

Dietonomics: A junior economist explores the other side of dieting

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ABSTRACT

Dietonomics: A junior Economist Researches the Other Side of Dieting” aims to provide an alternative outlook on the issue of weight loss and weight loss maintenance. Taking into account the discoveries done in the field of nutrition, dieting and fighting obesity, the academic reviews and data collected through a randomized experiment, the factors behind weight loss, result maintenance and regain have been explored. Through understanding the main dieting trends, eating habits and emotional patterns following weight loss, we have conducted multiple regression analysis to formulate the relationship between weight regain and other independent variables. In contrast to prior expectations, some of the fed dieting tips were not significantly correlated with weight regain or result maintenance. As a result, the final model of weight regain included the independent variables of lossperiod, i.e. the time period in months, required to lose weight, weightstart, starting weight of the respondent, and some factors, which relate to eating and behavioral patterns, such as having a breakfast, retaining moderate physical activity, acquiring some intuitive eating habits, and getting rid of restrictive eating habits, etc.

Keywords: weight-maintenance, dietonomics, weight regain minimzation

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I. Introduction

Statement of the Problem

Since 1975 obesity worldwide has tripled becoming a worldwide epidemic. In 2016 there were more than 1 billion overweight adults, children and adolescents aged 5-19, at least 30% of them being clinically obese. Obesity and overweight pose a major risk for chronic noncommunicable diseases: cardiovascular, heart disease and stroke; musculoskeletal disorders, especially osteoarthritis; some cancers, including endometrial, breast, ovarian, prostate, liver, gallbladder, kidney, and colon. The primary cause of excess weight is an energy imbalance between calories consumed and expended, either due to an increased intake of energy-dense foods high in fat; and/or refined carbohydrates, or because of sedentary lifestyle.

The problem as well as their related noncommunicable diseases, are largely preventable through supportive environments and shaping people's choices of healthier foods and regular physical activity. General recommendations are increasing the consumption of fruit and vegetables, as well as legumes, whole grains and nuts; limiting energy intake from total fats and shift fat consumption away from saturated fats to unsaturated fats; limiting the intake of sugars; and being physically active. Statistics show that 97 percent of those classified as obese in the US in 2016 had tried losing weight on their own through diet or exercise. Losing weight is not the main challenge, but long-term maintenance. Weight loss of 5%–10% can be achieved through incorporating healthy dietary recommendations into eating habits and increasing physical activity.

Definition of Terms

Different approaches to measuring obesity exist. The most common one is the Body Mass Index (BMI), a person's weight in kilograms per height in meters squared (kg/m^2). This value is then matched to a weight classification on a BMI chart, where underweight, normal weight, overweight and obesity are defined based on specific cut-offs.

BMI measurements are the same for both sexes and for all ages of adults. BMI classifications for Caucasians is as follows:

Table 9 BMI classification table for Caucasian people

Weight category	BMI range
Underweight	<18.5
Normal range	18.5–24.9
Overweight	25–29.9
Obesity	30–39.9
Severe obesity	≥ 40

BMI is considered more of a rough guide to determine obesity, as BMI doesn't account for body composition and distribution of body fat in people.

The amount of body fat located inside abdomen (belly-fat) is an important risk factor for diabetes, hypertension, heart disease, fatty liver and other metabolic problems, in contrast to the fat on hips and thighs that are less associated with health problems. Measuring waist circumference to determine obesity related health risks is another commonly used method. In

Caucasians, a waist circumference of more than 89 cm in females and more than 100 cm in males suggests at a higher risk of developing metabolic problems related to obesity.

Basal metabolic rate (BMR) is the minimum level of energy required to sustain all of the primary bodily functions. Combined with the physical activities the total daily calorie count is derived. Calorie balance, the difference between calories got from eating and drinking and those used up through physical activity and body processes like breathing, digesting food, and, in children, growing is the key to fat loss. Negative calorie balance accounts for weight loss, zero calorie balance-weight maintenance and positive balance-to weight gain.

Theoretical Background

Caloric deficit is provided through different methods and types of dieting. The information is presented in the tables below.

Table 10 Methodology of diets and examples of products providing it

Diet method	Description	Example product
Meal prepping	Providing pre-prepared food with a clear plan of what the dieter should eat at each meal	"Arogj snund" LLC; Ingredient; Life Food
Calorie Counting	Requires the dieter to count calories and restrict the number of calories they consume each day	MyFitnessPal; FatSecret
Meal Replacement	Provides the dieter with specifically formulated weight-loss products (e.g. “shakes,” soups, mousse, or “bars”) that replace most or all of their normal daily meals	Herbalife; Leovit
Meal planning	Providing clear plan of what the dieter should eat at each meal without preparing it.	Lazar Angelov Online Meal planning tool

Table 11 Typology of diets

Type	Description
Balanced	types of foods a patient usually eats, but in lower quantities
High-Protein,	the high-protein diet has been reported to stimulate greater improvements in body composition by sparing lean body mass (Layman et al., 2003a; Piatti et al., 1994).
Low-Fat Diets	recommend fat intakes of no more than 10 percent of total caloric intake.
Low-carb	Reduced intake of carbohydrates.
Very-Low-Calorie Diets	as a diet that provides 800 kcal/day or less

In order to burn 1 g of fat our body needs 9 calories of energy, thus to lose half a kilogram of fat in a week, 4500 calories in deficit should be provided. This means that to lose this much in a week, either food intake should be cut by 650 calories daily, or physical activity of corresponding energy level should be performed. For better results, a weight loss plan incorporating both decrease in food intake and increase in physical activity is implemented.

The long-term weight management of obesity remains a very difficult task, associated with a high risk of failure and weight regain. In the short-term almost all the diets are efficient, however correlation doesn't mean causation, implying that there may be a third factor influencing weight management. Many people report that they have successfully managed weight loss maintenance in the long term. Several personality traits have been associated with better weight loss

maintenance, such as habitual patterns of behavior, emotional and psychological well-being, body image, and eating behaviors.

Since the statistics shows that weight-management becomes possible due to behavioral adaptations of lifestyle and following those in the long-term, instead of types of dieting, consistency should be considered as the main characteristic of weight-loss success and efficient weight-management.

This study intends to examine weight maintenance outside nutrition attributing the success in weight management to another behavioral trait-consistency. The research will cover analysis weight management across the different variables of interest such as styles of dieting, time period, age of the patient and other characteristics. A forecast model predicting consistency to habits will be developed and tested.

II. Research Methodology

Type of Research

The type of research used in this study is both quantitative and qualitative. To examine the phenomenon of weight loss and maintenance through numerical and statistical analysis, people who recorded weight loss success in the past three years were asked to complete an online questionnaire. Due to privacy concerns their personal identification data is protected. Additionally, in depth interviews with some of the respondents and a few experts in this field was also conducted.

Sampling Method and Bias

To represent the entirety of the population the research sampling method used in this study is random. A list of personal trainers and dietitians was acquired from social media. From 27 sources 10 were targeted randomly, 6 professionals agreed to anonymous research contribution and administered the questionnaire to their clients. Data collection was conducted online.

The sampling bias include but were not restricted to

- Under-coverage
- Non-response bias
- Voluntary response bias

The selected professionals providing weight management services were providing access only to the people approaching weight loss with their help. However, there should have been people who attempted weight loss on their own. Accordingly, under-coverage bias occurs because of not all the weight watchers being represented in the sample.

Taking into account that only 60% of the professional agreed to demonstrate contribution to the research, the unwillingness or inability to participate might mean that non-respondents differ in meaningful ways from responders, i.e. 4 of them refusing to contribute might have less success stories of their customers losing weight. Since, non-response bias occurs, results based on this sample will be underestimating the weight loss regain and failure.

On the other hand, professional agreeing to participate in the survey are self-selecting themselves on voluntary basis. i.e. the effectiveness of their weight loss strategies and success stories of weight loss will be overestimated.

In order to reduce the sampling bias, the methodology of sampling has been adapted to some changes. Additionally, because the responding professionals were very peculiar in their answers and wanted to prove how efficient their weight loss strategies are, the analysis conducted had more qualitative nature communicating in depth insights about different approaches to weight loss.

For the purpose of providing a better sampling approach Google Trends tool has been used and the trending queries on the topic of weight loss and dieting for the past 5 years obtained.

To collect data from people who have a history of attempting weight loss we have set a sponsored advertisement of on an online meal plan generator Smartfit.am on Facebook and Instagram and set the targeting according to the results from the Google trends platforms and social media platforms. By clearly mentioning on the tool that the meal plan is generated both for weight maintenance and loss purposes, we aimed to target not only people who are looking for weight loss but also those who have successfully attempted and want to maintain the results.

Respondents and questionnaire

The respondents in this research are all coming from one single location – Yerevan, because of the socio-economic conditions present in the area relevant to the study and the time frame and resources of the researcher. Respondents were asked to complete the survey in order to receive a personalized meal-plan based on the personal data input. Acknowledging that the information submitted directly influences the quality of meal plan created as part of the experiment the sincerity and objectivity of the data is provided.

The questionnaire requires information about the measurements, eating habits and behavioral background of the client. It also has questions related to previous eating practices and emotional

well-being. Statements that are perceived to be factors that influence weight loss success were presented.

Limitations

Although the new experiment design was better in terms of reducing selection biases, the study takes into account the activity a person demonstrates on social media and how their interests and life intentions are reflected through such platforms, i.e. people who have a weight management problem, but don't have active social media accounts were not taken under consideration.

Additionally, the self-selection bias was not completely eliminated. On one hand, voluntary self-selection of the respondents emphasizes their motivation to start a new diet, so the data includes people who still believe in their ability to lose the extra pounds. On the other hand, non-response indicates either antitrust towards any online tool for weight loss and stays committed to the traditional weight loss techniques or reflects the weight watchers who have lost any hope.

III. Literature Review

Hypo-energetic diets and their composition

Two primary approaches to dieting are hypo-energetic, i.e. energy restricted diets, and/or macronutrient managed, i.e. through prioritization of macronutrient composition. Very-low-energy diets, (400-800 kcal daily) have been beneficial in short-term with estimated weight loss of 0.300-0.500 kg per day on average. In contrast, weight loss from either low-carbohydrate or low-fat but moderately energy-restricted diets account for 0.500-1.000 kg weekly weight loss, while diets with high protein content 0.200-0.400 kg weekly. (Abete, I., Parra, M., Zulet, M., & Martínez, J. ,2006).

Although in the short-term very low energy restricted diets are proven to be efficient, higher amounts of protein facilitate weight loss in the long-term. Higher protein intake increases

thermogenesis and satiety compared to diets of lower protein content. High protein meals lead to a reduced subsequent energy intake, thus dietary practice, it may be efficient to partially replace refined carbohydrate with protein sources low in saturated fat. Although recent evidence supports potential benefit, rigorous longer-term studies are needed to investigate the effects of high protein diets on weight loss and weight maintenance. (Halton, T. L., MD, & Hu, F. B., PhD., 2004)

Managing weight regain

Despite the comparative advantage some dieting strategies have over the other in the shorter term there is significant evidence that losing excess body fat in the long-term is difficult for most individuals and the risk of regaining lost weight is very high. From the first day of entry, an understanding of the fundamental causes of excess weight gain must be communicated to each individual personally and a customized strategy for maintaining a healthy body weight as a way of life be designed. (Institute of Medicine, 2003).

According to the same study conducted by the Institute of Medicine in 2003 the eating habits that promote weight gains are as follows:

- Eating few or no meals at home
- Opting for high-fat, calorie-dense snack foods from vending machines
- Eating out at restaurants that feature excessive portion sizes or unhealthy combinations

It is also suggested to modify weight management by implementing the following habitual changes:

- Preparing meals at home
- Estimating portion sizes

- Recognizing different foods and their macronutrient composition
- Eliminating smoking and reduce alcohol consumption
- Substituting calorie-dense foods for high-volume ones
- Lifestyle modification for weight management

Although, there is still high risk of failure and weight regain associated with weight loss maintenance in the long term, several factors have been associated with better weight loss maintenance in long-term: behavioral (high levels of physical activity, eating a low-calorie, low-fat diet; frequent self-monitoring of weight) and cognitive component (reduced disinhibition, satisfaction with results achieved, confidence in self-support. Additionally, lifestyle modifications have shown promising long-term weight loss results. (Diabetes, Metabolic Syndrome and Obesity: Targets and Therapy,2016(9), 37-46).

Weight loss maintenance

According to a 10-year observational study of self-reported weight loss and behavior change in 2886 participants (78% female; mean age 48 years) in the NWCR who at entry had lost at least 30 lbs (13.6 kg) and kept it off for at least one year, more than 87% of participants were estimated to be still maintaining at least a 10% weight loss at Years 5 and 10. Larger weight losses and higher maintenance were associated with better long-term outcomes. In contrast, decreases in physical activity, dietary restraint, and frequency of self-weighing were associated with greater weight regain. Accordingly, long-term weight-loss maintenance is possible and requires sustained behavior change.

IV. Data

Data description

Initial data of the respondents has been collected through the subscription form available on the website smartfit.am. Each of the subscribers has been contacted through a phone call in order more accurate and detailed data to be obtained. The form had 124 respondents, 29 out of which haven't been contacted, 8-refused to provide more private information. As a result, the data obtained consists of 86 observations: 57 females and 29 males. The average age of the participants was 37 years ranging from 18 to 59. On average, there has been a weight loss of 16 kilograms, with mean regain of 8 kilograms. Moreover, the mean weight loss among women was 18 kilograms compared to 11 kilograms among male participants. However, the amount of weight regain among women was also higher than for men. The mean amount of time in months required for a person to achieve their target weight was approximately 5 months, followed by one more extra month of dieting on average. The regain time was almost equal to the period of weight loss itself, being 5 months on average. On average a dieter was consuming from 3 to 4 meals daily. According to the data, the dominant type of diet was the one with high-protein content (fats: 20%, protein: 45%, carbs: 35%). The second most popular was low-fat diet (fats: 10%, protein: 45%, carbs: 45%).

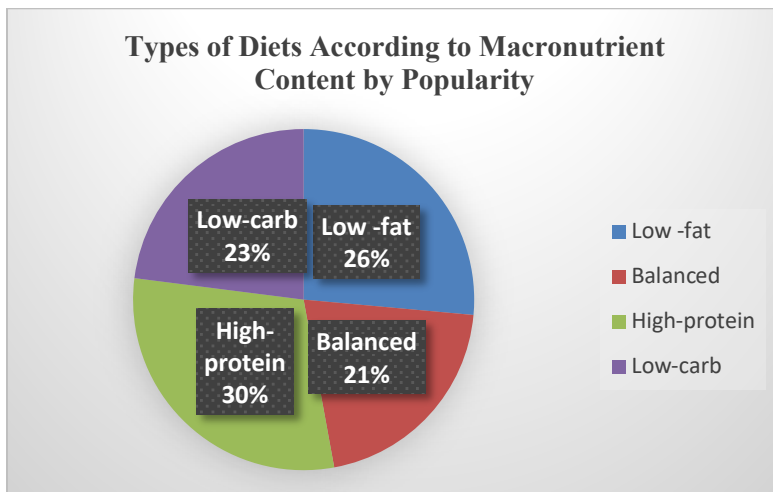


Figure 5: Distribution of different macronutrient diets

Similarly, if four different dieting approaches, i.e. meal planning, meal prepping, calorie-counting and fitness coaching analyzed, although meal planning is dominant, the others are almost as much popular as the latter.

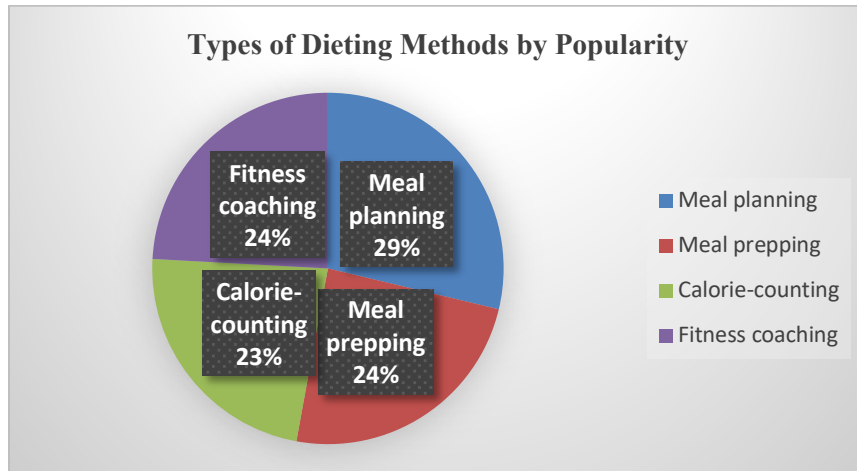


Figure 6: Distribution of different dieting methods

Participants have demonstrated a slight decrease in BMI over the past 2 years from 28 to 25.2 still remaining in the category of overweight. During the phone call interviews the participants have describes their eating patterns and habits. As a result, they have been categorized into these five types of eaters:

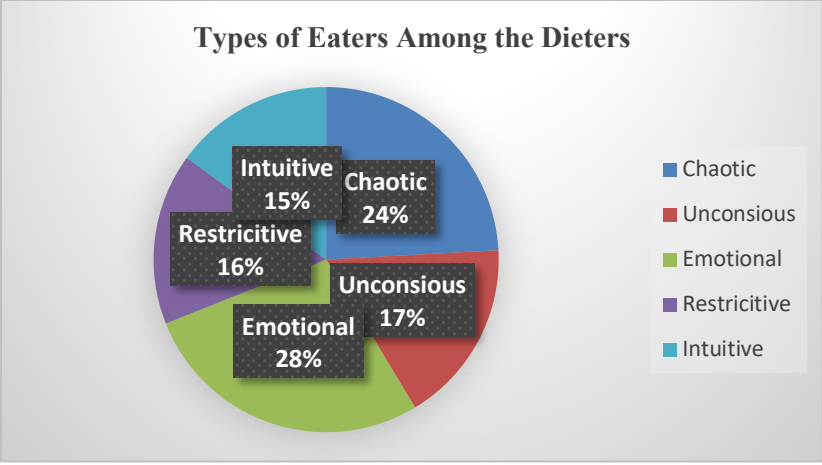


Figure 7: Distribution of eating types among the participants

The majority of participants have been identified as emotional eaters, accounting for the 28% of the dieters. The second dominant type, were chaotic eaters-24%.The mean amount of meals consumed by participants was 3.7, i.e. approximately 4, mode equal to 3 meals per day. Respondents were also asked to rate their daily cravings. The results are illustrated below:

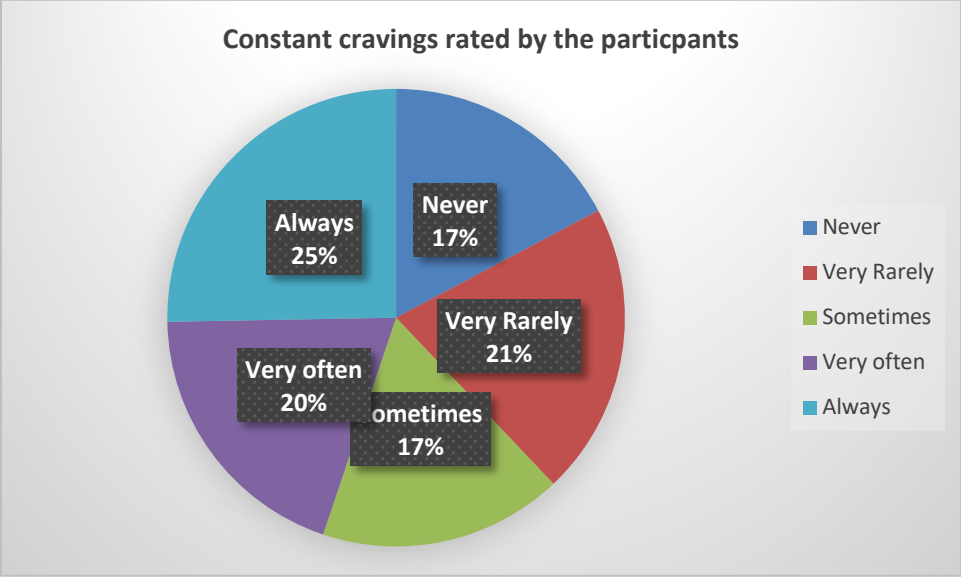


Figure 8: Constant craving rated by the respondents.

According to the respondents 37%, i.e. 25% -“Always”, and 20% -“Very Often” have been facing constant cravings while trying to manage their weight. Finally, the average rate of weight loss was 3.87 kg and the weight regain rate was 2.29kg

Estimation and hypothesis testing

To get more insight of what drives weight gain we have conducted multiple regression analysis by taking the proportion of weight regain, i.e. weight regain divided by the weight loss as the dependent variable and the following variables as independent:

Table 12: Independent variables used in multiple regression analysis

Variable name	Description
age	The age of the respondent in years.
gender	The gender of the respondent as a dummy variable: 1-Female, 0-Male.
height	The height of the respondent in cm.
weight_lost	The maximum weight the respondent has lost over the course of two years.
diettype	The type of diet the respondent used. (1: Low-fat, 2: Balanced, 3: High-Protein, 4: Low-carb)
dietmethod	The method of dieting the respondent took: meal-planning, meal-prepping, calorie-counting, coaching.
cheat	The casualty of cheats.
lossperiod	The time period it took for a participant to lose weight expressed in months.
NPS	Net promoter score. To what extent would the dieter recommend the diet to others.
sugar	Sugar being included in the diet plan or not. 1-Yes, 0-No

chewinggum	Excessing gum chewing. 1-Yes, 0-No
mealsperday	Number of meals consumed per day.
breakfast	Presence of breakfast in the meal plan. 1-Yes, 0-No
intuitive eating	Eating habit described as intuitive. 1-Yes, 0-No.
restrictive eating	Eating habit described as restrictive. 1- Yes, 0-No.
craving	Casualty of cravings rated from 1-5.
physical	Physical activity rated from 1-5.

Table 13: Correlation matrix of the independent variables

	age	gender	start_weight	weight_lost	diet_type	diet_method	cheat	loss_period	sugar	chewing_gum	meals_per_day	breakfast	intuitive_eating	restrictive_eating	craving	physical	regain_rate
age	1.0																
gender	-0.3	1.0															
start_weight	0.2	-0.5	1.0														
weight_lost	-0.3	0.4	0.2	1.0													
diet_type	-0.1	0.1	-0.1	0.0	1.0												
diet_method	0.1	0.0	0.2	0.2	-0.1	1.0											
cheat	0.1	0.1	0.0	0.1	-0.2	0.0	1.0										
loss_period	0.1	0.0	0.2	0.3	-0.2	0.1	0.5	1.0									
sugar	0.2	-0.1	0.0	0.0	0.0	0.2	0.0	-0.1	1.0								
chewing_gum	-0.1	0.2	-0.1	0.1	0.2	-0.1	-0.2	-0.4	0.0	1.0							
meals_per_day	0.1	-0.1	0.1	-0.1	-0.1	-0.1	-0.1	0.0	0.1	-0.1	1.0						
breakfast	0.0	-0.1	0.0	-0.1	0.0	-0.1	0.1	0.0	0.1	-0.1	0.1	1.0					
intuitive_eating	0.0	0.0	0.0	0.1	-0.2	-0.1	0.5	0.6	0.0	-0.3	0.3	0.2	1.0				
restrictive_eating	-0.1	0.2	-0.2	-0.1	0.2	-0.1	-0.6	-0.4	0.0	0.4	0.1	-0.1	-0.3	1.0			
craving	-0.1	0.1	-0.1	0.1	0.1	0.0	-0.5	-0.4	0.1	0.3	-0.1	0.0	-0.5	0.5	1.0		
physical	0.0	-0.2	0.3	0.1	-0.1	0.1	0.5	0.5	0.1	-0.3	0.1	0.1	0.5	-0.6	-0.5	1.0	
regain_rate	-0.1	0.0	0.0	-0.1	0.3	0.0	-0.7	-0.7	0.0	0.4	-0.1	-0.2	-0.7	0.7	0.7	-0.7	1.0

No strong correlation is existent among the independent variables which means that multiple regression analysis can be performed. Using the stepwise backward elimination approach the results of the updated regression are as follows:

Table 14 Regression Statistics Results

Regression Statistics	
Multiple R	0.94
R Square	0.88
Adjusted R Square	0.86
Standard Error	0.11
Observations	87.00

Table 15 Regression ANOVA-test results

ANOVA					
	<i>df</i>	<i>SS</i>	<i>MS</i>	<i>F</i>	<i>Significance F</i>
Regression	8	6.62	0.83	68.26	0.00
Residual	78	0.94	0.01		
Total	86	7.56			

Even though, $r^2_{adj} = 0.862$ is higher than for the very initial model, meaning that 86.2% of the change in weight regain proportion is explained by the changes in the independent variables and the F test level of significance is smaller than 5%, implying a strong linear relationship between the dependent and independent variables at 95% level of confidence, in order to obtain better results diet_type categorical variable should be generated into low_fat, high_protein and low_carb dummy variables and perform regression analysis once more. Most importantly, the

independent variables like sugar, cheating, meals_per_day, diet_method, age, gender, weight_lost, chewing_gum have been eliminated due to insufficient significance.

The final regression output is the demonstrated below:

Table 16: Final regression output

	Coefficients	Standard Error	t Stat	P-value
Intercept	0.333	0.105	3.167	0.002
start_weight	0.004	0.001	3.561	0.001
Low-carb	0.065	0.029	2.238	0.028
loss_period	-0.031	0.007	-4.760	0.000
breakfast	-0.075	0.024	-3.095	0.003
intuitive eating	-0.211	0.042	-4.955	0.000
restrictive eating	0.263	0.036	7.290	0.000
craving	0.032	0.011	2.878	0.005
physical	-0.023	0.011	-2.038	0.045

The formula below represents the existing linear relationship between the rate of weight regain and the remaining independent variables.

$$y = 0.333 + 0.004 x_1 + 0.065x_2 - 0.031x_3 - 0.075x_4 - 0.211x_5 + 0.263x_6 - 0.032x_7 - 0.023x_8 \quad (1)$$

where

y , dependent variable, the rate of regain, i. e. $\frac{\text{weight gain}}{\text{weight lost}}$,

x_1 , independent variable, the starting weight of the dieter

x_2 , dummy independent variable, which equals 1 when a person stick to a low
– carbohydrate diet

x_3 , independent variable of the time period for the weight loss weight

x_4 , dummy independent variable, which equals 1 when a person has a breakfast

x_5 , dummy independent variable, which equals 1 when a person sticks to the concept of
intuitive eating

x_6 , dummy independent variable, which equals 1 when a person is a restrictive eater

x_7 , ranking independent variable, which takes a value from 1 to 5 describing constant
cravings from never to always.

x_8 , ranking independent variable, which takes a value from 1 to 5 describing physical
activity from never to always.

Every additional kilogram of starting weight increases the proportion of weight regain by 0.004 (0.4%). Following a low-carb diet increases the proportion of weight regain by 6,5% .By extending the weight-lost time period with a month the proportion of weight regained can be decreased by 3,1% and vice versa, speeding up the weigh-loss procedure, increase the weight regain proportion by the same amount. Inclusion of breakfast in the meal plan, will decrease the weight regain proportion by 7.5%. Adopting intuitive eating habits, the weight regain proportion can be decreased by 21,1%. Getting rid of the habit of restrictive eating, the weight regain proportion can be decreased by 26.3%. Adapting mechanisms to cope with cravings, and achieving one level of change, i.e. observing cravings “Sometimes” instead of “Very often” can decrease the weight regain by 3.2%. Incorporating physical activity more often and increasing the level of activity by one unit the weight regain proportion can be decreases by 2.3%.

Discussion of the results

The discuss the results and see how applicable the findings are, consider the formula once more:

$$y = 0.333 + 0.004 x_1 + 0.065x_2 - 0.031x_3 - 0.075x_4 - 0.211x_5 + 0.263x_6 - 0.032x_7 - 0.023x_8$$

(1)

$$y = 0.333 + 0.004 x_1 - 0.031x_3 + \underbrace{(0.065x_2 - 0.075x_4 - 0.211x_5 + 0.263x_6 - 0.032x_7 - 0.023x_8)}_{X_{habits}} = 0.333 + 0.004 x_1 - 0.031x_3 + X_{habits}$$

(2)

The habits are controllable. In the best case scenario, weight regain is minimized when a person doesn't stick to low carbohydrate diet, eats a breakfast, is an intuitive and non-restrictive eater, experiences craving never and maintains moderate physical activity,

i.e. $x_2 = 0; x_4 = 1; x_5 = 1, x_6 = 0, x_7 = 1, x_8 = 3$

The maximum of absolute

$$X_{habits} = 0 - 0.075 - 0.211 + 0 + 0.032 - 0.023 * 3 = -0.387$$

$$\begin{aligned} regain &= 0.333 + 0.004 x_1 - 0.031x_3 + X_{habits} \\ &= 0.004 x_1 - 0.031x_3 - 0.054 \quad (3) \end{aligned}$$

On the other hand, $startweight = normalweight + extraweight$. A BMI lower 25 is considered as normal. Considering that the Armenian average female height is 158 cm, male height-172 cm and $BMI = \frac{weight (kg)}{height(m)^2}$. The upper boundary for not being overweight for an Armenian woman is 62.4 kg, for man-73.96kg.

Additionally, the regain itself $y = \frac{weightgain}{weightloss}$. Assuming, that a person wants to lose all the extra pounds, $weightloss = extraweight = x_9$.

$$\text{Thus, } regain = \frac{weightgain}{x_9} = 0.004x_1 - 0.031x_3 - 0.054$$

$$regain = \frac{gain}{x_9} = 0.004(\bar{w} + x_9) - 0.031x_3 - 0.054.$$

$$\text{Accordingly, } gain = 0.004x_9(\bar{w} + x_9) - 0.031x_9x_3 - 0.054x_9$$

$$\begin{aligned}
y &= (0.004 * (62.4 + x_9) - 0.031x_3 - 0.054)x_9 = \\
&= 0.196x_9 + 0.004x_9^2 - 0.031x_9x_3
\end{aligned}$$

for women in Armenia.

$$\begin{aligned}
y &= (0.004(73.96 + x_9) - 0.031x_3 - 0.054)x_9 \\
&= 0.242x_9 + 0.004x_9^2 - 0.031x_9x_3,
\end{aligned}$$

for men in Armenia.

We want to minimize y , weight gain, function of x_9 , the extra kilograms and x_3 , the period in months for achieving the weight loss goals.

According to prior academic literature, 1 pound of body fat equals 3500 calories, and by providing a mean of 500 calorie deficit it requires at least a month to lose 10 pounds (4.536 kg) in a healthy way. In other words, marginal rate of weight loss, $MRW = -4.536$, i. e.

$$x_9 + 4.536x_3 = c = const, \text{ where is the weight loss constraint.}$$

Using the LaGrange method of multipliers, we get the following LaGrangian equations:

$$L(x_9, x_3) = 0.196x_9 + 0.004x_9^2 - 0.031x_9x_3 - \lambda(x_9 - 4.536x_3)$$

$$\nabla L(x_9, x_3) = 0.196x_9 + 0.004x_9^2 - 0.031x_9x_3 - \lambda(x_9 - 4.536x_2) = 0$$

$$\frac{\partial L(x_9, x_3, c)}{\partial x_9} = 0.196 + 0.008x_9 - 0.031x_3 + \lambda = 0$$

$$\frac{\partial L(x_9, x_3, c)}{\partial x_3} = -0.031x_9 + 4.536\lambda = 0$$

From the first partial derivative we obtain that $\lambda = 0.031x_3 - 0.196 - 0.008x_9$. By inputting the result into the second partial derivative, we get

$$-0.031x_9 - 4.536\lambda = -0.031x_9 - 4.536(0.031x_3 - 0.196 - 0.008x_9) = 0$$

$$-0.031x_9 - 0.14x_3 + 0.88 + 0.036x_9 = 0$$

$$0.05x_9 - 0.14x_3 + 0.889 = 0$$

$$x_3 = \frac{0.05x_9 + 0.889}{0.14}$$

$$x_3 = 0.35x_9 + 6.35$$

And for man the formula will be,

$$x_3 = 0.35x_9 + 7.84$$

This means that an in order to lose 10 kg weight and never get it back an average statistical woman in Armenia will need to control and weight watch for 11 months, and man 12.5 months.

V. Conclusion

“Dietonomics: A junior Economist Researches the Other Side of Dieting” provides an alternative outlook on the issue of weight loss. Taking into account the discoveries done in the field of nutrition, dieting and fighting obesity, the academic reviews and data collected through a randomized experiment, the factors behind weight loss, result maintenance and regain have been explored. Through understanding the main dieting trends, eating habits and emotional patterns following weight loss, we have conducted multiple regression analysis to formulate the relationship between weight regain and other independent variables. In contrast to prior expectations, some of the fed dieting tips were not significantly correlated with weight regain or result maintenance. As a result, the final model of weight regain included the independent variables of lossperiod, i.e. the time period in months, required to lose weight, weightstart, starting weight of the respondent, and some factors, which relate to eating and behavioral patterns, such as having a breakfast, retaining moderate physical activity, acquiring some intuitive eating habits, and getting rid of restrictive eating habits, etc.

Although the development and strategic management of different lifestyle habits is another topic of consideration, it is possible to maximize its value, thus diminishing the weight regain. Only, 33% of weight regain is due to unexplainable factors, which means that the rest are determined through habits and the two other variables of interest, i.e. startweight and lossperiod.

Taking some weight loss facts and figures as a priori, and assuming that a weightwatcher aims to lose all the extra weight, we have done some alterations and by using the technique of La Grange multiplier method for optimization, obtained that the weight regain is minimized, when the following is satisfied:

$$x_3 = 0.35x_9 + 6.35 \text{ for women}$$

$$x_2 = 0.35x_1 + 7.84 \text{ for men}$$

In order to lose weight and never gain back the weight loss period can be calculated for both genders.

Limitations of the results include but are not restricted to sample size, measures used to report obesity, channels to collect data and the problems associated with self-reported data.

Additionally, the model was developed based on the linearity assumption of the coefficients, however, it is possible that other models produce completely different results and follow radically other conclusions.

VI. References

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VII. Appendixes

Table 9: Data

age	gender	start_weight	weight_lost	diet_type	diet_method	cheat	loss_period	sugar	chewing_gur	meals_per_c	breakfast	eating_habit	craving	physical	regain_rate	
48	1	78	19	4	1	3	4	0	1	3	0	4	3	1	0.84210526	
27	1	73	28	3	3	5	6	0	1	3	1	3	1	4	0.39285714	
23	1	68	4	4	1	1	3	0	1	4	0	4	4	1	1.25	
41	1	78	9	2	3	3	3	1	1	2	1	4	3	3	0.44444444	
24	1	68	25	2	4	5	3	1	1	4	0	4	5	4	0.6	
22	1	89	22	3	3	1	4	0	0	5	1	3	2	4	0.68181818	
37	1	76	14	3	3	3	6	0	1	5	0	2	2	3	0.57142857	
48	1	79	14	3	4	1	5	1	0	5	1	4	4	5	0.78571429	
18	1	75	19	1	3	2	5	0	0	3	0	1	2	1	0.47368421	
40	1	65	13	1	2	3	3	0	0	3	0	1	5	2	0.38461538	
19	1	67	9	2	1	4	7	3	0	1	2	1	3	1	0.55555556	
23	1	63	23	4	1	4	5	0	1	1	1	4	5	2	0.65217391	
31	1	67	22	4	1	1	7	3	0	1	4	1	2	5	4	0.90909091
47	1	94	29	4	4	3	4	0	1	4	0	4	3	4	0.86206897	
47	1	68	7	3	4	1	3	0	1	4	0	4	5	4	1	
34	1	74	16	1	1	1	8	1	1	5	0	3	2	4	0.8125	
22	1	90	18	4	1	1	3	0	1	4	0	4	4	2	1	
37	1	74	14	2	2	2	4	0	1	5	1	2	5	2	0.71428571	
47	1	68	19	3	2	3	4	1	1	4	0	1	2	5	0.36842105	
28	1	78	10	3	1	4	3	0	0	4	0	3	2	1	0.7	
34	1	68	13	4	2	3	4	1	0	3	1	4	5	2	0.38461538	
47	1	89	30	1	1	4	6	0	1	4	1	3	3	4	0.53333333	
45	1	76	21	3	4	1	7	3	0	1	3	0	2	4	2	0.80952381
47	1	84	17	1	1	3	5	0	0	5	1	3	3	1	0.41176471	
23	1	76	13	3	1	3	3	0	1	3	0	1	1	1	0.69230769	
25	1	85	28	1	2	2	6	0	0	3	1	4	4	3	0.60714286	
24	1	104	38	4	3	3	9	0	0	3	0	3	3	5	0.68421053	
42	1	79	34	3	4	3	10	0	0	3	0	5	3	1	0.35294118	
44	1	67	24	3	3	4	6	1	0	3	0	2	5	3	0.54166667	
22	1	88	24	2	4	4	9	1	1	1	0	1	5	5	0.70833333	
25	1	64	10	4	2	1	4	0	1	3	0	4	5	2	1.1	
33	1	72	27	4	3	1	7	1	1	4	1	3	5	1	0.7037037	
44	1	75	27	1	3	4	8	0	0	4	1	3	4	2	0.25925926	
48	1	69	10	2	2	2	7	1	0	3	0	3	4	2	0.4	
28	1	74	24	2	2	4	10	0	1	3	0	5	1	5	0.16666667	
18	1	85	31	2	1	4	7	1	1	4	1	5	2	5	0.09677419	
35	1	96	36	1	4	4	6	0	0	5	0	5	1	4	0.16666667	
48	1	81	19	2	3	3	6	1	1	4	0	4	5	2	0.42105263	
39	1	80	13	3	4	4	4	1	1	2	1	5	2	4	0.38461538	
18	1	78	13	1	1	2	3	1	1	4	1	4	5	3	1	
42	1	94	32	3	2	3	9	1	1	2	0	4	3	2	0.375	
46	1	75	12	4	1	3	4	0	0	5	0	3	2	1	0.33333333	
45	1	64	19	2	1	5	6	0	1	5	1	5	1	5	0	
23	1	67	14	3	4	2	6	1	0	3	0	1	4	3	0.78571429	
43	1	78	20	3	4	2	4	1	0	3	0	4	4	5	0.85	
32	1	67	18	4	1	3	4	0	1	3	0	4	5	2	1	
26	1	63	8	2	1	5	5	0	0	3	1	5	3	5	0.125	
40	1	89	25	3	3	4	3	1	1	5	0	3	2	1	0.32	
18	1	72	9	4	3	5	4	0	0	3	1	3	1	5	0.33333333	
23	1	64	18	3	2	4	6	0	0	4	1	5	2	5	0.11111111	
44	1	86	22	4	4	1	4	0	1	3	0	4	4	2	1	
24	1	68	18	2	4	3	3	1	0	5	1	1	5	3	0.44444444	
39	1	73	12	2	3	5	11	1	1	5	0	5	2	5	0.08333333	
41	1	84	24	3	4	2	4	1	1	5	1	5	4	5	0.79166667	
47	1	74	9	1	2	5	3	0	0	5	0	5	4	4	0.66666667	
43	1	67	14	1	1	5	8	0	0	4	0	4	2	4	0	
47	1	78	18	2	3	5	4	1	1	3	1	2	4	2	0.55555556	
26	0	85	11	4	3	2	4	0	0	3	0	5	1	5	0.36363636	
33	0	84	14	3	2	3	5	1	1	5	1	4	5	4	0.42857143	
58	0	85	5	4	1	1	2	1	0	5	1	5	1	4	0.8	
26	0	93	11	2	1	5	6	0	1	5	1	1	4	5	0.09090909	
38	0	92	14	1	2	4	5	0	1	1	0	1	2	5	0.5	
37	0	84	8	4	1	1	3	1	1	5	0	1	5	4	0.5	
35	0	86	13	2	4	2	5	1	1	5	0	5	1	3	0.69230769	
41	0	85	4	3	1	1	1	0	1	4	1	1	5	2	1	
48	0	75	11	1	2	2	4	1	0	3	0	4	4	3	1	
59	0	85	7	4	1	3	4	1	1	4	1	4	5	4	1	
43	0	95	10	4	3	2	4	0	0	3	1	2	5	4	0.5	
32	0	98	27	3	2	4	4	0	1	4	0	3	5	5	0.7037037	
56	0	107	8	1	1	5	12	0	0	5	1	5	1	4	0	
47	0	105	26	2	2	2	4	1	0	3	0	1	4	5	0.53846154	
41	0	90	20	3	4	4	9	1	0	3	1	5	1	5	0.25	
28	0	97	25	2	4	2	4	0	1	4	1	4	5	3	1	
22	0	86	14	3	1	4	5	1	0	5	0	3	3	4	0.28571429	
58	0	79	8	1	3	3	1	1	0	4	1	3	4	2	0.625	
29	0	85	13	1	2	1	3	0	1	4	0	3	5	3	0.92307692	
44	0	92	13	3	3	5	6	1	0	5	1	4	5	4	0.61538462	
58	0	88	8	1	4	3	1	0	1	3	0	5	2	2	0.625	
54	0	79	5	4	2	3	4	0	0	3	1	2	5	3	0.6	
46	0	98	26	2	3	3	11	0	0	3	0	2	3	4	0.42307692	
50	0	84	7	1	2	5	10	1	0	4	1	4	1	5	0	
56	0	80	9	4	2	5	2	1	0	3	0	1	1	3	0.77777778	
51	0	86	6	3	4	5	6	0	1	4	1	5	4	5	0	
52	0	87	6	1	4	4	6	0	0	4	0	5	2	5	0.5	
18	0	91	17	2	2	1	7	0	0	5	0	1	5	5	0.82352941	
52	0	85	4	1	4	2	5	0	0	4	1	5	3	4	0.25	
40	0	82	6	1	3	1	5	1	0	3	1	1	3	5	0.5	