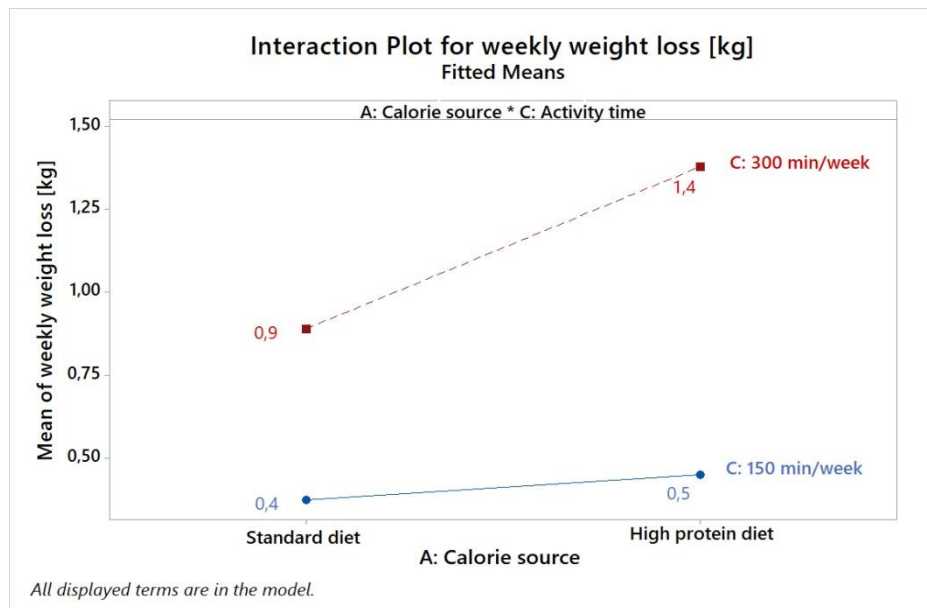
Term	Effect [kg]
A: Źródło kalorii	0,2813
C: Czas ćwiczeń [min/tydz]	0,7212
E: Źródło białka	- 0,2312
A * C	0,2063

R-sq **R-sq(adj)**
96,68% **95,47%**

With these 4 effects we can explain 97% of the variation created in this DOE.

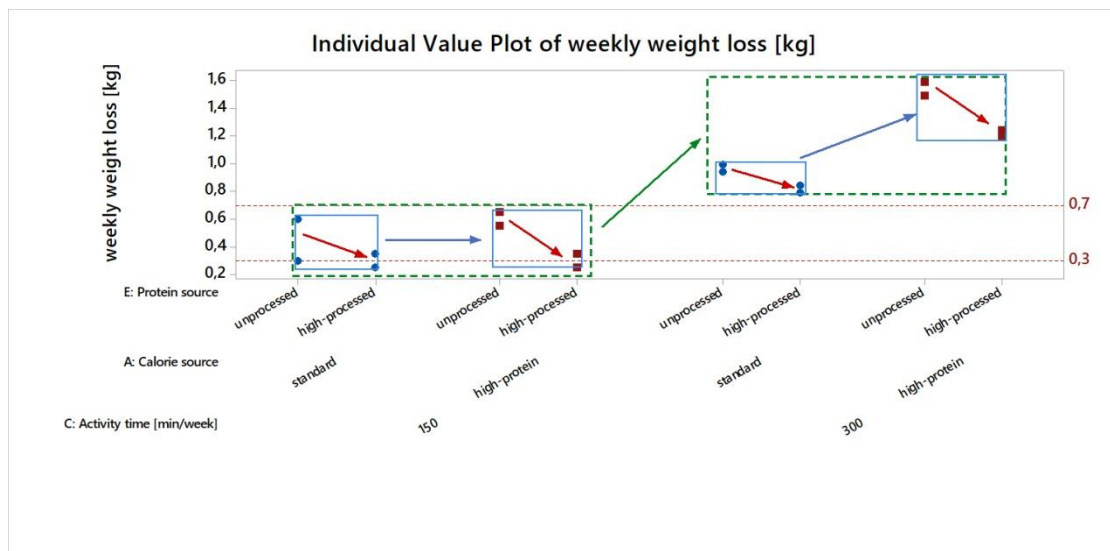


- Effect A: Switching from a standard balanced diet to a high-protein diet increases average weekly weight loss by 0.3 kg.
- Effect C: Increasing physical activity from 150 to 300 minutes per week results in an additional weight loss of 0.7 kg per week.
- Because factors A and C are in an active AC interaction, final conclusions will only be possible after analyzing this interaction.
- Effect E: Switching from unprocessed to highly processed protein sources reduces the rate of weight loss by 0.2 kg per week. This effect does not interact actively with any other factor tested in this experiment. This means that it will proceed in a very similar manner regardless of the levels of the other factors tested in this DOE.



- Interaction A*C: when there is less exercise (150 min/ week), a high-protein diet makes practically no difference (the weight loss will be on average 0.45 kg), but already with 300 minutes of activity, its introduction increases the weight loss from an average of 0.9 to 1.4 kg per week.

SUMMARY



By far the greatest impact on weekly weight loss comes from increasing physical activity. It's important to remember that throughout the diet, Adam maintained a calorie deficit and drank approximately 3 liters of water daily.

- **150 minutes of exercise per week = average weight loss of approximately 0.4 kg/week.**
 - A high-protein diet provides no additional benefits.
 - Highly processed protein slows weight loss regardless of other factors.

- **300 minutes of exercise per week = average weight loss of 1.1 kg/week.**
 - With a high-protein diet and unprocessed protein – up to 1.4 kg/week.

The type of physical activity, number of meals per day, eating or skipping breakfast, drinking water with vinegar on an empty stomach, or taking L-Carnitine supplements do not affect weekly weight loss.

Questions we need to answer:

- Who can benefit from these conclusions? Will they be applicable to others?
- What should Adam do to weigh 70 kg? How long will it take?
- Does the type of activity—running vs. cycling—remain irrelevant?
- Is the number of meals really irrelevant? Does eating/not eating breakfast really not important?
- Is drinking water with vinegar and supplementing with L-Carnitine really irrelevant?

This is just one example of how to use DOE in practice. If you'd like to learn how to design and analyze experiments yourself, check our [Six Sigma Green Belt](#), [Black Belt](#), and DOE ([basic](#) and [advanced](#)) training courses.

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