A Study on Weight Loss: Measuring the Effects of Healthy, Vegetarian, and Ketogenic Diets With Weight

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1. Abstract

As the population of obesity and diabetes has been increasing rapidly, it has brought people's attention to a crucial question – how do we maintain health? Diet has been one of the most common methods, however, with all the misleading information online, there is the necessity to examine the most effective ways to prevent or decrease comorbidities associated with obesity and to understand which restrictive diets do not help. In this study, we aimed to determine, among Ketogenic, Vegetarian and Healthy Food diets, the one(s) resulted in the most weight loss in a 14-day period. We started our experiment design with determining the sample population – at least 197 participants. We obtained consents from as many islander as we could, randomly selected 198 people across all three islands, divided them into 9 groups for our two-way randomized block design, and randomly assigned them a treatment. To obtain our data, we measured the weights of islanders before and after the diets and conducted data analysis afterwards. From our results, 14 days was not long enough to see distinctive outcomes from the diets, and the only significant variable was our blocking variable, which was gender.

2. Introduction

According to CDC, obesity prevalence has been epidemic in the US, increasing from 30.5% of the population to 41.9% from 1999 –2000 to 2017 –March 2020. Currently, the percentage of obese population is 39.8% among adults aged 20 to 39 years, 44.3% among adults aged 40 to 59 years, and 41.5% among adults aged 60 and older. Moreover, obesity could also lead to conditions such as heart disease, stroke, and type 2 diabetes, which could be the causes of preventable, premature death. From the data on the CDC website, 11.3% of the US population is diagnosed with diabetes and 38.0% of the adult US population with prediabetes, and type 2 diabetes is the most common, which 90% to 95% of the diabetes patients have it. This raises the question to a very important issue, how do we keep ourselves healthy and prevent being obese or diabetic? This topic has caught experts' attention, and several methods were suggested – diet being one of them. From literature review, study has found that type 2 diabetes can be reversible with weight loss, ketogenic is one of the popular ones since this low carbohydrate diet also helps reduce the potential error when calculating the insulin doses for type 1 diabetes. Due to the limited options on The Islands, in this paper we will examine the effect between weight loss and Ketogenic, along with Vegetarian and Healthy Food diets to find out which diet is the most effective for this health issue.

3. Methods

a. Participants

For participants, we used the Island software to simulate our experiment. Islanders on the Island behave like normal people do in real life. Our research indicated that three age groups(20 - 39 years old, 40 - 59 years old, 60 years old and older) are having major health concerns with obesity. We decided to select people who belong to these age groups as our research subjects.

Since our primary interest in this study is to find the effects of diets on different age groups, we decided to block gender, as gender could be a potential factor that affects the variability within each group. The process of obtaining necessary data required us to go into different cities and islands to ask people for consent to be in our study based on their age and gender. Sample size determination was also performed, and in order to have enough power for the analysis. We needed 197 islanders from the Island in this study.

b. Design

We chose two-way randomized block design, since it is beneficial for controlling confounding variables, in our case, gender. It also reduces within block-variability and it is efficient in terms of statistical power, since our number of experiments is limited due to long periods of observation time and cost of experiment would be high in real life. Experimental design for the study is shown:

Response Variable	Weight loss		
Treatment 1: Diet	Healthy Food	Vegetarian	Ketogenic
Factor 2: Age	20-39 years old	40-59 years old	60 and older
Block: Gender	Male	Female	

The intention of the design is to equally assign participants to a healthy food diet, Vegetarian diet, and ketogenic diet. Within each diet, participants will be assigned to their appropriate age group, with an equal number of males and females. The number of participants in each age group across diets are also equally assigned. In total we would have 9 groups, 3 age groups in each diet choice. This would ensure reduction within block-variability and ease of measuring and recording data. In consideration of how long it would take for diets to have effects, we decided to measure each subject with diet for a quite long period, however, due to the limitation of the software, we were able to task the subject for 14 days.

c. Instruments

The experiment is conducted on the Island for participants selection and measurement of data. Link for the simulation software is provided.(https://islands.smp.uq.edu.au/login.php) All participants are randomly selected by each team member, by choosing a person and asking for consent. Many tasks are already implemented by the software itself. As permitted by the technology, choosing a diet, taking a diet for a certain amount of time, and measuring weight were all conducted on the Island. We used google sheets as our tool to collect and record data: https://workspace.google.com/products/sheets/ For randomly selecting and assigning participants to the corresponding groups, we performed this procedure in R studio using code. Further data visualization and analysis were also performed in R.

d. Procedure

We needed at least 197 participants to ensure statistical power. Since our design required 9 equally numbered groups of participants. We added 1 more participant (total of 198) to ensure equal distribution for each group. Finalized design for the assigning groups was 3 age groups for each diet choice. Each diet choice would have 66 participants , within each diet, each age would have 22 participants, 11 males and 11 females. This way a total of 198 participants were evenly distributed to 9 groups, with 22 participants in each group. Since the Islanders on the island are not all willing to participate in studies, and the software itself does not permit outside implementation of random generators. Our team decided that each of us would go to the islands and randomly select people regardless of gender and age. We recorded a very large number of names and ages of participants who were willing to be in our study on a spreadsheet. We used R coding to group them by their age group and gender, then used the software to randomly assign them to each group along with the diets. Thus we obtained a data sheet of 198 participants randomly assigned in each cell with 11 males and 11 females along with diet choice for each person. We used the names and location of the chosen participants, to find them on the Island, measure and record their weight before attempting any diets. Finally we tasked each participant with assigned diets with a duration of 14 days, then measured the weight and recorded the weight change, compared to the initial weight. We then had finalized data, ready to be analyzed.
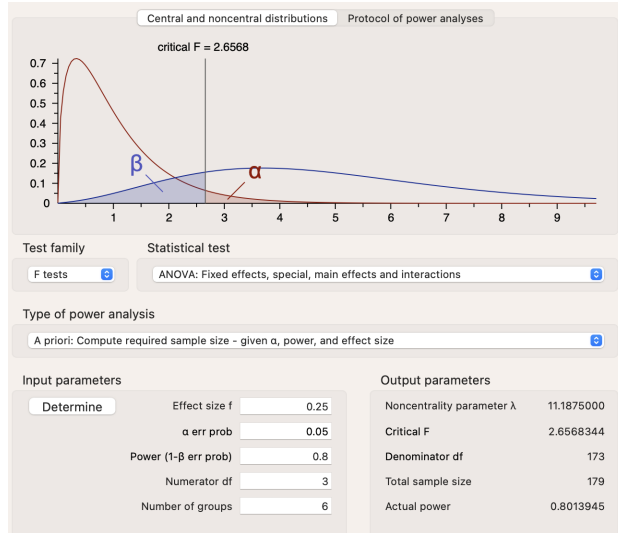
4. Data Analysis

a. Type of Statistical Analysis

Since all of our data and analysis were going to be performed in R, we decided to use functions provided in R to help us analyze our code. Firstly we plotted our data into interaction plots to see if there were any indications of variables affecting each other. We used ANOVA tables to see the actual effects of variables. Diagnostics tools were implemented to determine whether our model was effective or not. Box plots and tables of effects were also added to help with our study.

b. Sample Size Determination

In order to determine the sample size needed for our experiment, so that the desired   statistical power was satisfied. We used G-Power software, and set a test family for F tests, given the desired power, effective size, significance level and degrees of freedom. We were able to obtain a sample size of 197. Details of G-Power result shown below:

Central and noncentral distributions   Protocol of power analyses

critical F = 2.6568

Test family   **Statistical test**

F tests   ANOVA: Fixed effects, special, main effects and interactions

Type of power analysis

A priori: Compute required sample size – given α, power, and effect size

Input parameters

Determine	Effect size f	0.25
	α err prob	0.05
	Power (1-β err prob)	0.8
	Numerator df	3
	Number of groups	6

Output parameters

Noncentrality parameter λ	11.1875000
Critical F	2.6568344
Denominator df	173
Total sample size	179
Actual power	0.8013945

5. Results

a. ANOVA Analysis

	DF	Sum Sq	Mean Sq	F value	P-value
Diet	2	0.0028	0.001414	0.0617	0.9401555
Age Group	2	0.0149	0.007475	0.3263	0.722004
Gender	1	0.2546	0.254596	11.1137	0.001032
Diet:Age Group	4	0.0593	0.014823	0.6471	0.629618
Residuals	188	4.3068	0.022908		

Table 1: Two-way ANOVA with Blocking and Interaction. Our ANOVA table shows a p-value of 0.94 for the diet factor meaning diet does not have a significant impact on weight loss when implemented for two weeks. The age group factor has a p-value of 0.72, therefore we conclude the mean of weight loss from the different age groups are the same. We also found that the interaction between diet and age group does not have a significant effect on weight loss. We blocked by gender and found it to have a p-value of 0.001032, meaning gender plays a role in determining weight loss. In all, we conclude the difference of means within each factor (Diet and Age Group) are equal and gender has an effect on weight loss.

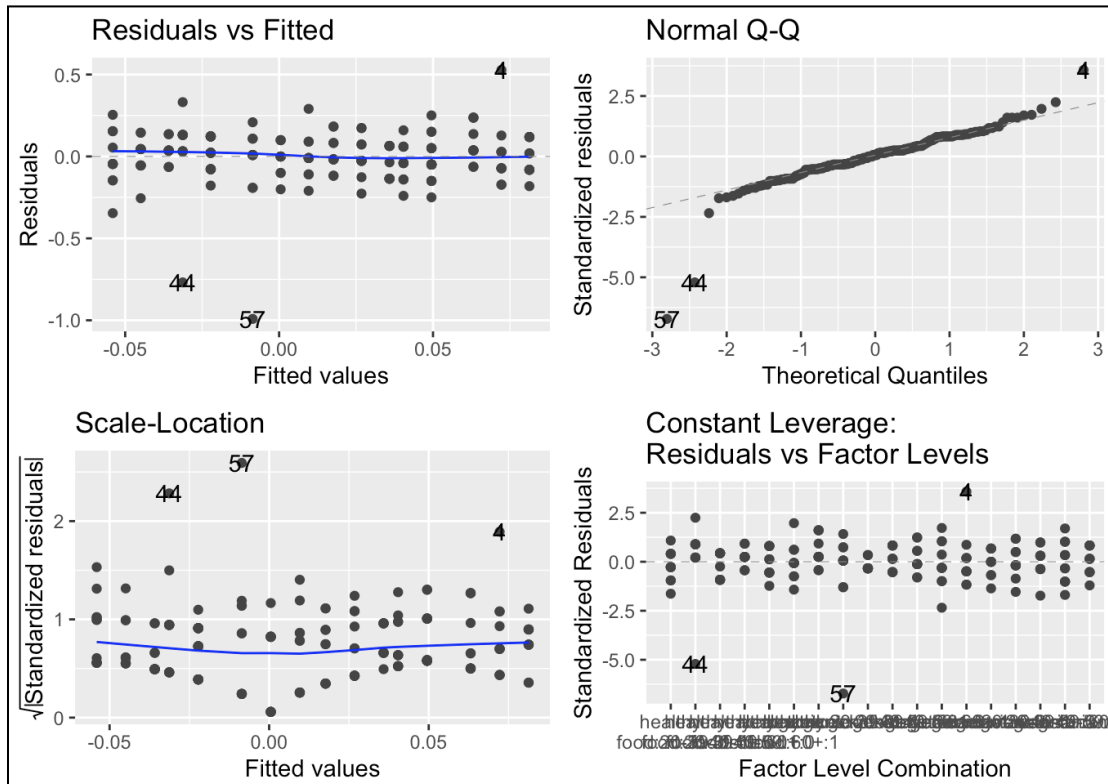## b. Residual Diagnostics

Figure 1: Model Diagnostics Plot for ANOVA. The Residuals vs Fitted, Scale-Location, and Constant Leverage: Residuals vs Factor Levels show constant variance in the residuals along the horizontal axis. The Normal Q-Q plot also suggests the residuals follow normal distribution.
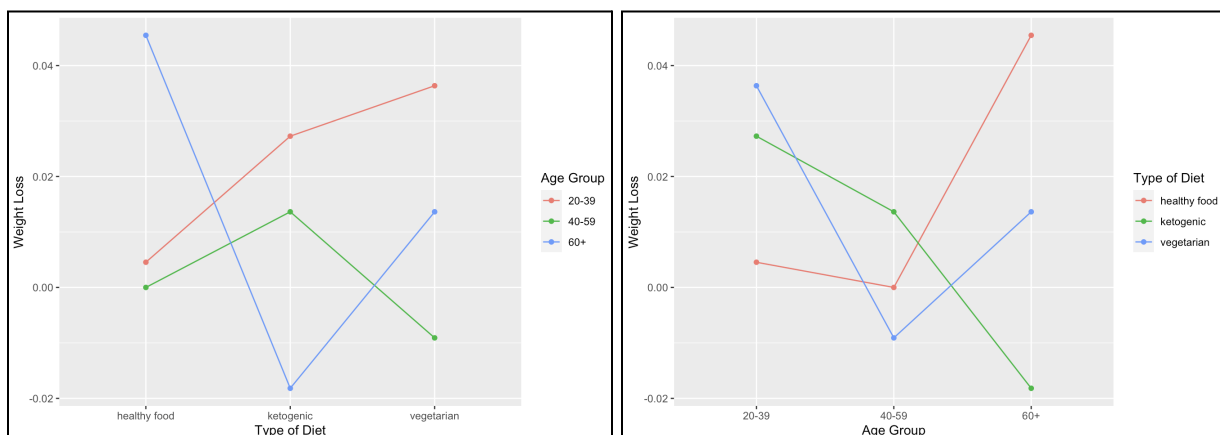
c. Interaction Plots

Figure 2: Interaction Plots. The age group 20-39 tends to have the highest weight loss across the three diets. As the islander's age increases, the ketogenic diet becomes less effective for weight loss. The plots suggest there might be an interaction between the diet and age group, however the ANOVA results demonstrate the interaction does not have a significant effect on weight loss.
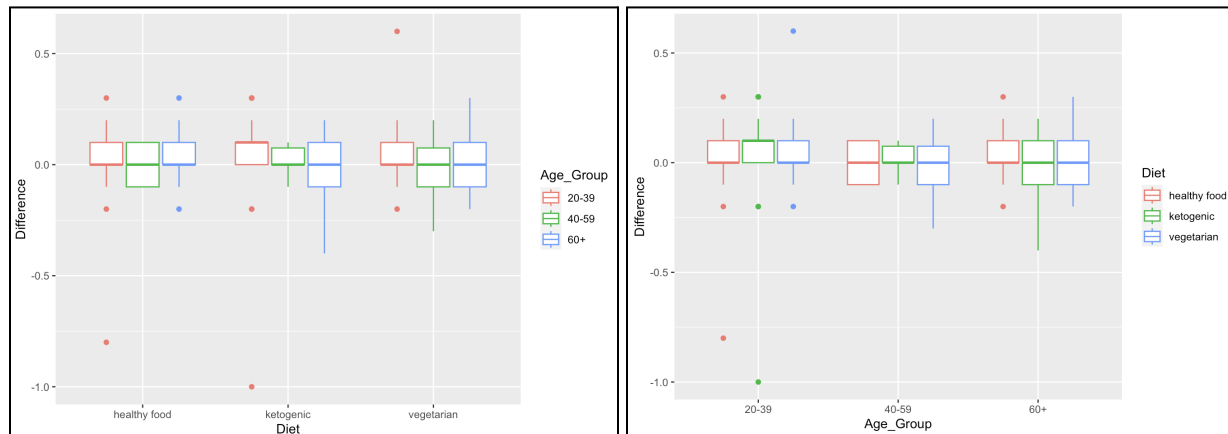
d. Box Plots

Figure 3: Diet vs Difference and Age Group vs Difference Box Plots. The median is represented by the darker shaded bars within the box and outliers are noted by the points outside the boxes. The median under the ketogenic diet for age group 20-39, is higher than the median of weight lost for the other age groups. The distribution of the different groups are very similar and align with our ANOVA result, that the group means are equal.

6. Discussion

The aim of this study was to determine the effectiveness of three different diets: healthy, vegetarian, and ketogenic in weight loss and the impact of different age groups. Our results attempt to support or refute the idea of a specific diet having a bigger impact on weight loss or any impact at all of any diet. Our goal was to determine if diet was an impactful factor of a weight loss journey in just 14 days.

We had a sample size of 197, but since our factor diagram was in multiples of 9, we decided to add one more sample to our study. We used an effect size of 0.025 and a power of 0.8. After running our experimental design on the Islanders, our ANOVA analysis demonstrated that although the ketogenic diet had a slightly more impactful effect, none of the diets were able to significantly change the mean of the weights of the Islanders. However, our blocking factor, gender, did have a significant impact on the change of mean of weight.

The lack of significance in both our age group and diet, along with its interaction, indicates that 14 days of a harsh diet cannot significantly change the weight of an Islander. Our experimental design used gender as a block. We used diet as a treatment taking into account age groups, and weight was the response variable. It is important to take into account age groups because as age increases, metabolism decreases. Because of this, its lack of statistical significance using $\alpha = 0.05$ on our p-values, it shows that diets cannot significantly change the mean of weights of the Islanders within just 14 days.

Going deeper into our analysis, since we did not find any significance among our treatments, the Tukey HSD plot is unnecessary. However, our interaction plot showed something interesting. Our

interaction plot showed a lot of interactions with lines consistently crossing and intersecting each other. This shows the flaws of the interaction plot and how just because there is an intersection between lines does not mean that the interaction is significant. We acknowledge that the treatment limitations on the Islanders inhibited us from performing these diets for more than 14 days straight.

The boxplots continued to prove our lack of significance. With the majority of the differences not differentiating between diets and not straying away from 0. This shows that the difference in mean was close to 0. Not only that, the boxplots between age groups are nearly identical. It is important to note that this does not mean that age groups have no significance in weight loss and metabolism, but the fact that no one lost weight in general.

We acknowledge that there were some limitations to our experimental design which can be improved upon for any follow up studies. One of our primary limitations was the number of days we could perform the experiment on individuals on the Islands. It was not possible to perform the ketogenic diet for more than 14 days on an individual, so we had to limit all diets to just 14 days. Unfortunately, the way the human body works, diet plans cannot see significant effects within just 2 weeks solely based on diet. If diets can be performed on the Islanders for more than 14 days, there could be much more significance in the effect of diet on weight loss. Another aspect we can improve on is weight classes in terms of different weights. Biologically, if an individual's body mass index is higher, they burn more calories daily on average, and hence, they lose more weight. Another thing to consider next time is to compare the exercise habits of these individuals. No matter the weight class, age group, or gender, there was no way to ask what the daily activity of the individual is, whether it is activity at their occupation or just in general. Thus, overall we must overall measure the amount of calories burned daily by individuals, and then separate these individuals into different groups. This will help us solely track the effectiveness of diet on weight loss.

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