

AN EXPERIMENTAL STUDY TO ANALYZE THE FACTORS AFFECTING WEIGHT LOSS

Gülin Bahçıvan and Demet Özgür-Ünlüakın
Industrial Engineering Department
Bahçeşehir University, Beşiktaş, Istanbul, Turkey

ABSTRACT

Overweight and obesity are defined as abnormal or excessive fat accumulation that presents risks to health. Being around the ideal weight and doing exercise regularly provide healthier lives, and reduce illnesses and many health problems such as high blood pressure, cancer, type-2 diabetes, cardiovascular disease, etc. There are many factors affecting weight loss. In this study, sport, diet and supplement are taken into consideration to analyze whether they affect weight loss or not and to find the optimum levels for these factors to maximize the weight loss. Results indicate that only diet has significant effect on losing weight and combining jogging with low-carbohydrate diet is the most effective way to lose weight.

Keywords: factorial experiment, fixed effects model, weight loss

1. INTRODUCTION

One of the main health problems in all over the world is obesity. According to World Health Organization, worldwide obesity has more than doubled since 1980. Evolution of humanity is the biggest reason of gaining weight, for instance, a stressful life, a desk-bound work or eating junk foods. Carrying around too much weight feels uncomfortable, and it can also damage health seriously. Overweight and obesity increase the risks of diabetes and cardiovascular disease [1].

It is of high priority to prevent obesity and lose excessive weight [2,3]. One method that can help a person to lose weight is to limit the number of calories taken in through a diet program. The other way is to burn extra calories with exercise. Combining exercise with a relevant diet and supplement type is a more effective way to lose weight than depending on calorie restriction alone. In this respect, weight loss programs offer all sorts of diets, supplements and sports [4,5,6].

There are many real-life problems where empirical models [7,8] are used for analysis. Factorial design is an empirical model used frequently in the literature to analyze the significant effects on the response variable and to propose robust designs. In this study, we construct a fixed effects model based on an experimental study and analyze the factors affecting weight loss by considering various types of diet, supplement and sport.

2. FACTORIAL DESIGN

We use three-factor factorial design in the experimental study. Sport, diet and supplement are taken as main factors in the study. Each factor has three levels and these are presented in Table 1.

Table 1. Experimental factors and their levels

	Factors		
Levels	Sport	Diet	Supplement
Level-1	Tennis	Protein diet	Protein powder
Level-2	Jogging	Low-carbohydrate diet	Weight loss pill
Level-3	Lifting weight	Detox diet	L-carnitine

2.1. Description of the factors and their levels

Sport: Three different types of sport are chosen to evaluate in this experiment. These are tennis, jogging and lifting weight. We are interested in whether there exists significant difference in the efficiency of these three common activity types on losing weight.

Diet: We consider three different types of diet which are protein diet, low-carbohydrate diet and detox diet. If the maximum benefit is wanted, it is advised that diet should be chosen according to the sport type. Protein diet is not only useful for bodybuilders or marathoners. High protein diets optimize body composition, enhance satiety, and hence promote weight loss. Besides, keeping protein levels high is actually a big advantage not only for the weight loss phase, but also for the maintenance of health.

The second diet type is low-carbohydrate diet. It limits carbohydrates such as those found in grains, starchy vegetables and fruits, and emphasizes foods high in protein and fat. Finally, the last one is the detox diet which is a quick way to start weight loss and kick some bad habits like relying on caffeine to get out of bed or consuming too much sugar.

Supplement: Sometimes, doing gym and diet is not enough to lose weight. In that case, we need to take extra help. Thus the third and last factor of the experiment is using supplements. Three types of supplement are chosen according to the type of sport that the individual prefers to do. The first is protein powder. If we're doing good quality exercises and sticking to a diet full of lean protein, fiber- and vitamin-rich vegetables and fruits, and still not seeing the results we want, protein powder may help us to have greater results. Weight loss pill is the second supplement type that is considered in the study. There are many different weight loss solutions out there. This includes all sorts of pills, drugs and natural supplements which are claimed to help lose weight, or at least make it easier to lose weight combined with other methods. They tend to work via one or more of these mechanisms: Reduce appetite so that we eat less, reduce absorption of nutrients like fat so that we take in fewer calories, increase fat burning so that we burn more calories. L-carnitine which is one of the most popular supplements for weight loss and fat burning is the third supplement type that we consider. It has been used for athletes from different sports around the world to improve performance by helping the body to use body fat for fuel.

2.2. Data collection

In this experiment, the response variable is weight loss in kilograms in one month. We use four replicates. We collect the data by conducting a survey to people in Turkey going to gyms and working out with a personal trainer for at least one month. The subjects are randomly chosen. During a weight loss program, people may gain weight rather than lose weight in cases where there exists water retention or an increase in the muscle cells of the body. Such cases result in negative values of response variable and we keep them in our dataset.

2.3. The fixed effects model

Fixed effects model with three factors, explained in Section 2.1, each of which has three levels is constructed in the study. The effects model given in Equation 1 is used for the factorial experiment where the indices i, j and k are the levels of the factors and l is the index for the replication number.

$$y_{ijkl} = \mu + \tau_i + \beta_j + \gamma_k + (\tau\beta)_{ij} + (\tau\gamma)_{ik} + (\beta\gamma)_{jk} + (\tau\beta\gamma)_{ijk} + \varepsilon_{ijkl} \quad i, j, k = 1, 2, 3 \quad l = 1, 2, 3, 4 \quad (1)$$

Here μ is the overall mean effect, τ_i is the effect of the i^{th} level of the sport type, β_j is the effect of j^{th} level of the diet type, γ_k is the effect of the k^{th} level of the supplement type; $(\tau\beta)_{ij}$, $(\tau\gamma)_{ik}$ and $(\beta\gamma)_{jk}$ are the pairwise interaction effects among the related factors, $(\tau\beta\gamma)_{ijk}$ is the triple interaction effect among the factors and ε_{ijkl} is the random error term in the model.

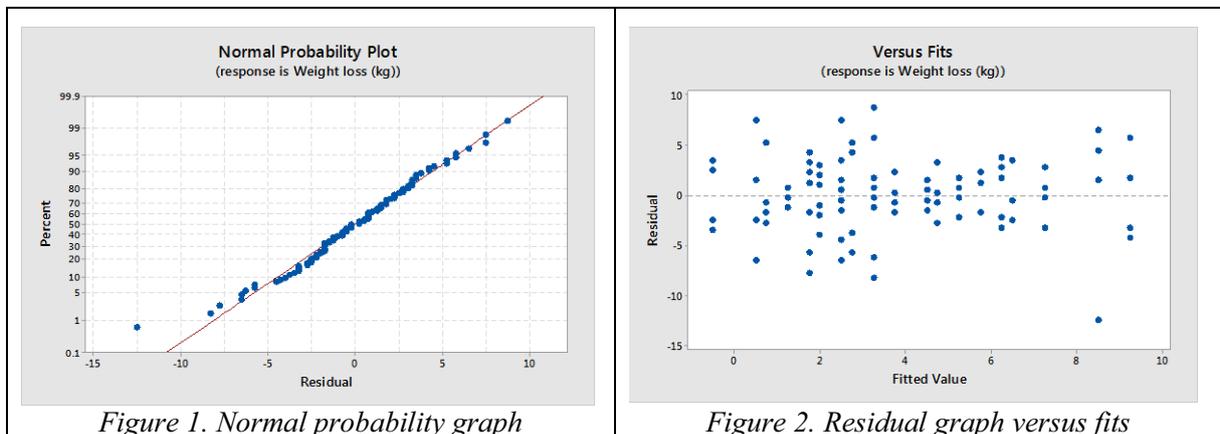
3. ANALYSES

Analyses of the factorial design are performed in Minitab. The results of analysis of variance of the 3^3 factorial design experiment are presented in Table 2. According to the tabulated p-values, only diet has a significant effect on losing weight at $\alpha=0.05$ since its p-value is less than α . Furthermore, there exists no significant interaction effect on the response variable.

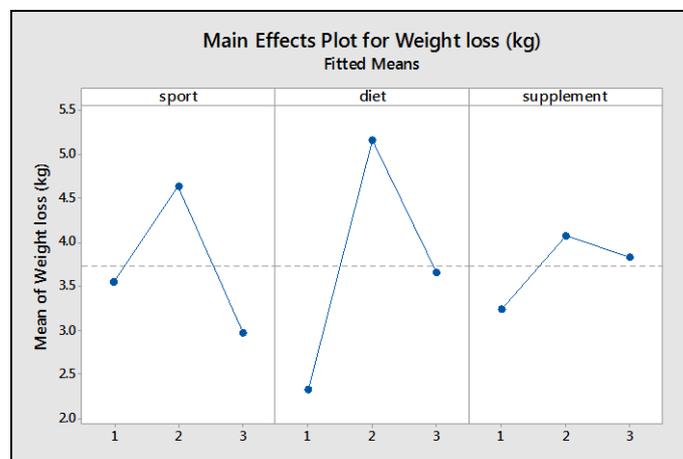
Table 2. Analysis of variance output.

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Model	26	639.17	24.583	1.53	0.076
Linear	6	209.33	34.889	2.18	0.054
sport	2	51.50	25.750	1.61	0.207
diet	2	144.67	72.333	4.51	0.014
supplement	2	13.17	6.583	0.41	0.665
2-Way Interactions	12	233.67	19.472	1.21	0.288
sport*diet	4	49.33	12.333	0.77	0.548
sport*supplement	4	88.00	22.000	1.37	0.251
diet*supplement	4	96.33	24.083	1.50	0.209
3-Way Interactions	8	196.17	24.521	1.53	0.160
sport*diet*supplement	8	196.17	24.521	1.53	0.160
Error	81	1298.50	16.031		
Total	107	1937.67			

Model adequacy checking is done on the residuals of the model given in Equation 1 to check whether the assumptions on the random error term are satisfied or not. Figure 1 gives the normal probability plot of the residuals which indicate that normality assumption is almost perfectly satisfied. Furthermore, constant variance and zero mean assumptions of the random error term are also valid according to the residual vs fitted value plot given in Figure 2.



Factorial plots for the main effects and pairwise interaction effects are presented in Figure 3 and Figure 4 respectively. As a main effect, only diet has significant effect on losing weight. Among the diet types considered in the study, low-carbohydrate diet is the most effective one. With the help of the interaction plots, we can decide on the optimum levels of the factors. Hence, according to Figure 4, one can observe that combining jogging with low-carbohydrate diet enables one with the maximum weight loss although we conclude that there exists no interaction effect between sport and diet in Table 2.



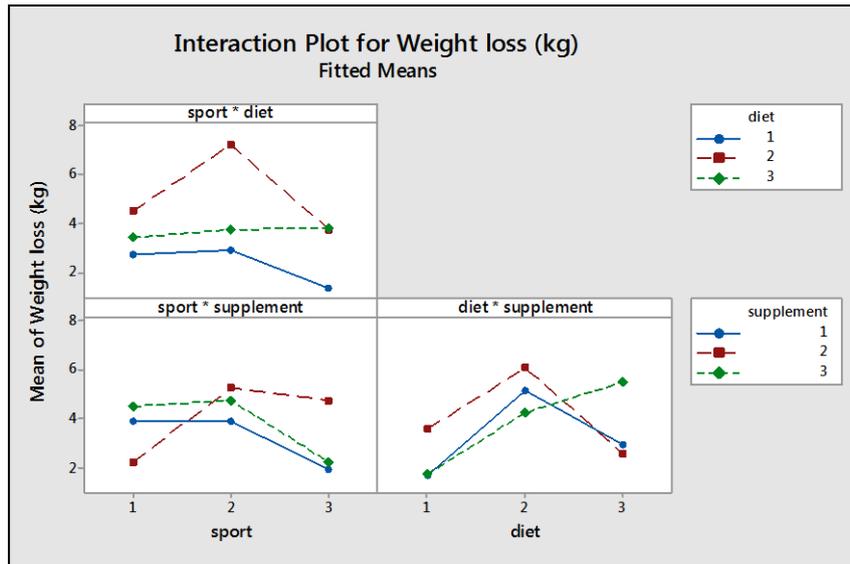


Figure 4. Pairwise interaction effects plots.

4. CONCLUSION

We perform factorial design on monthly weight loss of people guided with a personal trainer for at least one month in Turkey. According to the experimental study, we conclude that diet has significant effect on losing weight, and furthermore combining jogging with low-carbohydrate diet is the most effective way to lose weight. As a further study, one can enrich the model by introducing more levels to the factors and increasing the number of replications so that more confidential conclusions can be reached.

5. REFERENCES

- [1] Zomer, E., Gurusamy, K., Leach, R., Trimmer, C., Lobstein, T., Morris, S., James, W.P.T., & Finer, N.: Interventions that cause weight loss and the impact on cardiovascular risk factors: a systematic review and meta-analysis. *Obesity Reviews*, 2016.,
- [2] Gregg, E. W., Gerzoff, R. B., Thompson, T. J., & Williamson, D. F.: Trying to lose weight, losing weight, and 9-year mortality in overweight US adults with diabetes. *Diabetes care*, 27(3), 657-662.
- [3] Li, X., Zhou, X., & Hesketh, T. (2016). Experiences and perspectives of children attending a weight loss camp in China: a qualitative study. *Child: care, health and development*, 2004.,
- [4] Morgan, P. J., Hollis, J. L., Young, M. D., Collins, C. E., & Teixeira, P. J.: Workday Sitting Time and Marital Status Novel Pretreatment Predictors of Weight Loss in Overweight and Obese Men. *American Journal of Men's Health*, 2016.,
- [5] Jhj Bish, C. L., Blanck, H. M., Serdula, M. K., Marcus, M., Kohl, H. W., & Khan, L. K.: Diet and physical activity behaviors among Americans trying to lose weight: 2000 Behavioral Risk Factor Surveillance System. *Obesity Research*, 13(3), 596-607, 2005.,
- [6] Kaukua, J., Pekkarinen, T., Sane, T., & Mustajoki, P.: Health-related quality of life in obese outpatients losing weight with very-low-energy diet and behaviour modification—a 2-y follow-up study. *International journal of obesity*, 27(10), 1233-1241, 2003.,
- [7] Lukić U., Radomir Jovičić R., Prokić-Cvetković R., Burzić M., Popović O.: Determination Of Optimal Parameters For Self-Shielded Flux-Cored Welding Process, 17th International Research/Expert Conference, "Trends in the Development of Machinery and Associated Technology", TMT13, İstanbul, Turkey, 2013.,
- [8] Özgür-Ünlüakın D., Akkaya M.: Regression Analysis of Authorized Service Complaints in terms of Equipment Complaints, 19th International Research/Expert Conference, "Trends in the Development of Machinery and Associated Technology", TMT15, Barcelona, Spain, 2015.