Misperceptions and mismanagement in a weight loss regime

A gaming experimental analysis on weight loss strategies

by

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ABSTRACT

There is a significant number of people who do not succeed in reaching their desired weight after a weight loss regime. It has been argued that this inability to achieve the goal is because of the misperception of the adaptive mechanism of the human body. For this reason, this study aims to provide empirical evidence of people's weight expectations and performance during different weight loss regimes. To collect this data, a body weight management simulator was created so that different groups of participants could input their expectations and strategies to lose weight. From this data, it is observed that people's expectations were significantly higher, and that most participants failed to reach the desired goal weight. Furthermore, significant change is seen in people's expectations when undergoing a weight loss regime that includes physical activity. In general, the results show empirical evidence of people's misperception and performance during different weight loss approaches. For this reason, it is recommended to develop an interactive learning environment for weight loss management in order to increase people's knowledge of the different adaptive mechanisms of the human body. This could lead to an increased chance of success when pursuing a weight loss diet.

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1. INTRODUCTION

1.1. Background Information

Obesity is one of the most prevalent health epidemics of the 21st century with 39% of adults classified as overweight or obese worldwide (WHO, 2015). Overweight has brought many individuals to self-imposed diets, commercial diet plans and health professional guidance, being the first two the most popular courses of action with a lower rate of success (Julia et al., 2014). These popular diet plans mainly rely on high calorie restriction and the absence of specific macronutrients (Freedman, 2001).

It has been highly debated that a large portion of the dieting failures is due to the misperception of the mechanisms that regulate our body. In other words, people's expectations are usually higher than what it is possible to achieve when the person is following a diet. This high expectation crushes with reality and people usually go back to gaining weight. Another possible reason is that people underestimate the adaptability impact of commercial or popular diets. Studies have shown that most dieters do not reach their goal in a weight loss plan and tend to go back to their previous weight or even exceed their initial weight (Foster et al., 1997). Furthermore, people usually perceive difficulties to adapt to the diet as well as complications in everyday life while following the regime. These obstacles are especially highlighted in commercial and popular diets (Julia et al., 2014).

One of the reasons for dieting failures could be the lack of knowledge or the inappropriate mental model of the complex mechanism of the human body, and its effects on energy balance. The complexity relies on non-linear relationships of energy intake and expenditure over time, delays in the body energy process and balancing feedbacks that promote the equilibrium in the body energy balance. For this reason, the mental model of dieters plays an important role in managing their energy intake and expenditure to achieve their goals in a complex and dynamic system like the human body (Hamid, 2009).

As stated by Hamid (2009) 'our bodies are continuously changing and adapting over time, both autonomously as well as in reaction to our lifestyle choices. Managing our bodies can be linked to pursuing a target that not only moves, but also reacts to the actions of the pursuer'. The misperception of how the body works in a diet process has an important impact on the failure of the dieting. Thus, the strategies in food intake and exercise must adapt over time in order to achieve the desired weight.

This research therefore evaluates the performance and expectations of a group of people in a weight loss regime through an experimental setting. The idea is to shed some light on people's general mental model during a diet when aiming to lose weight. For this purpose, I develop a body weight management simulator that attempts to replicate the difficulties or the effort that people undergo during a weight-loss diet, which in turn will give some restrictions to the dieting strategy of the person. In this way, the simulator becomes closer to real life, as people would not be allowed to undergo unrealistic low-calorie intake diets or extremely high level of exercise for a long period. It is well known that dieting and physical activities are influenced by external factors such as advertising, food availability, food price, accessibility to areas for exercise, among others. However, these external factors will not be considered in this study.

In this thesis, I will firstly present the human metabolism model based on (K. D. Hall, 2006), followed by the hypothesis and the experimental design. I will then show the results of this study and draw some conclusions.

1.2. Problem formulation and research objective

A large number of people have undergone a weight-loss regime with a high percentage of them not succeeding in achieving their desired weight. There are numerous factors and explanations why it is so hard for people to lose weight and achieve their goal. These factors are genetic conditions, accessibility to exercise, the social environment, available food, individual psychology, among others. It has also been argued that one of the reasons for people failing in a weight-loss diet is that they do not account for the body adaptation to new diets or new physical activity. As the body adapts to the change in diet and/or physical activity, a dynamic decision making is needed in order to be able to achieve the goal. Computer simulators can replicate the high complexity of a system, so it is a recognized instrument to study dynamic decision making in a safe environment. In this study, a computer-based game is used in to evaluate people's performance on different weight-loss regimes, given restrictions such as willpower. Another aspect to be analysed in this study are people's expectations when undergoing a weight-loss diet. Although, these issues are well known, there is not enough empirical data of how these change at the face of different weight loss regimes such as, calorie restriction, different distribution of macronutrients in the diet and extra physical activity. Thus, this research aims to provide empirical evidence of people's expectations and performance when losing weight in different regimes.

2. LITERATURE REVIEW

2.1. Weight Management

Body weight is regulated by several mechanisms including genetic, physiologic, and behavioural factors. Obesity is a consequence of an imbalance between food intake and energy expenditure, which leads to an excess of fat accumulation and negative health outcomes (Assim, Reem, & Jiyoung, 2019). One of the major contributing factors to the increase in obesity worldwide is the inappropriate dietary intake and energy density of the diet, together with lower physical activity levels (James, 2008).

The rate of obesity and the number of "dieters" are increasing over time. Surveys consistently show that most adults are trying to lose or maintain weight (Serdula et al., 1999). If dieting worked, obesity should be decreasing or at least not increasing. While it is true that many dieters succeed in taking weight off, very few manage to keep the weight off over the long term (Foreyt & Goodrick, 1993), (Wing, 1988).

2.2. Dietary intake

The latest solution is the high-protein (or, more accurately, high-fat), low-carbohydrate diet. People lose weight while following this diet, but there is no evidence that the weight lost is maintained over the long term. In addition, these types of diets eliminate whole categories of foods known to have health benefits (i.e. fruits, whole-grains, vegetables, and milk). Energy restriction, not manipulation of macronutrients, is associated with weight reduction in the short term (French & Jeffery, 1997)

As stated by French et al. ((French et al., 1944)), reduction of particular food types such as French fries, dairy products, sweets, meat and cheese, butter, high-fat snacks, fried foods and desserts has also been observed in persons who better manage to maintain their weight. The importance of high-quality foods, such as fruits and vegetables, and healthy eating (Ogden, 2000) has also been noted.

2.3. Physical activity

Physical activity can facilitate weight maintenance through direct energy expenditure. Moreover, it can improve physical fitness, which facilitates the amount and intensity of daily activities (Saris, 1998).

Physical activity is recommended as an essential component of weight management for prevention of weight gain, for weight loss, and for prevention of weight regain after weight loss (Donnelly et al., 2009). In addition to increasing energy expenditure, exercise enhances the rate of fat loss and prevents the loss of lean body mass (Colvin & Olson, 1983).

2.4. Weight loss expectations

As research shows, hopes and expectations of people seeking weight loss are not as modest (Linde, Jeffery, Finch, Ng, & Rothman, 2004). When asked about weight loss objectives, overweight individuals typically select goals that are two to three times larger than average weight change outcomes (Foster et al., 1997).

The discrepancy between what people want from weight loss regimes and what is realistic to expect has led some to argue that unrealistic goals are themselves an obstacle to weight loss success. According to this reasoning, unrealistic goals have negative effects on task performance and psychological well-being that undermine behavioural effort (Cervone, Jiwani, Wood, & Sarason, 1991). Thus, encouraging dieters to adopt goals that are congruent with what they are likely to achieve may improve weight loss and psychosocial outcomes (Foster & Kendall, 1994).

It is theorized that unrealistic expectations impact the ability to maintain weight loss. This is because individuals who are unable to meet their unrealistic goals become dissatisfied with their progress and subsequently abandon weight maintenance behaviours (Elfhag & Rössner, 2005).

It has been suggested that the failure to reach a self-determined weight may discourage the person's belief in their ability to control their weight, which will result in an abandonment of weight maintenance behaviors (Cooper & Fairburn, 2001). This means that modifying weight loss goals can be important for subsequent results. Others have, however, questioned such a conclusion, arguing that the critical factor for long-term outcome may rather be the weight loss at the beginning of the diet (Rw, Mt, & Sa, 2002).

2.5. Psychological factors affecting weight control

Weight loss and maintenance may be influenced by many factors including behaviour, physiology, psychology, and environment. Psychological factors, although only one of many influences, are a critical component to consider. Evidently, individuals who have lost weight are able to implement the behavioural changes necessary to successful weight loss (Ohsiek & Williams, 2011).

2.6. Weight Cycling

In people trying to lose weight by dieting, there are often repeated cycles of weight loss followed by weight regain when the diet is interrupted. This is a phenomenon known as weight cycling or yo-yo dieting (Blackburn & Borrazzo, 1995).

Weight cycling is important to consider when studying weight management, as it represents failure in weight maintenance followed by renewed attempts to reduce weight. Weight cycling has sometimes been associated with mental distress and psychopathology (Brownell & Rodin, 1994); (Foreyt et al., 1995), although others who found no such relationship concluded that weight cycling does not seem to impact psychological health in negative way (Simkin-Silverman, Wing, Plantinga, Matthews, & Kuller, 1998). The prevalence of repeated dieting to lose weight and weight cycling is high in the general population and is not restricted to obese and overweight persons (Montani, Schutz, & Dulloo, 2015)

2.7. Laboratory Experiments in System Dynamics

System dynamics is a structural theory of dynamic systems Lane (1999) characterized by feedback loops, accumulation processes, and delays between cause and effect (Forrester, 1961). System Dynamics uses a combination of first-order linear and non-linear equations to relate qualitative and quantitative factors within and across time periods. It is based on the principles developed by Forrester to study managerial and dynamic decisions using control principles ((Forrester, 1961); (Homer & Oliva, 2001);

(Sterman, 2000)). Moreover, System Dynamics allows the modeller to replicate the system structure and to know how such structure induces the system behaviour ((Ponzo, Dyner, Arango, & Larsen, 2011). On this line, System Dynamics is a powerful method to design and conduct laboratory experiments that replicate complex environments, such as supply chains (Cantor & Katok, 2012) and natural resources markets (Moxnes, 2011)

Laboratory experiments with System Dynamics models have been used to test decision-making processes made by human subjects in complex and dynamic environments ((Lara-Arango, Arango-Aramburo, & Larsen, 2017); (Moxnes, 1998a), 1998b; (Sterman, 1989a), 1989b), finding interesting results that highlight people's limited mental models when it comes to decide about complex problems. These weaknesses are consistent with the Bounded Rationality theory which states that human decision-makers do not have the abilities assumed by the Perfect rationality theory. Moreover, it is expected that individuals make satisfying rather than optimal decisions ((H. A. Simon, 1955), (H. Simon, 1979)). Typically, human decision makers use simple decision rules called heuristics (Tversky & Kahneman, 1974), which serve as tools to make decisions without too much mental energy (time and effort spent on making a decision). The quality of the decisions determined by heuristics seems to be near optimal when people face simple tasks, but the quality reduces as the complexity of the task increases ((Arango & Moxnes, 2012); (Moxnes, Ford, & Cavana, 2004)).

Similar to traditional laboratory experiments in economics, a laboratory experiment in System Dynamics is composed of a goal, a system and the subjects' behaviour (Smith, 1982). The goal is the objective pursued by the experimental subjects, whereas the system is formed by the restrictions, institutions, and behavioural rules, among other specific conditions (Arango Aramburo, Castañeda Acevedo, & Olaya Morales, 2012)The decisions made by the subjects of the experiment are known as subjects' behaviour ((Daniel Friedman & Sunder, 1994);(Daniel. Friedman, Cassar, & Selten, 2004)).

The typical experimental settings applying System Dynamics ask subjects to perform tasks using computer simulators with an underlying System Dynamics model. This model is linked to a user's interface, where the user can input their decisions. In the model, some of the feedback loops have been cut out, allowing users to effect control of the interface and the researcher is able to study the subjects' decisions (Gary & Wood, 2008). Other approaches to experimentation in System Dynamics, ask subjects to forecast a system's behaviour based on a given scenario, or, similarly, ask subjects to answer questions about the system's behaviour (Moxnes et al., 2004). While researchers can vary delay lengths, feedback strength and other variables to isolate factors influencing subjects' behaviour, other elements of the experimental design, such as number of treatments, payoffs and information, depend on the purpose of the research and are not changed (Arango Aramburo et al., 2012).

3. RESEARCH METHODOLOGY

This research aims to provide empirical evidence of people’s misperception and mismanagement on a weight-loss diet. For this reason, it was decided to perform a computer-based experiment in order to collect empirical data about the strategies people follow in a weight-loss diet, and the expectations they have during such process. This simulator allows people to make their own decisions on daily total calorie intake and level of physical activity with the final aim of losing weight. Furthermore, the experimental setting allows for data collection of strategies in different scenarios, such as regular distribution of macronutrients or a low-carbohydrate diet.

3.1. Research Ethics

For data collection in the experimental design, Denscombe (2012) identifies three points: No harm to the participants, voluntary consent and scientific integrity.

The game experiment is performed online and there is no physical contact with the participants. ID numbers are generated to randomly assign different treatments to the people willing to play the game. Although weight loss could be a sensitive topic, the game uses an imaginary person as the main character in order to minimise emotional attachment to the problem. This characteristic of the experiment diminished possible psychological and physical threats. All the participants were free to leave the simulation at any time and the data collection was anonymous. This study follows the research integrity requirements of the University of Bergen.

4. MODEL DESCRIPTION

The changes in body weight and composition of the Body Weight Management Simulator are based on the computational model of in vivo human energy metabolism during semistarvation and refeeding develop by K. D. Hall (2006). This mathematical model was replicated in Stella Architect in order to represent the long-term dynamics of body weight.

4.1. Physiological model

This model describes the dynamics of the intake, utilization and storage of three macronutrients in the body: fat, glycogen and protein. Thus, representing the changes in body weight and composition over a long time scale, the model does not represent the changes of metabolism during a day, but it is based on a daily nutrient balance (K. D. Hall, 2006). The model takes as exogenous inputs the macronutrient intake (consumed food) and describes the body adaptation and macronutrient metabolism as a result of a variation in the diet (K. Hall, 2010). The physical activity energy expenditure in the model is proportional to the body weight and the physical activity coefficient. This physical activity coefficient can vary by external decisions.

The human body has various internal mechanisms that regulate the energy conversion and oxidation of the macronutrients present in the body. Figure 1 shows the most important mechanisms. On the one hand, we have the mechanism involving the metabolism of conversion, which regulates the energy expenditure in the transformation from one macronutrient to another. This conversion is also influenced by the food intake. On the other hand, the metabolism of body cells determines the energy required to maintain the living conditions, which depends on the current content of macronutrients. The fat and glycogen stored in the body require less maintaining energy compared to the protein molecules, therefore, the energy from the metabolism of body cells is highly dependent on the total protein content in the body (Nuhoglu, 2009).

The Resting Metabolic Rate refers to the energy required for the internal processes of the body to keep it alive, which include the metabolism of conversion and the metabolism of body cells.

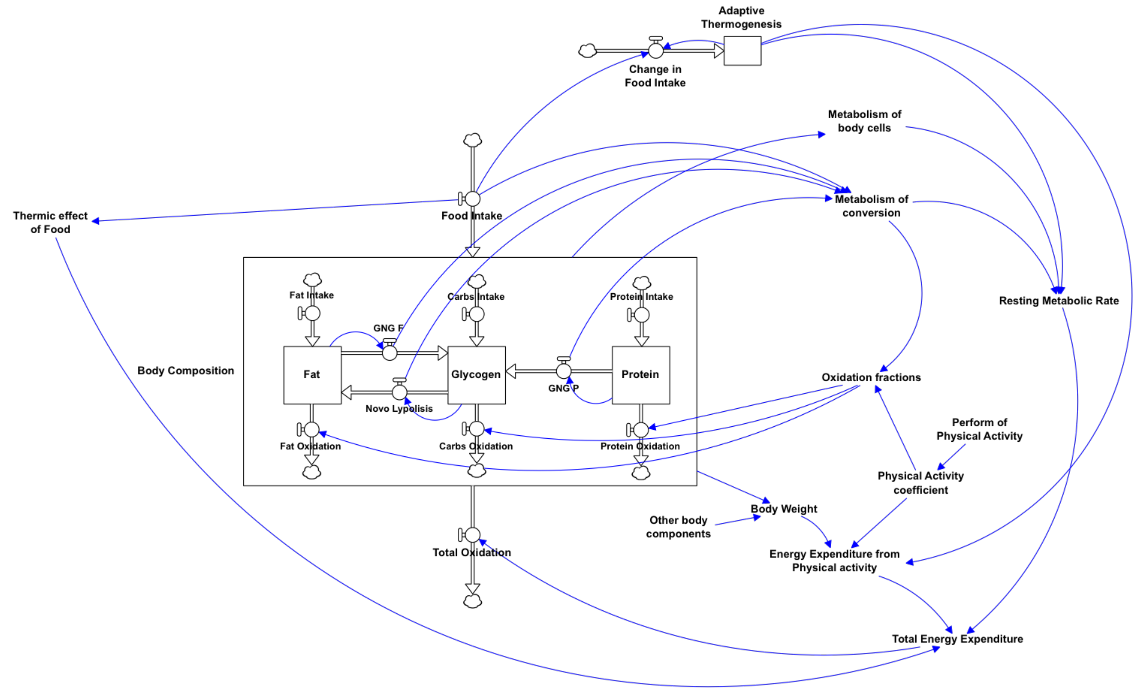

Figure 1: Aggregated stock and flow diagram of the body mechanisms of nutrient conversion and oxidation.

The thermic effect of feeding refers to the energy expenditure in the digestion of food. Each macronutrient has their own short-term thermic effect factor.

The physical activity energy expenditure in the model is proportional to the body weight and the physical activity coefficient. The physical activity coefficient, on the other hand, can vary by external decisions.

The adaptive thermogenesis refers to a body mechanism that opposes weight change and that is proportional to the change in the baseline calorie intake diet. This mechanism affects the resting metabolic rate and the physical activity energy expenditure. The total energy expenditure is the sum of the resting metabolic rate, the energy expenditure from physical activity and the thermic effect of food. The total energy expenditure is then distributed in the oxidation of the three macronutrients. This allocation of energy expenditure mainly depends on the balancing mechanism of metabolism of conversion, and the performance of physical activities.

K. Hall (2010) describes some fluxes between the macronutrient content in the body that are responsible of the change in macronutrient as shown in Figure 1. This diagram is a representation of the main flows influencing the storage of the macronutrient, and it does not attempt to represent biochemical pathways (K. D. Hall, 2006). The intake rates correspond to the daily food consumption. The oxidation rates are determined by the total energy expenditure and influenced by the level of macronutrients in the body. For instance, the change in level of fat, glycogen and protein over time is determined by the net imbalance of the flows influencing the stocks of the macronutrients.

In this way, Hall represents the macronutrient content in the following differential equations (adopted from Hall, 2006):

$$\rho_F \frac{dF}{dt} = FI + (DNL + G3P) - GNG_F - FatOx$$

$$\rho_C \frac{dC}{dt} = CI + GNG_P + GNG_F - (DNL + G3P) - CarbOx$$

$$\rho_P \frac{dP}{dt} = PI - GNG_P - ProtOx$$

Where F represents the fat, C the glycogen and P the protein content in the body. FI, CI and PI are the fat, carbohydrate and protein intake, respectively. DNL + G3P is the novo lipolysis rate, and the GNG_P and GNG_F are the gluconeogenesis rate from protein and fat, respectively. Finally, the FatOx, CarbsOx and ProtOx refer to the oxidation rates of fat, glycogen and protein. Appendix C shows a detailed description of the physiological model.

4.2. Decision making model

In order to mimic the constraints that most people have when they are on a weight-loss diet, a few concepts like willpower, adaptation cost of new diet and extra physical activity were introduced to the model. This part of the model tries to reproduce the motivational experiences that people undergo during a weight-loss regime, and also serves as a restriction for the game experiment. In this way, people cannot undergo unrealistic calorie restriction or extremely high physical activity. This dynamic is represented by three major elements: the willpower level, the calorie intake adaptability and the adaptability to extra physical activity. The willpower is depleted by the cost or effort to undergo a diet and perform physical activity. The replenishment of willpower depends on the weight loss and the energy balance of the person. Appendix C shows a detailed description of the decision-makingss model.

5. EXPERIMENTAL DESIGN

5.1. Experimental setting

The body weight management simulator is an experimental game based on the model described in the previous section. The simulator can be found on the following link: https://exchange.iseesystems.com/public/luisgavidia/bwms

In the game, the player is directed to play the role of an overweight person who is 1.8 meters tall and has a weight of 95 kilograms. He/she has the opportunity to decide the total daily calorie intake every week in order to achieve the desired weight. There is a limit in the calorie restriction that the player can decide to have, which is given by the willpower structure. The game starts in an equilibrium condition where the person has an intake of 3000 kcal per day and do not perform any extra physical activity. Therefore, the willpower also stays in equilibrium under this setting. The regular diet has the following distribution of macronutrients: 36% of fat, 49% of carbohydrates and 15% of protein.

There are four treatment groups in the experimental design. In these groups, players have different distributions of macronutrients in the diet, as well as the inclusion or not of extra physical activity. The groups are presented in Table 1.

Table 1: Experimental setting.

	No Extra Physical Activity	**Extra Physical Activity**
Regular diet	T1	T2
Low-carb diet	T3	T4

Treatment group - T1

The subjects in this group face the task to lose weight by the variation of the total daily calorie intake. This group maintains the initial distribution of macronutrients in the diet. The goal is to reach a weight of 80 kg by the end of the simulation.

Treatment group - T2

The subjects in this group face the same task to lose weight as in Treatment T1, with the difference that in this group the player also performs extra physical activity. Therefore, participants have the possibility to change their daily calorie intake and the amount of extra physical activity. For the physical activity, the player can select between 15, 30, 60, 90 or 120 minutes of extra physical activity per day. The goal in this group is to reach a weight of 82 kg at the end of the simulation.

Treatment group - T3

The subjects in this group also face the task to lose weight. As in Treatment T1, they are only allowed to change the total daily calorie intake. However, the distribution of macronutrients is different from the regular diet. This group undergoes a low-carb diet with the following distribution of macronutrients: 65% fat, 10% carbohydrates and 25% protein. The goal in this group is to reach a weight of 82 kg at the end of the simulation.

Treatment group - T4

In this group, subjects have the same goal to lose weight while undergoing the same low-carb diet as in treatment T3. This treatment group, on the other hand, has the option to choose the level of extra physical activity as in Treatment T2. The goal in this group is to reach a weight of 83 kg at the end of the simulation.

The equilibrium conditions can only be kept in the treatment group T1 as this is the one that follows the same regular diet and does not have extra physical activity.

The instructions in the simulator (Appendix A) give the player the general characteristics of the person that they would take the role of. They also include the characteristics of the macronutrient distribution of the diet that they will undergo to achieve the goal. They are also given the goal weight that they have to accomplish. On the instruction page there is also a short explanation of the willpower variable that they have to manage to achieve their goal. They are informed about the variables they can change and how often they can modify their decisions. Subjects have a total of 35 weeks to achieve the goal.

On the decision page (Appendix B), the player can input the desired daily calorie intake, and in treatments T2 and T4 they also decide on the extra physical level. Moreoever, they also need to say what their expected weight would be for the following week in relation to their decision on food intake and exercise. They have access to the willpower current level and the amount of willpower required for their decisions. In this way, if the willpower is not enough to proceed with their decisions, the game will show a message and the person will have to change their decision. On the decision page, they can also observe the initial and current weight, as well as the weight for the past three weeks and the goal.

5.2. Experimental procedure

The experiment was distributed online, so different links were created to assign participants to different treatment groups. In order to identify the groups, unique ID numbers were created. The numbers were in the order of 1100 for treatment group T1, 2200 for the treatment group T2 and so on. In this way, participants with ID number 1110, 1111, 1112 and subsequently were part of treatment group T1. For treatment group T2 the number sequence started in 2210, for treatment T3 in 3310 and for treatment T4 in 4410. According to this pattern, there was a total of 70 links created for each treatment group. These links were randomly allocated by email and social media like Facebook.

The links were distributed indistinctly of sex, background knowledge, or experience in weight loss diets. As this research tries to understand the general mental model, the participants were selected even if they have not been on weight loss regime. The collection of data was for over two weeks from the 15th of May until the 31st of May. In this period of time, a total of 320 run counts were registered in the isee systems. The data from the participants that did not complete the simulation or that had problems accessing into the interface by using mobile phone were excluded from the analysis. In total there were 122 completed simulations without technical problems. Twelve of these simulations were second and third tries as the participants had the opportunity to play the simulation as many times they wished. The number of participants who played the simulation more than once was very low to perform statistical analysis. For this reason, the study will only analyse the first trial of the different treatment groups. There was a total of 27 participants in treatment T1, 26 in T2, 29 in T3 and 28 in T4.

6. RESEARCH HYPOTHESES

Hamid (2003) argues that a big part of the dieting failure is due to people's inability to account for the balancing mechanisms of the human body when facing a calorie restriction. Furthermore, people often have higher expectations with a diet, which has been related to the failure of the diet. This study aims to evaluate how expectations and performance change in the face of different macronutrient distribution in the food diet, as well as the inclusion of extra physical activity. The experiment thus enables a test to the following research hypotheses:

Research Hypothesis 1: participants will not reach the goal weight.

Research Hypothesis 2: participants will fail to predict the change in body weight.

When starting a weight loss regime, some dieters also include extra physical activity in order to increase their energy expenditure. However, they often do not consider the increase in muscle preservation during an increment in physical activity. For instance, people perceive a high mismatch between the expected weight and the achieved one. For this reason, this study would like to discern if there is a significant difference in the expected weight between the participants that include extra physical activity and the ones who do not. On the other hand, the ones that include extra physical activity are expected to be closer to the goal. For these assumptions, the following hypotheses were stablished:

Research Hypothesis 3: the participants with extra physical activities (T2 and T4) will reach a weight closer to their goal than the participants with no extra physical activity (T1 and T3).

Research Hypothesis 4: the mismatch in the weight prediction from the participants with extra physical activity (T2 and T4) will be greater than the ones without physical activity (T1 and T3).

As mentioned in the introduction and literature review, there is a lower rate of success in a weight-loss regime when people undergo popular diets. For this reason, this study aims to test if there is a significant difference in the success between a regular diet and the well-known low-carb diet. The associated hypotheses are outlined as follows:

Research Hypothesis 5: the participants in a low-carb diet (T3 and T4) will have at the end a higher weight from the goal than the participants in a regular diet (T1 and T2).

Research Hypothesis 6: the expected weight of the participants in a low-carb diet (T3 and T4) would differ more from the real wright than that of the participants with a regular diet (T1 and T2).

Furthermore, the participants are expected to improve their weight predictions over time within a single play. Thus, the mismatch between the expected weight and the real one is expected to decrease over time within the same simulation.

7. RESULTS

From the 110 participants in this study, 58% were between 30 and 39 years old, 34% were between 40 and 49 years old, 6% were between 50 and 59 years old and the rest were older than 60. On the other hand, 48% of the participants were female and 52% were male. The participants were asked if they had been on a weight-loss diet before and 44% of them said that they had. The last question of the survey was if they had knowledge in system dynamics with a positive answer of 32%.

Results by group

Treatment group - T1

Figure 2 shows the results of the participants allocated to treatment group T1. It can be observed that some participants were close to the goal weight of 80 kg. This group has a mean final weight equal to 81.9 kg.

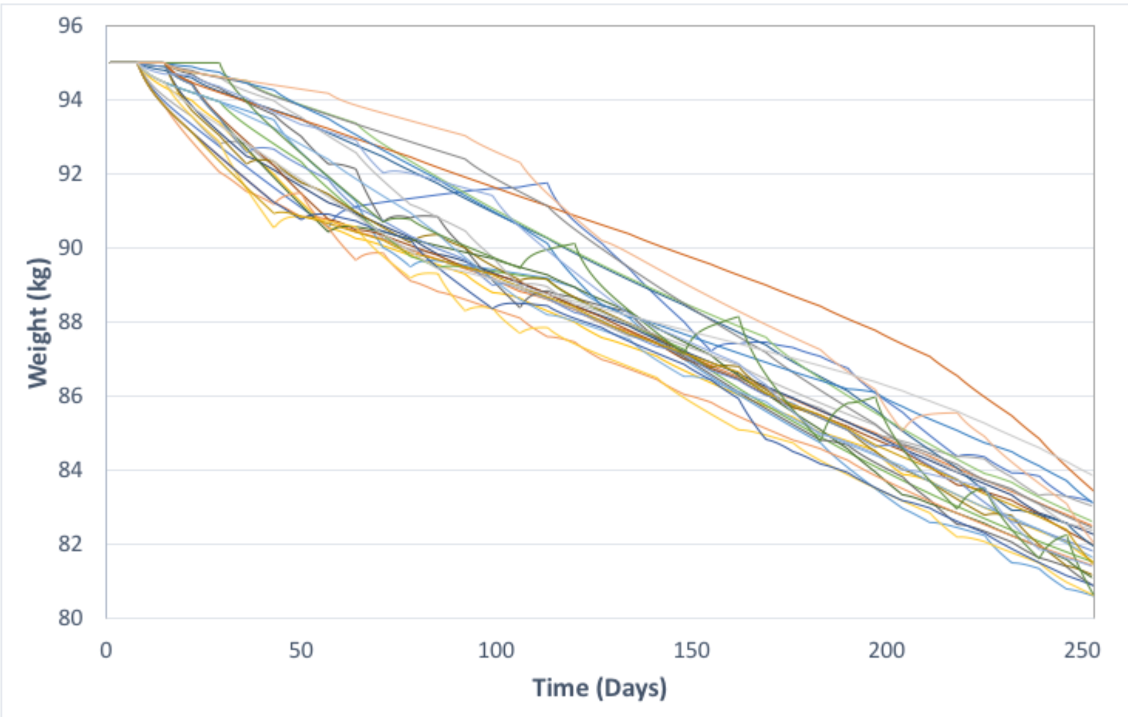

Figure 2: Results from treatment group T1. The colour lines are the actual results from the 27 participants in this group.

In Figure 2 we can see that none of the participants reached 80 kg. We can also appreciate that most of the participants gradually decrease their weight and some of them had significant high amplitude oscillations in their weight. A one-sample t-test was performed in order to assess if there is a statistically significant difference between the mean final weight of the group and the goal. The result is presented in Table 2.

Table 2: One sample t-test of the final weight achieved in the treatment group T1

	Final Weight - T1
Mean	81.90419125
Variance	0.816404738
Observations	27
Hypothesized Mean	80
Degreed of freedom	26
t Stat	10.9506447
P(T<=t) one-tail	1.54827e-11
t Critical one-tail	1.70561792

In this t-test, the null hypothesis H_0 is that the mean final weight μ_1 is less or equal to 80 (H_0: $\mu_1 \leq 80$), and the opposite hypothesis H_1 is $\mu_1 > 80$. We reject the null hypothesis if the t Stat is greater than the t Critical or if p-value is less than 0.05. In this case, t Stat > t Critical (10.95 > 1.71), so we reject the null hypothesis. This shows that the mean of the final weight is significantly greater than the goal weight. This supports Research Hypothesis 1, which states that the participants would not reach the goal weight.

To evaluate if there is an important variation in daily calorie intake over time, the following general regression model was made:

$$Intake_{T1} = \varphi_0 + \varphi_1 t$$

Where: $Intake$ refers to the daily calorie that the participants enter, and t refers to time. φ_0 and φ_1 are the coefficients of the regression for the intercept and the time, respectively.

If players do not vary their calorie intake over time, the regression will not provide any result and the coefficients will be equal to zero. Table 3 shows the results of the regression for treatment group T1.

Table 3: Regression result from the Intake vs Time in treatment group T1.

Coefficients	Estimate	Std. Error	t-value	p-value
φ_0	2453.72	16.1936	151.52	< 2e-16
φ_1	-2.1159	0.1114	-18.99	< 2e-16

Residuals:

Min	1Q	Median	3Q	Max
-892.37	-103.97	30.75	109.43	933.48

Residual standard error: 228.3 on 838 degrees of freedom
Multiple R-squared: 0.3009, Adjusted R-squared: 0.3001
F-statistic: 360.7 on 1 and 838 DF, p-value: < 2.2e-16

From the regression result, it can be seen that the time coefficient is different from zero, which means people vary their strategies in daily calorie intake throughout time. This fact is also validated by the very low p-value, which indicates that time is a significant variable.

A two-sample t-test assuming unequal variance was made to evaluate the participants' performance in predicting the change in body weight as a result of their decision on daily calorie food intake. In this case, the expected weight was compared to the real weight. The unequal variance was chosen because the two samples are the results of two different process: one comes from the mental model of the participant, while the other from the model. Table 4 shows the result of the t-test.

In this case, the null hypothesis is that the means of the two variables are equal, $H_0: \mu_1 = \mu_2$ and $H_1: \mu_1 \neq \mu_2$. The p- and t- value that were chosen to evaluate the results from the t-test are the two-tail outputs, this is due to the fact that the expected weight could be higher or lower than the real one. The p-value is 1.17e-10 which is less than $\alpha = 0.05$, this means that the null hypothesis H_0 is rejected. Thus, there are a significant difference between the expected and the real weight. This result supports the Research Hypothesis 2 which states that the participants would fail to predict the changes in weight. From this result we can also appreciate that in general terms the expected weight is lower than the real one.

Table 4: Two-sample t-test assuming unequal variance of the expected and real weights.

	Real weight	*Expected weight*
Mean	88.0935995	86.93087757
Variance	13.91473563	15.8059924
Observations	923	923
Hypothesized Mean Difference	0	
Degreed of freedom	1837	
t Stat	6.479582003	
P(T<=t) two-tail	1.17804e-10	
t Critical two-tail	1.961256205	

This study also evaluates if the weight expectations become closer to the real weight towards the end of the simulation. For this evaluation, the absolute value of the differences between the real and expected weight were compare over time. In order to have a statistical assessment, a paired two sample t-test was made between the absolute value of the difference between the expected and real weight in two period of time. The first period is from week 2 to week 5 and the second period was from week 32 to week 35. The paired two sample t-test was chosen because this is used to assesses means of the same group at different points in time. Table 5 shows the results.

Table 5: Paired two sample t-test of the absolute values of the difference between the expected and the real weight in the first and last weeks.

	First 4 weeks	*Last 4 weeks*
Mean	1.487225857	0.859885321
Variance	3.095383351	1.205667065
Observations	100	100
Pearson Correlation	0.023177314	
Hypothesized Mean Difference	0	
Degreed of Freedom	99	
t Stat	3.05692589	
P(T<=t) two-tail	0.002875168	
t Critical two-tail	1.984216952	

In this case, the null hypothesis is that the means of the two samples are equal, $H_0: \mu_1 = \mu_2$ and the opposite hypothesis $H_1: \mu_1 \neq \mu_2$. The p-value is 0.0029, which is less than $\alpha = 0.05$. This means that the null hypothesis H_0 is rejected. Thus, there is a significant difference between the first week expectations and that from the last week. The mean for the first weeks is equal to ± 1.49 kg of discrepancy between the expected and the real weight. In the last weeks, this discrepancy is equal to ± 0.86, whereby suggesting that there could be a learning process during the simulation.

Treatment group – T2

Figure 3 shows the results of the participants allocated to treatment group T2. It can be observed that some participants were close to the goal weight of 82 kg. We can see in Figure 3 that one of the participants may have misunderstood the dynamics of the simulation (grey line); consequently, the data from this participant was excluded from the analysis. This group has a mean final weight equal to 85.62 kg.

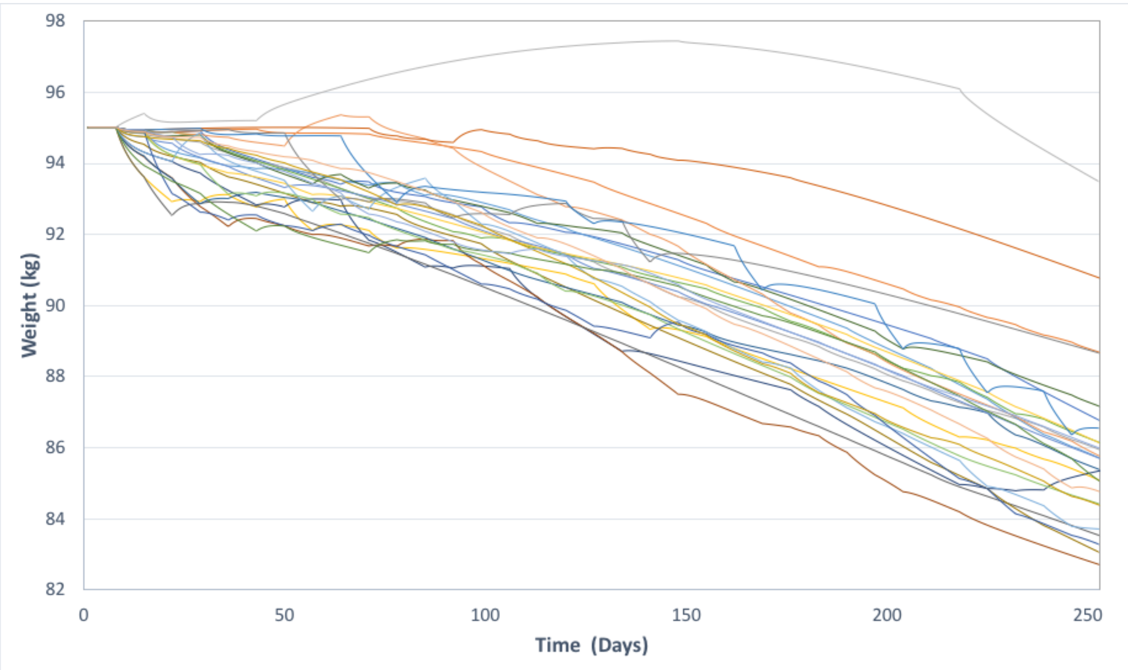

Figure 3: Results from treatment group T2. The colour lines are the actual result from the 26 participants in this group.

In Figure 3 we can see that none of the participants reaches 82 kg, although some of them were very close. We can also appreciate that most of the participants gradually decrease their weight and there are almost no weight oscillations in this group. A one-sample t-test was performed in order to assess if there is a statistically significant difference between the mean final weight of the group and the goal. The result is presented in Table 6.

Table 6: One-sample t-test of the final weight achieved in the treatment group T2.

	Final Weight – T2
Mean	85.6225819
Variance	3.4818201
Observations	25
Hypothesized Mean	82
Degreed of freedom	24
t Stat	9.70700046
P(T<=t) one-tail	4.379E-10
t Critical one-tail	1.71088208

In this t-test, the null hypothesis is that the mean is less or equal to 82, H_0: $\mu_1 \leq 82$, and the opposite hypothesis H_1: $\mu_1 > 82$. We reject the null hypothesis if the t Stat is greater than the t Critical or if p-value is less than $\alpha = 0.05$. In this case t Stat $>$ t Critical, so we reject the null hypothesis of the t-test. This shows that the mean of the final weight is significantly greater than the hypothesized goal weight, whereby supporting the Research Hypothesis 1, which states that the participants would not reach the goal weight.

To evaluate if there is an important variation of daily calorie intake over time in this group, the following general regression model was made:

$$Intake_{T2} = \varphi_0 + \varphi_1 t$$

Where: $Intake_{T2}$ refers to the daily calorie that the participants enter in treatment group T2, and t refers to time. φ_0 and φ_1 are the coefficients of the regression for the intercept and the time, respectively.

If players do not vary their calorie intake over time, the regression will not provide any result and the coefficients will be equal to zero. Table 7 below shows the results of the regression for treatment group T2.

Table 7: Regression result from the Intake vs Time in treatment group T2.

Coefficients	Estimate	Std. Error	t-value	p-value
φ_0	2727.6491	22.1083	123.377	< 2e-16
φ_1	-0.8356	0.1521	-5.494	5.22e-08

Residuals:

Min	1Q	Median	3Q	Max
-1215.1	-197.6	-45.2	172.6	948.7

Residual standard error: 311.7 on 838 degrees of freedom
Multiple R-squared: 0.03476, Adjusted R-squared: 0.03361
F-statistic: 30.18 on 1 and 838 DF, p-value: 5.22e-08

From the regression it can be seen that the time coefficient is different from zero, meaning that the participants change their calorie intake over time. This also suggested by the very low p-value, which indicates that time is a significant variable.

This group also has the option to change the extra physical activity. The following regression model was therefore made to evaluate if there is an important variation of this over time:

$$PA_{T2} = \omega_0 + \omega_1 t$$

Where: PA_{T2} refers to the daily extra physical activity in treatment T2, and t refers to time. ω_0 *and* ω_1 are the coefficients of the regression for the intercept and the time, respectively.

If the players do not vary their physical activity over time, the coefficients would be equal to zero. Table 8 shows the results of the regression for physical activity over time in treatment group T2.

Table 8: Regression result from the Physical Activity vs Time in treatment group T2.

Coefficients	Estimate	Std. Error	t-value	p-value
ω_0	42.14911	2.49088	16.921	< 2e-16
ω_1	-0.15026	0.01714	8.768	< 2e-16

Residuals:

Min	1Q	Median	3Q	Max
-64.11	-30.45	-0.18	26.93	72.44

Residual standard error: 35.11 on 838 degrees of freedom
Multiple R-squared: 0.08403, Adjusted R-squared: 0.08294
F-statistic: 76.88 on 1 and 838 DF, p-value: <2e-16

From this regression it can be seen that the time coefficient is different from zero, thus suggesting that the participants change their extra physical activity over time. Similarly, the result also shows a very low p-value, which indicates that the time is a significant variable.

A two-sample t-test assuming unequal variance was made to evaluate the participants' performance in predicting the change in body weight as a result of their decision on daily calorie food intake and extra physical activity. In this case, the expected weight was compared to the real weight. The unequal variance was chosen because the two samples are the results of two different processes: one comes from the mental model of the participant and the other from the model. Table 9 shows the result of the t-test.

Table 9: Two-sample t-test assuming unequal variance of the expected and real weight for treatment group T2.

	Real weight	*Expected weight*
Mean	90.529414	87.9692932
Variance	8.90856359	21.0537776
Observations	863	863
Hypothesized Mean Difference	0	
Degreed of freedom	1481	
t Stat	13.7397231	
P(T<=t) two-tail	1.6015e-40	
t Critical two-tail	1.96156708	

In this case, the null hypothesis is that the means of the two variables are equal, $H_0: \mu_1 = \mu_2$, and the opposite hypothesis $H_1: \mu_1 \neq \mu_2$. The p- and t- value that were chosen to evaluate the results from the t-test are the two-tail outputs, as the expected weight could be higher or lower than the real one. The resulting p-value is 1.6015e-40, which is less than $\alpha = 0.05$, whereby suggesting that the null hypothesis H_0 is rejected. Thus, there is a significant difference between the expected and the real weight. This result supports Research Hypothesis 2, which states that the participants would fail to predict the changes in weight. From this outcome, we can also appreciate that, in general terms, the expected weight is lower than the real one.

This study also evaluates if the weight expectations become closer to the real weight towards the end of the simulation. To assess this, the absolute value of the differences between the real and expected weights were compared over time. In order to have a statistical assessment, a paired two-sample t-test was made between the absolute value of the difference between the expected and real weight in two periods of time. The first period is from week 2 to week 5, while the second period is from week 32 to week 35. The paired two-sample t-test was chosen because this type of test is used to assess the means of the same group at different points in time. Table 10 shows the results.

Table 10: Paired two sample t-test of the absolute values of the difference between the expected and the real weight in the first and last weeks (Treatment group T2).

	First 4 weeks	*Last 4 weeks*
Mean	2.16296637	2.4684408
Variance	9.07524066	10.8377234
Observations	100	100
Pearson Correlation	0.02910433	
Hypothesized Mean Difference	0	
Degreed of Freedom	99	
t Stat	-0.6946965	
P(T<=t) one-tail	0.24443636	
t Critical one-tail	1.66039116	

In this case, the null hypothesis is that the means of the two samples are equal, $H_0: \mu_1 = \mu_2$, while the opposite hypothesis satisfies $H_1: \mu_1 \neq \mu_2$. The p-value is 0.244, which is higher than $\alpha = 0.05$, suggests that we cannot reject the null hypothesis H_0. Thus, there are not significant differences between the first weeks' discrepancy in the expectations and the last weeks. The mean for the first weeks is equal to ±2.16 kg of discrepancy between the expected and the real weight. In the last weeks, on the other hand, this discrepancy is equal to ±2.46.

Treatment group – T3

Figure 4 shows the results of the participants allocated to treatment group T3. It can be observed that some participants were close to the goal weight of 82 kg. This group has a mean final weight equal to 85.27 kg.

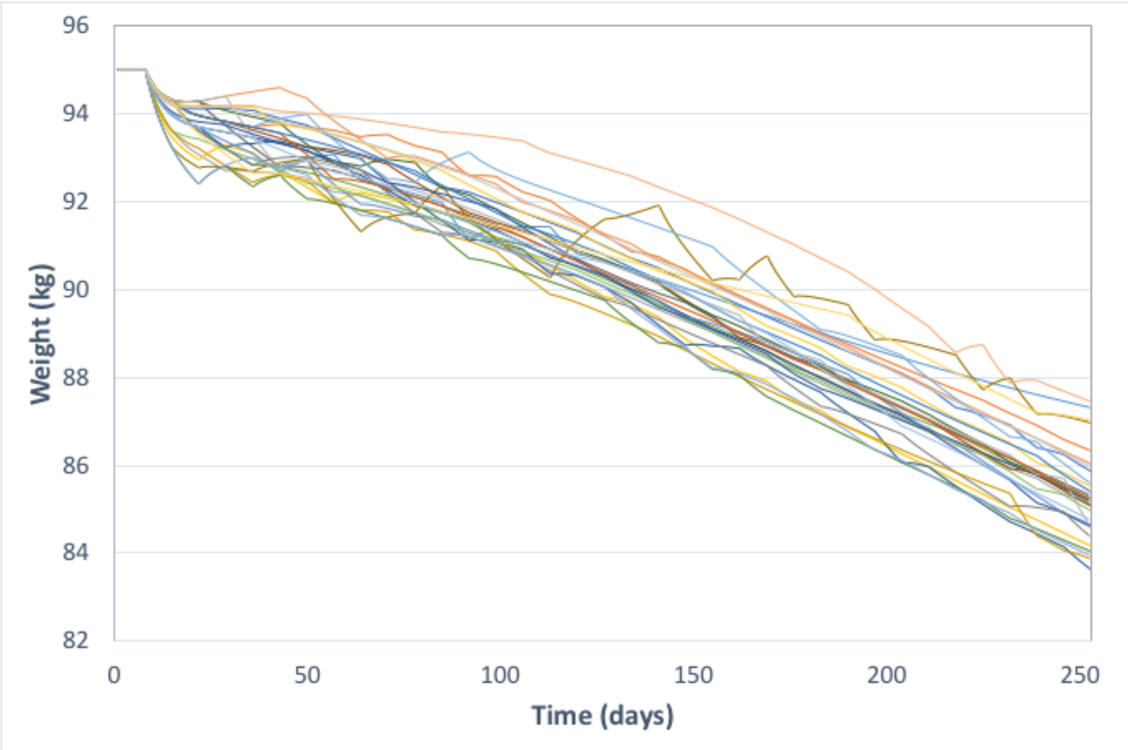

Figure 4: Results from treatment group T3. The colour lines are the actual results from the 29 participants in this group.

In Figure 4 we can see that none of the participants reached 82 kg, being the best final weight 83.61 kg. We can also appreciate that most of the participants gradually decrease their weight, while one of them has significant high amplitude oscillations in his/her weight. A one-sample t-test was performed in order to assess if there is a statistically significant difference between the mean final weight of the group and the goal. The result is presented in Table 11.

Table 11: One sample t-test of the final weight achieved in the treatment group T3.

	Final Weight – T3
Mean	85.2758274
Variance	1.05298335
Observations	29
Hypothesized Mean	82
Degreed of freedom	28
t Stat	17.1913214
P(T<=t) one-tail	1.0302e-16
t Critical one-tail	1.70113093

In this t-test, the null hypothesis is that the mean is less or equal to 82, H_0: $\mu_1 \leq 82$, while the opposite hypothesis satisfies H_1: $\mu_1 > 82$. As mentioned before, we reject the null hypothesis if the t Stat is greater than the t Critical, or if p-value is less than $\alpha = 0.05$. In this case, t Stat $>$ t Critical and p-value is less than 0.05, so we reject the null hypothesis. This shows that the mean of the final weights is significantly greater than the goal weight. This supports Research Hypothesis 1, which states that the participants would not reach the goal weight.

To evaluate if there is an important variation of daily calorie intake over time, the following general regression model was made.

$$Intake_{T3} = \varphi_0 + \varphi_1 t$$

Where: $Intake$ refers to the daily calorie that the participants enter in treatment T3, and t refers to time. φ_0 and φ_1 are the coefficients of the regression for the intercept and the time, respectively.

If the players do not vary their calorie intake over time, the regression will not provide any result and the coefficients will be equal to zero. Table 12 shows the results of the regression for treatment group T3.

Table 12: Regression result from the Intake vs Time in treatment group T3.

Coefficients	Estimate	Std. Error	t-value	p-value
φ_0	2550.3869	20.2455	125.97	< 2e-16
φ_1	-1.4385	0.1393	-10.33	< 2e-16

Residuals:

Min	1Q	Median	3Q	Max
-892.37	-103.97	30.75	109.43	933.48

Residual standard error: 285.4 on 838 degrees of freedom
Multiple R-squared: 0.1129, Adjusted R-squared: 0.1119
F-statistic: 106.7 on 1 and 838 DF, p-value: < 2.2e-16

From the regression result it can be seen that the time coefficient is different from zero, meaning that the participants vary their strategies in daily calorie intake throughout time. This is also validated by the fact that the result shows a very low p-value, which indicates that time is a significant variable.

A two-sample t-test assuming unequal variance was made to evaluate the participants' performance in predicting the change in body weight as a result of their decision on daily calorie food intake. In this case, the expected weight was compared to the real weight. The unequal variance was chosen because the two samples are the results of two different processes. One comes from the mental model of the participant and the other from the model. Table 13 shows the results of the t-test.

Table 13: Two-sample t-test assuming unequal variance of the expected and real weight for treatment group T3.

	Real weight	*Expected weight*
Mean	90.0526962	88.4627513
Variance	7.3494377	14.034395
Observations	945	945
Hypothesized Mean Difference	0	
Degreed of freedom	1720	
t Stat	10.5695185	
P(T<=t) two-tail	2.4233e-25	
t Critical two-tail	1.96134417	

In this case, the null hypothesis is that the means of the two variables are equal, $H_0: \mu_1 = \mu_2$, and the opposite hypothesis satisfies $H_1: \mu_1 \neq \mu_2$. The p- and t- values that were chosen to evaluate the results from the t-test are the two-tail outputs, as the expected weight could be higher or lower than the real one. The p-value is 2.42e-25, which is less than $\alpha = 0.05$. As t Stat is higher than t Critical, the null hypothesis H_0 is rejected. Thus, there are significant differences between the expected and the real weight. This result supports Research Hypothesis 2, which states that the participants would fail to predict the changes in weight. From this result we can also appreciate that, in general terms, the expected weight is lower than the real one.

This study also evaluates if the weight expectations become closer to the real weight towards the end of the simulation. For this evaluation, the absolute value of the differences between the real and expected weight were compared over time. In order to have a statistical assessment, a paired two-sample t-test was made between the absolute value of the difference between the expected and real weight in two periods of time. The first period is from week 2 to week 5, and the second period is from week 32 to week 35. The paired two sample t-test was chosen because this is used to assess the means of the same group at different points in time. Table 14 shows the results.

Table 14: Paired two sample t-test of the absolute values of the difference between the expected and the real weight in the first and last weeks.

	First 4 weeks	*Last 4 weeks*
Mean	1.93026608	1.51558973
Variance	9.97749695	5.36635067
Observations	100	100
Pearson Correlation	0.19747473	
Hypothesized Mean Difference	0	
Degreed of Freedom	99	
t Stat	1.21548244	
P(T<=t) two-tail	0.22688238	
t Critical two-tail	1.98259726	

In this case, the null hypothesis is that the means of the two samples are equal, $H_0: \mu_1 = \mu_2$, while the opposite hypothesis satisfies $H_1: \mu_1 \neq \mu_2$. The p-value is 0.2268 which is higher than $\alpha = 0.05$, so t Stat is less than t critical. This means that we cannot reject the null hypothesis H_0. Thus, there is not significant difference between the two periods of time. The mean for the first period is equal to ±1.93 kg of discrepancy between the expected and the real weight. In the last period, the discrepancy is equal to ±1.52 kg.

Treatment group – T4

Figure 5 shows the results of the participants allocated to treatment group T4. It can be observed that some participants were close to the goal weight of 83 kg, being the best final weight 83.61 kg. We can see in Figure 4 that one of the participants may have decided to increase his/her weight at the end of the simulation; consequently, the data from this participant was excluded from the analysis. This group has a mean final weight equal to 86.06 kg.

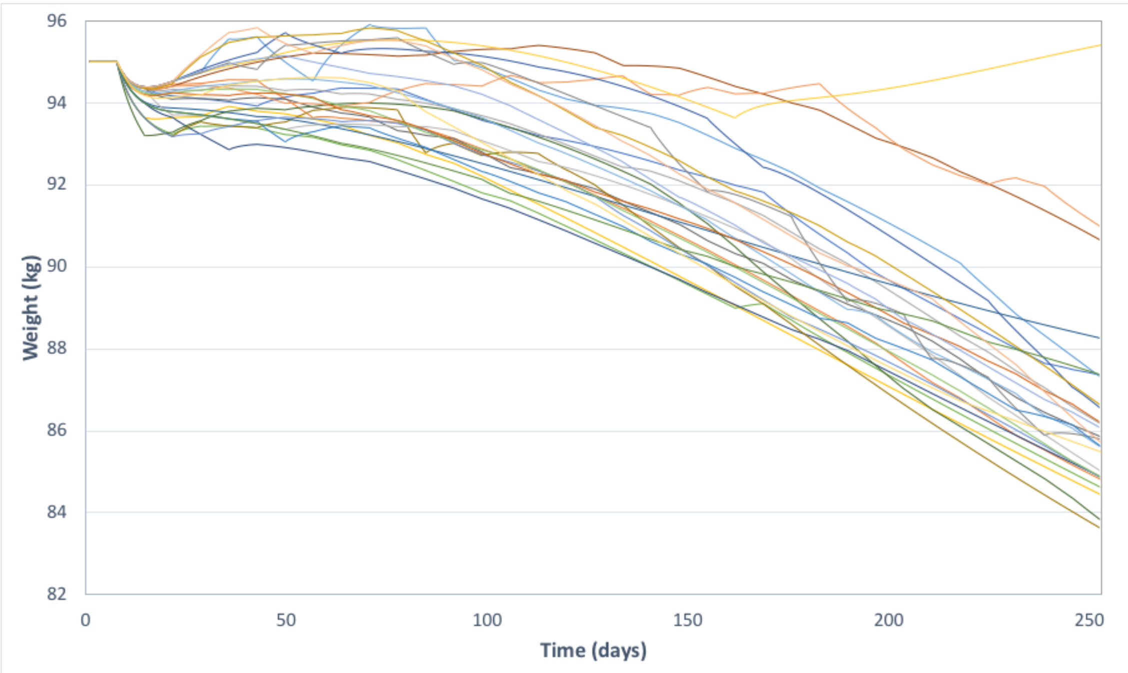

Figure 5: Results from treatment group T4. The colour lines are the actual result from the 28 participants in this group.

In Figure 5 we can also appreciate that at the beginning there is a significant drop in the weight, this is due to the fact that the body loses the water associated to the glycogen. In this group most of the participants gradually decrease their weight and there are almost no weight oscillations in this group. A one-sample t-test was performed in order to assess if there is a statistically significant difference between the mean final weight of the group and the goal. The result is presented in Table 15.

Table 15: One sample t-test of the final weight achieved in the treatment group T4.

	Final Weight – T4
Mean	86.0607832
Variance	3.08361156
Observations	27
Hypothesized Mean	83
Degreed of freedom	26
t Stat	9.05700519
P(T<=t) one-tail	7.9956E-10
t Critical one-tail	1.70561792

In this t-test the null hypothesis is that the mean is less or equal to 83, H_0: $\mu_1 \leq 83$, and the opposite hypothesis satifies H_1: $\mu_1 > 83$. We reject the null hypothesis if the t Stat is greater than the t Critical or if p-value is less than $\alpha = 0.05$. In this case, t Stat $>$ t Critical and the p-value is less than 0.05, so we reject the null hypothesis of the t-test. This shows that the mean of the final weight is significantly greater than the hypothesized goal weight. This supports Research Hypothesis 1, which states that the participants would not reach the goal weight.

To evaluate if there is an important variation in the daily calorie intake over time in this group, the following general regression model was made:

$$Intake_{T4} = \varphi_0 + \varphi_1 t$$

Where: $Intake_{T4}$ refers to the daily calorie that the participants enter in treatment T4, and t refers to time. φ_0 *and* φ_1 are the coefficients of the regression for the intercept and the time, respectively.

If the players do not vary their calorie intake over time, the regression will not provide any result and the coefficients will be equal to zero. Table 16 below shows the results of the regression for treatment group T4.

Table 16: Regression result from the Intake vs Time in treatment group T4.

Coefficients	Estimate	Std. Error	t-value	p-value
φ_0	2754.3887	17.1949	160.187	< 2e-16
φ_1	-1.0085	0.1183	-8.525	< 2e-16

Residuals:

Min	1Q	Median	3Q	Max
-1246.32	-133.37	-18.67	125.37	1310.15

Residual standard error: 242.4 on 838 degrees of freedom
Multiple R-squared: 0.0798, Adjusted R-squared: 0.0787
F-statistic: 72.67 on 1 and 838 DF, p-value: < 2e-16

From the regression it can be seen that the time coefficient is different from zero, meaning that the participants change their calorie intake over time. This is also suggested by the fact that the p-value is very low, which indicates that the time is a significant variable.

This group also has the option to change the extra physical activity. To evaluate if there is an important variation of this over time, the following regression model was made:

$$PA_{T4} = \omega_0 + \omega_1 t$$

Where: PA_{T4} refers to the daily extra physical activity, and t refers to time. ω_0 *and* ω_1 are the coefficients of the regression for the intercept and the time, respectively.

If the players do not vary their physical activity over time, the coefficients would be equal to zero. Table 17 shows the results of the regression for physical activity over time in treatment group T4.

Table 17: Regression result from the Physical Activity vs Time in treatment group T4.

Coefficients	Estimate	Std. Error	t-value	p-value
ω_0	35.67960	2.20347	16.19	< 2e-16
ω_1	0.06200	0.01516	4.09	4.73e-05

Residuals:

Min	1Q	Median	3Q	Max
-35.93	-23.35	-11.38	19.05	81.65

Residual standard error: 31.06 on 838 degrees of freedom
Multiple R-squared: 0.01957, Adjusted R-squared: 0.0184
F-statistic: 16.73 on 1 and 838 DF, p-value: 4.73e-05

From this regression it can be seen that the time coefficient is different from zero, meaning that the participants change their extra physical activity over time. The result also shows a very low p-value, which indicates that the time is a significant variable. Both facts suggest that people vary their strategies about physical activity throughout time.

A two-sample t-test assuming unequal variance was made to evaluate the participants' performance in predicting the change in body weight as a result of their decision on daily calorie food intake and extra physical activity. In this case, the expected weight was compared to the real weight. The unequal variance was chosen because the two samples are the results of two different processes: one comes from the mental model of the participant, while the other comes from the model. Table 18 shows the result of the t-test.

Table 18: Two-sample t-test assuming unequal variance of the expected and real weight for treatment group T4.

	Real weight	*Expected weight*
Mean	91.3734458	89.2454286
Variance	8.90124243	15.0850878
Observations	875	875
Hypothesized Mean Difference	0	
Degreed of freedom	1639	
t Stat	12.8527859	
P(T<=t) two-tail	4.3099E-36	
t Critical two-tail	1.96141243	

In this case, the null hypothesis is that the means of the two variables are equal, $H_0: \mu_1 = \mu_2$, and the opposite hypothesis satisfies $H_1: \mu_1 \neq \mu_2$. The p- and t- values that were chosen to evaluate the results from the t-test are the two-tail outputs, as the expected weight could be higher or lower than the real one. The p-value is 4.31e-36, which is less than $\alpha = 0.05$, meaning that the null hypothesis H_0 is rejected. Thus, there is a significant difference between the expected and the real weight. This result supports Research Hypothesis 2, which states that the participants would fail to predict the changes in weight. From this result, we can also appreciate that in general terms the expected weight is lower than the real one, having a mean of 91.37 kg for the real weight and 89.25 kg for the expected weight.

This study also evaluates if the weight expectations become closer to the real weight towards the end of the simulation. For this evaluation, the absolute value of the differences between the real and expected weights were compare over time. In order to have a statistical assessment, a paired two-sample t-test was made between the absolute value of the difference between the expected and real weight in two periods of time. The first period was from week 2 to week 5, and the second period was from week 32 to week 35. The paired two-sample t-test was chosen because this is used to assess the means of the same group at different points in time. Table 19 shows the results.

Table 19: Two sample t-test of the absolute values of the difference between the expected and the real weight in the first and last weeks (Treatment group T4).

	First 4 weeks	*Last 4 weeks*
Mean	1.43999107	2.3179897
Variance	2.17917174	10.1416617
Observations	100	100
Pearson Correlation	0.23524779	
Hypothesized Mean Difference	0	
Degreed of Freedom	99	
t Stat	-2.7614686	
P(T<=t) one-tail	0.00685911	
t Critical one-tail	1.98421695	

In this case, the null hypothesis is that the means of the two samples are equal, $H_0: \mu_1 = \mu_2$, and the opposite hypothesis satisfies $H_1: \mu_1 \neq \mu_2$. The p-value is 0.0068 which is less than $\alpha = 0.05$, meaning that we reject the null hypothesis H_0. Thus, there is a statistically significant difference between the two periods of time. The mean for the first period is equal to ± 1.44 kg of discrepancy between the expected and the real weight. In the last period, the mean discrepancy is equal to ± 2.32 kg.

Comparison of results between groups

Treatments T1 and T2

One of the research hypotheses is that the performance for the treatment groups that include extra physical activity is lower than that from the ones that do not include physical activity. A two-sample t-test assuming unequal variance was made to evaluate the participants' performance in reaching the goal weight among treatment groups. In this case, the mean difference between the final weight and the goal weight for each treatment was compared. The unequal variance t-test was chosen because the two samples are the result of two different treatment groups. Table 20 shows the results of the t-test.

Table 20: Two sample t-test of the difference between the achieved and goal weight between treatment groups T1 and T2.

	Weight difference -T2	*Weight difference -T1*
Mean	3.62258187	1.82068811
Variance	3.4818201	0.71788492
Observations	25	25
Hypothesized Mean Difference	0	
Degreed of freedom	33	
t Stat	4.39632503	
P(T<=t) one-tail	5.3936E-05	
t Critical one-tail	1.69236031	

In this case, the null hypothesis is given by $H_0: \mu_1 \leq \mu_2$ and the opposite hypothesis is given by $H_1: \mu_1 > \mu_2$. The p- and t- values that were chosen to evaluate the results from the t-test are the one-tail outputs. The p-value is 5.139e-05, which is less than $\alpha = 0.05$, meaning that the null hypothesis H_0 is rejected. Thus, the mean difference between the weight achieved by the participants and the goal is significantly higher in treatment group T2 than in treatment group T1. This result does not reject Research Hypothesis 3, which states that the participants would finish with a higher weight from the goal when they perform physical activities.

Treatments T3 and T4

To evaluate this, a two-sample t-test assuming unequal variance was made to evaluate the participants' performance in reaching the goal weight among treatment groups. In this case, the difference between the final weight and the goal weight for each treatment was compared. The unequal variance t-test was chosen because the two samples are the results of two different treatment groups. Table 21 shows the result of the t-test.

Table 21: Two sample t-test of the difference between the achieved and goal weight between treatment groups T3 and T4.

	Weight difference -T4	*Weight difference -T3*
Mean	3.12239438	3.11322748
Variance	3.28425696	0.84604794
Observations	25	25
Hypothesized Mean Difference	0	
Degreed of freedom	36	
t Stat	0.02255286	
P(T<=t) one-tail	0.49106575	
t Critical one-tail	1.68829771	

In this case, the null hypothesis is given by $H_0: \mu_1 \leq \mu_2$, while the opposite hypothesis is given by $H_1: \mu_1 > \mu_2$. The p- and t- values that were chosen to evaluate the results from the t-test are the one-tail outputs. The p-value is 0.4910, which is greater than $\alpha = 0.05$, meaning that the null hypothesis H_0 cannot be rejected. Thus, the mean difference between the weight achieved by the participants and the goal is not significantly higher in treatment group T4 compared to the treatment group T3. This result rejects Research Hypothesis 5, which states that the participants would finish with a higher weight from the goal when they perform physical activities compared to the treatment group that does not include physical activity.

Treatments T1 and T2

One of the research hypotheses is that the weight expectations would differ more from the real weight when physical activity is included in the weight loss diet. To evaluate this, a two-sample t-test assuming unequal variance was performed to evaluate the discrepancy between the expected and real weight among treatment groups. The unequal variance t-test was chosen because the two samples are the results of two different treatment groups. Table 22 shows the result of the t-test.

Table 22: Two sample t-test of the difference between the discrepancy between expected and real weight among treatment group T1 and T2.

	Discrepancy in T2	*Discrepancy in T1*
Mean	2.64679556	1.19462208
Variance	14.7828834	3.02250748
Observations	863	863
Hypothesized Mean Difference	0	
Degreed of freedom	1200	
t Stat	10.1099299	
P(T<=t) one-tail	2.0402E-23	
t Critical one-tail	1.64612442	

In this case, the null hypothesis is given by $H_0: \mu_1 \leq \mu_2$, while the opposite hypothesis is given by $H_1: \mu_1 > \mu_2$. The p- and t- values that were chosen to evaluate the results from the t-test are the one-tail outputs. The p-value is 2.04e-23, which is less than $\alpha = 0.05$, meaning that the null hypothesis H_0 is rejected. Thus, the mean discrepancy between the expected and real weight is significantly higher in treatment group T2 than treatment group T1. This result does not reject Research Hypothesis 4, which states that the participants' expectation would differ more from the real weight when the physical activity is included in the weight loss regime.

Treatments T3 and T4

One of the research hypotheses is that the weight expectations would differ more from the real weight when physical activity is included in the weight loss diet. To evaluate this, a two-sample t-test assuming unequal variance was made to evaluate the discrepancy between the expected and real weights among treatment groups. The unequal variance t-test was chosen because the two samples are the results of two different treatment groups. Table 23 shows the result of the t-test.

Table 23: Two sample t-test of the difference between the achieved and goal weight between treatment groups T3 and T4.

	Discrepancy - T4	*Discrepancy - T3*
Mean	2.17543467	1.78397339
Variance	8.02888308	7.64120283
Observations	863	863
Hypothesized Mean Difference	0	
Degreed of freedom	1723	
t Stat	2.90508282	
P(T<=t) one-tail	0.00185919	
t Critical one-tail	1.64573848	

In this case, the null hypothesis is given by $H_0: \mu_1 \leq \mu_2$, while the opposite hypothesis is given by $H_1: \mu_1 > \mu_2$. The p- and t- values that were chosen to evaluate the results from the t-test are the one-tail outputs. The p-value is 0.0018, which is less than $\alpha = 0.05$. As t Stat is greater than t Critical, the null hypothesis H_0 is rejected. Thus, the mean discrepancy between the expected and real weight is significantly higher in treatment group T2 than treatment group T1. This result does not reject Research Hypothesis 4, which states that the participants' expectation would differ more from the real weight when the physical activity is included in the weight loss regime.

Low-carb Performance comparison

Treatments T1 and T3

One of the research hypotheses is that the general performance would be lower with a low-carb diet. To evaluate this, a two-sample t-test assuming unequal variance was made to evaluate the participants' performance in reaching the goal weight among treatment groups. In this case, the difference between the final weight and the goal weight for each treatment was compared. The unequal variance t-test was chosen because the two samples are the results of two different treatment groups. Table 24 shows the result of the t-test.

Table 24: Two sample t-test of the difference between the achieved and goal weight between treatment groups T1 and T3.

	Weight difference -T3	*Weight difference -T1*
Mean	3.11322748	1.82068811
Variance	0.84604794	0.71788492
Observations	25	25
Hypothesized Mean Difference	0	
Degreed of freedom	48	
t Stat	5.1677885	
P(T<=t) one-tail	2.2709E-06	
t Critical one-tail	1.6772242	

In this case, the null hypothesis is given by $H_0: \mu_1 \leq \mu_2$ and the opposite hypothesis is given by $H_1: \mu_1 > \mu_2$. The p- and t- values that were chosen to evaluate the results from the t-test are the one-tail outputs. The p-value is 2.27e-06, which is less than $\alpha = 0.05$. This means that the null hypothesis H_0 is rejected. Thus, the mean difference between the weight achieved by the participants and the goal is significantly higher in treatment group T3 than in treatment group T1. This result does not reject Research Hypothesis 5, which states that the participants would finish with a higher weight from the goal when they are on a low-carb diet.

Treatments T2 and T4

To evaluate this, a two-sample t-test assuming unequal variance was made to evaluate the participants' performance in reaching the goal weight among treatment groups. In this case, the difference between the final weight and the goal weight for each treatment was compared. The unequal variance t-test was chosen because the two samples are the results of two different treatment groups. Table 25 shows the result of the t-test.

Table 25: Two sample t-test of the difference between the achieved and goal weight between treatment groups T2 and T4.

	Weight difference -T4	*Weight difference -T2*
Mean	3.12239438	3.62258187
Variance	3.28425696	3.4818201
Observations	25	25
Hypothesized Mean Difference	0	
Degreed of freedom	48	
t Stat	-0.961467	
P(T<=t) one-tail	0.17056802	
t Critical one-tail	1.6772242	

In this case, the null hypothesis is given by H_0: $\mu_1 \leq \mu_2$, and the opposite hypothesis is given by H_1: $\mu_1 > \mu_2$. The p- and t- values that were chosen to evaluate the results from the t-test are the one-tail outputs. The p-value is 0.1705, which is greater than $\alpha = 0.05$. This means that the null hypothesis H_0 cannot be rejected. Thus, the mean difference between the weight achieved by the participants and the goal is not significantly higher in treatment group T4 compared to the treatment group T2. This result rejects Research Hypothesis 5, which states that the participants would finish with a higher weight from the goal when they are in a low-carb diet.

Low-carb Expectation comparison

Treatment T1 and T3

One of the research hypotheses is that the weight expectations would differ more from the real weight when low-carb diet is followed in a weight loss regime. To evaluate this, a two-sample t-test assuming unequal variance was made to evaluate the discrepancy between the expected and real weight among treatment groups. The unequal variance t-test was chosen because the two samples are the results of two different treatment groups. Table 26 shows the result of the t-test.

Table 26: Two sample t-test of the difference between the discrepancy between expected and real weight among treatment groups T1 and T3.

	Discrepancy in T3	*Discrepancy in T1*
Mean	1.78397339	1.19462208
Variance	7.64120283	3.02250748
Observations	863	863
Hypothesized Mean Difference	0	
Degreed of freedom	1452	
t Stat	5.30182622	
P(T<=t) one-tail	6.6188E-08	
t Critical one-tail	1.64590373	

In this case, the null hypothesis is given by $H_0: \mu_1 \leq \mu_2$, while the opposite hypothesis is given by $H_1: \mu_1 > \mu_2$. The p- and t- values that were chosen to evaluate the results from the t-test are the one-tail outputs. The p-value is 6.61e-08, which is less than $\alpha = 0.05$, meaning that the null hypothesis H_0 is rejected. Thus, the mean discrepancy between the expected and real weight is significantly higher in treatment group T3 than in treatment group T1. This result does not reject Research Hypothesis 6, which states that the participants' expectation would differ more from the real weight when following a low-carb diet in the weight loss regime.

Treatments T2 and T4

One of the research hypotheses is that the weight expectations would differ more from the real weight when a low-carb diet is followed in a weight loss regime. To evaluate this, a two-sample t-test assuming unequal variance was made to evaluate the discrepancy between the expected and real weight among treatment groups. The unequal variance t-test was chosen because the two samples are the results of two different treatment groups. Table 27 shows the result of the t-test.

Table 27: Two sample t-test of the difference between the achieved and goal weight between treatment groups T2 and T4.

	Discrepancy - T4	*Discrepancy - T2*
Mean	2.17543467	2.64679556
Variance	8.02888308	14.7828834
Observations	863	863
Hypothesized Mean Difference	0	
Degreed of freedom	1585	
t Stat	-2.8992087	
P(T<=t) one-tail	0.00189628	
t Critical one-tail	1.64581556	

In this case, the null hypothesis is given by H_0: $\mu_1 \leq \mu_2$, and the opposite hypothesis is given by H_1: $\mu_1 > \mu_2$. The p- and t- values that were chosen to evaluate the results from the t-test are the one-tail outputs. The p-value is 0.0018, which is less than $\alpha = 0.05$. As t Stat is less than t Critical, the null hypothesis H_0 is rejected. Thus, the mean discrepancy between the expected and real weight is not significantly higher in treatment group T4 than in treatment group T2. This result rejects Research Hypothesis 6, which states that the participants' expectations would differ more from the real weight when the physical activity is included in the weight loss regime.

8. DISCUSSION

In general, very interesting results were obtained from the Body Weight Management Simulator. It can be observed that the different treatments have a significant impact on the performance and the expectations of the participants that face the task of losing weight in the simulator.

Table 28 shows the mean final weight achieved by the participants in the different treatment groups. The t-tests performed in the different groups show that all of the mean final weights were significantly greater than the goal weight. Consequently, we cannot reject Research Hypothesis 1, which states that the participants will not reach the goal weight.

Table 28: Goal weight and mean final weight obtained by the participants in the different treatment groups.

Treatment Group	Goal weight (kg)	Mean final weight (kg)
T1	80	81.9
T2	82	85.6
T3	82	85.3
T4	83	86.1

As mentioned in the literature review, it has been argued that people fail to achieve their goal because they do not adjust their diets over time to compensate for the body adaptability to new regimes. In order to observe in general terms if people made adjustments in their weight loss strategies over time, a simple regression model of the intake over time was made. Table 29 shows the mean values of the intercept and time coefficients.

Table 29: Regression coefficients from the calorie intake versus time model for treatment groups T1, T2, T3 and T4.

Treatment Group	φ_0	φ_0 Std Error	φ_1	φ_1 Std Error
T1	2453.72	16.19	-2.1159	0.1114
T2	2727.65	22.10	-0.8356	0.1521
T3	2550.38	20.24	-1.4385	0.1393
T4	2754.39	17.19	-1.0085	0.1183

These results indicate that the participants adjusted their daily calorie intake over time. In general, it can be established from the time coefficients that most of the participants reduce the total intake with time. It can also be appreciated that φ_1 varies among the treatment groups, having the highest magnitude value in treatment group T1. This high value can be interpreted as a highly significant change in calorie intake over time. The participants from treatment group T3 have the second highest magnitude value in φ_1. This change in magnitude between treatments T1 and T3 could be caused by the higher effort to reduce calorie intake when the participants follow a low-carb diet. The lowest value for φ_1 belongs to treatment groups T2 and T4. From these results, we can infer that, when the participants have the option for extra physical activity, their calorie intake changes at a lower rate compared to when they do not have control over the physical activity level.

From the regression model of the physical activity the following results were obtained (Table 30):

Table 30: Regression coefficients from the calorie intake versus time model for treatment groups T2 and T4.

Treatment Group	ω_0	ω_0 Std Error	ω_1	ω_1 Std Error
T2	42.14	2.49	-0.1502	0.0171
T4	35.68	2.20	0.0620	0.0151

These results show that the participants changed their extra activity level over time as the time coefficient ω_1 differs from zero in both groups. We can observe that the magnitude of ω_1 is higher in treatment T2 than in treatment T4. This means that the average participant in treatment T2 changes the physical activity more significantly over time than the participants in group T4. The decrease in the physical activity variation in treatment group T4 could be explained by the high effort involved in performing physical activity on a low-carb diet.

For the assessment of the participants' weight expectation, the mean real and expected weights were compared for each group as shown in Table 31.

Table 31: Mean real and expected weights among all the treatment groups.

Treatment Group	Real weight (kg)	Variance	Expected weight (kg)	Variance
T1	88.09	13.91	86.93	15.80
T2	90.53	8.90	87.97	21.05
T3	90.05	7.35	88.46	14.03
T4	91.37	8.90	89.24	15.08

As we can see in Table 31, the mean expected weight is always lower than the mean real weight among all the groups. All the t-tests performed on this data showed statistically significant differences between the real and expected weights. These results support Research Hypothesis 2, which states that participants fail to predict weight changes during a weight loss regime.

In order to compare the performance between the treatment groups various t-tests were conducted on the data. Table 32 shows the mean weight difference between the final weight achieved by the participants and the goal weight among the treatment groups

Table 32: Mean difference between the achieved and goal weight among all treatment groups.

Treatment Group	Weight difference (kg)	Variance
T1	1.8206	0.7178
T2	3.6225	3.4818
T3	3.1132	0.8460
T4	3.1223	3.2842

The t-test showed that the mean difference between the final and the goal weight in T2 was significantly greater than the mean weight difference in treatment T1. This supports Research Hypothesis 3, which states that the participants would finish with a higher weight from the goal when they perform physical activities. However, comparing the results from treatments T3 and T4, the t-test showed that there was not significant difference between the data. For this reason, Research Hypothesis 3 is rejected.

The t-test also showed that the mean difference between the final and the goal weight in treatment T3 was significantly greater than the mean weight difference in treatment T1. This supports Research Hypothesis 5, which states that the participants would finish with a higher weight from the goal when they undergo a low-carb diet. However, comparing the results from treatments T2 and T4, the t-test showed that there was not significant difference between the data. For this reason, Research Hypothesis 5 is rejected.

In order to compare people's expectations between the treatment groups, various t-tests were conducted on the data. Table 33 shows the mean discrepancy between the real and the expected weight among the treatment groups.

Table 33: Mean discrepancy between expected and real weight among the treatment groups.

Treatment Group	Discrepancy (kg)	Variance
T1	1.1946	3.0225
T2	2.6467	14.7828
T3	1.7839	7.6412
T4	2.1754	8.0288

The t-tests showed that the mean discrepancy between the real and expected weight in treatment T2 was significantly greater than the mean discrepancy in treatment T1. This supports Research Hypothesis 4, which states that the participants' expectation would differ more from the real weight when the physical activity is included in the weight loss regime. Furthermore, comparing the results from treatments T3 and T4, the t-test also showed that the mean discrepancy between the real and expected weight in treatment T4 was significantly higher than the mean discrepancy in treatment T3. For this reason, Research Hypothesis 4 cannot be rejected.

The t-test showed that the mean discrepancy between the real and expected weight in treatment T3 was significantly higher than the mean discrepancy in treatment T1. This supports Research Hypothesis 6, which states that the participants' expectation would differ more from the real weight when following a low-carb diet in the weight loss regime. However, comparing the results from treatments T4 and T2, the t-test showed that the mean discrepancy between the real and expected weight in treatment T4 was not significantly higher than the mean discrepancy in treatment T3. For this reason, Research Hypothesis 4 is rejected.

In treatment group T4 there was a significant improvement in weight expectation over time. However, in the rest of the group there a significant difference in weight expectation was not found.

The experiment game show had some technical limitations when running the game. This was because a significant amount of the people tried to open the game in their mobile and the interface did not run properly. For this reason, it is advisable that if the experiment would be distributed online, the interface should be in the format for mobile phone as nowadays, most people uses their mobile phone in the daily basis.

A possible modification of the game could be the increase in the time step for every decision to observe a longer progress of the weight. For instance, the time step could be change to a month instead of a week to see the effect on people’s expectation and strategy over a longer period of time. The increase in time step could generate a larger discrepancy between the real and expected weight.

9. CONCLUSIONS

Overweight and obesity are very common conditions among the population in many industrialized and developing countries worldwide. They affect the wellbeing and economics of individuals and society, and represent a growing public health problem. Many individuals, in order to overcome obesity and overweight, undergo different weight loss regimes with and without health professional guidance. A large portion of these people do not succeed in achieving the desired weight. Body weight management is a matter of multiple factors, such as, genetic conditions, accessibility to exercise, the social environment, available food, individual psychology.

In this study, a body management weight simulator was developed in order to evaluate people’s performance and expectation during different weight loss approaches. This simulator was distributed among a group of people with a variety of ages, sex and background. There were 110 participants that completed the simulation, and the four different treatment groups had a reasonably even distribution of them. All the treatments have the same initial conditions in terms of body weight, body composition and willpower budget. They also had access to the same information of willpower and weight development. In general, the performance of the players was very low, having just 10% of the participants reaching a weight that was reasonably close to the goal at the end of the simulation. Most of these players were in the treatment group T1, while there was only one player who was close to the goal weight in treatment group T2.

From this study, we could learn that it can be more challenging to manage the body weight under a considerable restriction of a certain macronutrient such as carbohydrates. We also appreciated that the addition of extra physical activities during the diet can affect the success of a weight loss regime. However, the rate of fat loss is higher than when no physical activity is performed.

The results of the game show that people’s expectations were always higher than what they could achieve with the diet. This is in agreement with an inaccurate mental model of the mechanism that regulates body weight. In order to improve the decision making process, there must be an improvement in the mental model. This can be done by developing an interactive learning environment that gives people the opportunity to acquire an awareness of the relationship between the structural components and the behavioural results involved in body-weight management. For example, some of the treatment groups showed some improvement in their mean expectations over time. This highlights the potential for an interactive learning environment where people could run different simulations and update their mental models. It would also be advisable that people seek for professional advice when aiming to lose weight, making sure that this professional help is updated on the latest research findings involved in weight management.

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APPENDICES

Appendix A: Experiment instructions for each of the treatment groups

Instructions for the Treatment group T1:

In this simulator, you will play the role of an overweight person who wants to lose some weight. Every week you will be able to see your progress and make decisions about the amount of food.

You are 1.8 meters tall and your current weight is 95kg. Your goal is to have a weight of 80kg, which is considered a normal weight for a person with your height. You will have 35 weeks to reach your goal. Your current diet is 3000 kcal daily and you do not perform any extra physical activity. This is sufficient to keep your weight at 95kg.

The obvious strategy is to eat little, but you also need willpower to do so. For example, after every New Year's Eve people feel that they have the willpower to make serious changes in their lives. However, many people experience that their willpower disappears after days or weeks. Therefore, you have to manage your willpower, and not only what you eat. Low food intake lowers willpower in the short run, and less so in the long run. Your willpower will regenerate every week depending on your decisions. In this simulation, you have decided to continue with your regular distribution of macronutrients (protein, fats and carbohydrates).

On the next page, you will have the opportunity to decide on your total daily calorie intake. To learn about your decision making, also input the weight you expect to have in the following week as a result of your choice.

Instructions for the Treatment group T2:

In this simulator, you will play the role of an overweight person who wants to lose some weight. Every week you will be able to see your progress and make decisions about the amount of food and extra physical activity.

You are 1.8 meters tall and your current weight is 95kg. Your goal is to have a weight of 80kg, which is considered a normal weight for a person with your height. You will have 35 weeks to accomplish your goal. Your current diet is 3000 kcal daily and you do not perform any extra physical activity. This is sufficient to keep your weight at 95kg.

The obvious strategy is to eat little, but you also need willpower to do so. For example, after every New Year's Eve people feel that they have the willpower to make serious changes in their lives. However, many people experience that their willpower disappears after days or weeks. Therefore, you have to manage your willpower, and not only what you eat. Low food intake lowers willpower in the short run, and less so in the long run. Your willpower will regenerate every week depending on your decision. In this simulation, you have decided to continue with your regular distribution of macronutrients (protein, fats and carbohydrates).

On the next page, you will have the opportunity to decide on your total daily calorie intake and extra physical activity. To learn about your decision making, also input the weight you expect to have in the following week as a result of your choice.

Instructions for the Treatment group T3:

In this simulator, you will play the role of an overweight person who wants to lose some weight. Every week you will be able to see your progress and make decisions about the amount of food.

You are 1.8 meters tall and your current weight is 95kg. Your goal is to have a weight of 80kg, which is considered a normal weight for a person with your height. You will have 35 weeks to reach your goal. Your current diet is 3000 kcal daily and you do not perform any extra physical activity.

The obvious strategy is to eat little, but you also need willpower to do so. For example, after every New Year's Eve people feel that they have the willpower to make serious changes in their lives. However, many people experience that their willpower disappears after days or weeks. Therefore, you have to manage your willpower, and not only what you eat. Low food intake lowers willpower in the short run, and less so in the long run. Your willpower will regenerate every week depending on your decisions. In this simulation, you have decided to go on a low-carb diet.

On the next page, you will have the opportunity to decide on your total daily calorie intake. To learn about your decision making, also input the weight you expect to have in the following week as a result of your choice.

Instructions for the Treatment group T4:

In this simulator, you will play the role of an overweight person who wants to lose some weight. Every week you will be able to see your progress and make decisions about the amount of food and extra physical activity.

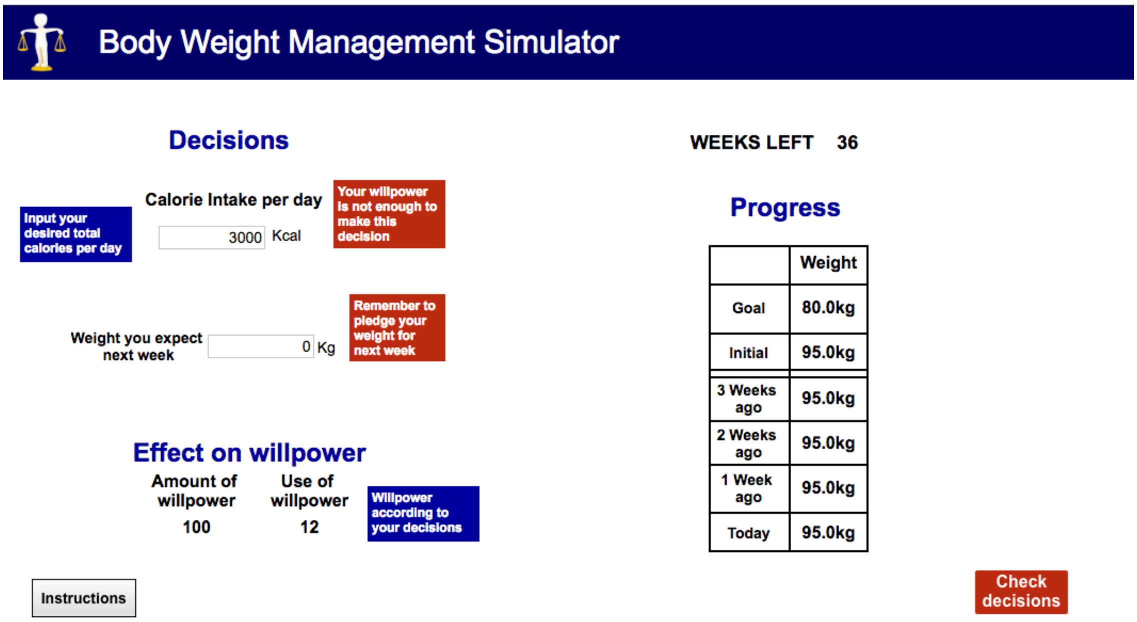
You are 1.8 meters tall and your current weight is 95kg. Your goal is to have a weight of 80kg, which is considered a normal weight for a person with your height. You will have 35 weeks to accomplish your goal. Your current diet is 3000 kcal daily and you do not perform any extra physical activity.

The obvious strategy is to eat little. Therefore, you also need willpower to do so. For example, after every New Year's Eve people feel that they have the willpower to make serious changes in their lives. However, many people experience that their willpower disappears after days or weeks. Therefore, you have to manage your willpower, and not only what you eat. Low food intake lowers willpower in the short run, and less so in the long run. Your willpower will regenerate every week depending on your decision. In this occasion, you have decided to follow a low carbs diet.

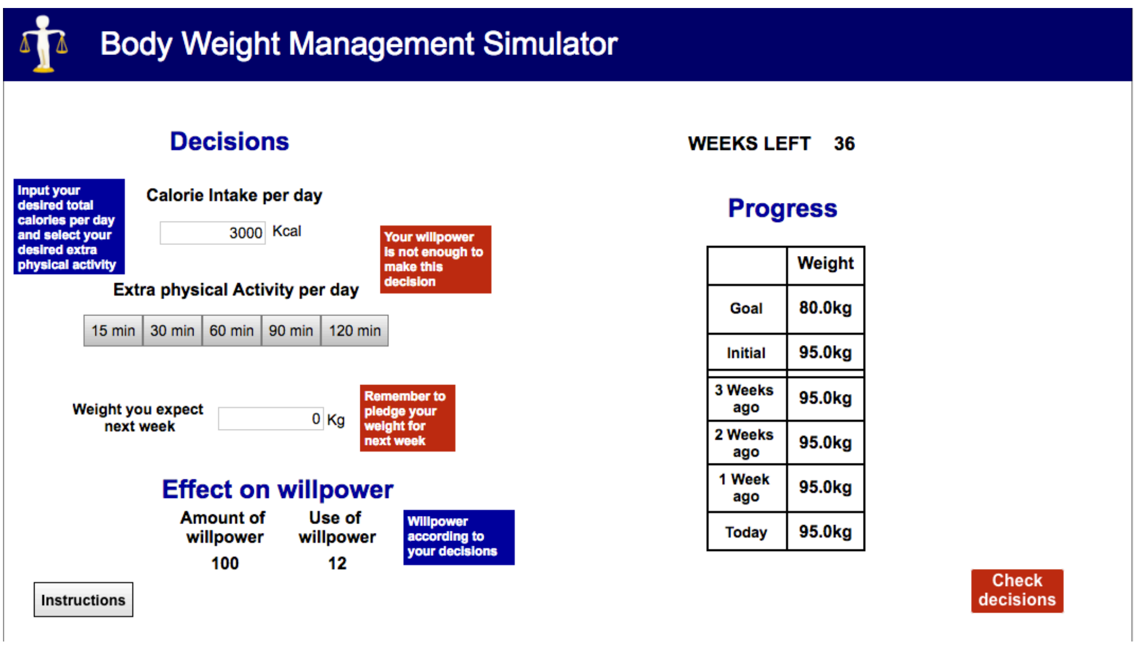
On the next page, you will have the opportunity to decide on your total daily calorie intake and extra physical activity. To learn about your decision making, also input the weight you expect to have in the following week as a result of your choice.

Appendix B: Decision pages

Decision page for treatment group T1 and T3. (No extra physical activity)



Decision page for treatment group T2 and T4. (Extra physical activity)



Appendix C: Model documentation

Top-Level Model:

Adaptive_MEI(t) = Adaptive_MEI(t - dt) + (Change_in_MEI) * dt

INIT Adaptive_MEI = Body.MEI_b

UNITS: kcal/day

INFLOWS:

Change_in_MEI = Calorie_Intake_Gap/time_to_adapt_to_calorie_deficit

UNITS: kcal/day/Days

Adaptive_PA(t) = Adaptive_PA(t - dt) + (Change_in_PA) * dt

INIT Adaptive_PA = Regular_PA

UNITS: dmnl

INFLOWS:

Change_in_PA = PA_Gap/time_to_adapt_to_PA

UNITS: Per Day

Will_Power(t) = Will_Power(t - dt) + (replenish - depletion) * dt

INIT Will_Power = 100

UNITS: WP

INFLOWS:

replenish = (recovery)*replenish_counter/WP_adjustment_time

UNITS: WP/day

OUTFLOWS:

depletion =
((Cost_of_desired_food_n_exercise)*depletion_counter)/WP_adjustment_time

UNITS: WP/day

advance_buttom = WP_Restriction*Expected_weight

UNITS: kg

Age[age_range] = 0

UNITS: dmnl

average_difference = IF TIME=STOPTIME THEN sum_of_difference/30 ELSE 0

UNITS: kg

Body_Mass_Index = ((Body_Mass.Body_Weight/g_to_kg)/(Height*Height))

UNITS: kg/square meters

BW = Body_Mass.Body_Weight/gtokg

UNITS: kg

BW_2_weeks_ago = HISTORY(Body_Mass.Body_Weight, TIME-14)

UNITS: Grams

BW_3_weeks_ago = HISTORY(Body_Mass.Body_Weight, TIME-21)

UNITS: Grams

BW_a_week_ago = HISTORY(Body_Mass.Body_Weight, TIME-7)

UNITS: Grams

Calorie_adaptation = ((Body.MEI_b-Calorie_Intake_Gap)/Body.MEI_b)*1 + ((Body.MEI_b-Body.Delta_MEI)/Body.MEI_b)*0

UNITS: dmnl

Calorie_Intake_Gap = (Body.MEI-Adaptive_MEI)*1

UNITS: kcal/day

cancel_advance = IF advance_buttom THEN 0 ELSE 1

UNITS: Dimensionless

change_in_weight = Body_Mass.Body_Weight-Weight_a_week_ago

UNITS: Grams

Cost_for_the_week = Cost_of_desired_food_n_exercise*1

UNITS: WP

Cost_of_desired_food_n_exercise = WP_total_cost

UNITS: WP

Current_Carbs_Intake = IF Low_Carbs_Diet THEN Total_Intake*0.10 ELSE Total_Intake*0.493961396

UNITS: kcal/day

Current_Fat_Intake = IF Low_Carbs_Diet THEN Total_Intake*0.65 ELSE Total_Intake*0.36015657

UNITS: kcal/day

Current_Protein_Intake = IF Low_Carbs_Diet THEN Total_Intake*0.25 ELSE Total_Intake*0.145882033

UNITS: kcal/day

depletion_counter = IF (TIME-1) MOD 7 = 0 THEN 1 ELSE 0

UNITS: dmnl

Diet[Diet_XP] = 0

UNITS: dmnl

Diet_Cost = (Regular_diet_cost*Effect_of_diet_adaptation_on_Calorie_Intake_Cost*Effect_of_Calorie_Intake_on_WP_cost)

UNITS: WP

Difference = (BW-Expected_BW)*Evaluation_counter

UNITS: kg

Effect_of_cabs_stored_on_PA = GRAPH(Body.Carbs_Mass)

(0.0, 1.150), (100.0, 1.130), (200.0, 1.080), (300.0, 1.030), (400.0, 1.000), (500.0, 1.000)

UNITS: dmnl

Effect_of_Calorie_Intake_on_WP_cost = GRAPH(Calorie_adaptation)

(1.0000, 1.00), (1.1600, 3.50), (1.3200, 4.50), (1.4800, 5.00), (1.6400, 13.00), (1.8000, 20.00)

UNITS: dmnl

effect_of_change_in_weight_on_WP_replenishment = GRAPH(change_in_weight)

(-840, 1.200), (-630, 1.150), (-210, 1.050), (-140, 1.020), (0, 1.000), (140, 0.950), (210, 0.935), (630, 0.800), (840, 0.700)

UNITS: dmnl

Effect_of_diet_adaptation_on_Calorie_Intake_Cost = IF Low_Carbs_Diet THEN 1.1 ELSE 1

UNITS: dmnl

effect_of_energy_balance_on_WP_replenishment = GRAPH(Body.Energy_Balance)

(-1000, 0.500), (-500, 0.710), (-250, 0.800), (-50, 0.950), (0, 1.000), (250, 1.000), (500, 1.000), (750, 1.000), (1000, 1.000)

UNITS: dmnl

Effect_of_PA_on_WP_cost = GRAPH(PA_adaptation)

(1.0000, 1.00), (1.8000, 7.00)

UNITS: dmnl

DOCUMENT: 8

Evaluation_counter = IF TIME>=15 AND (TIME-1) MOD 7 = 0 THEN 1 ELSE 0

UNITS: dmnl

EW_message = IF Expected_weight THEN 0 ELSE 1

UNITS: dmnl

Expected_BW = HISTORY(Expected_weight, TIME-7)

UNITS: kg

Expected_weight = 0

UNITS: kg

FM% = Body.Fat_Mass/(Body_Mass.Body_Weight)

UNITS: Unitless

G = INT(ID/1000)

UNITS: dmnl

g_to_kg = 1000

UNITS: g/kg

game_over_event = IF TIME=STOPTIME THEN 1 ELSE 0

UNITS: dmnl

Goal_weight = IF T1 THEN 80 ELSE IF T2 THEN 82 ELSE IF T3 THEN 82 ELSE IF T4 THEN 83 ELSE 80

UNITS: kg

gtokg = 1000

UNITS: g/kg

Height = 1.80

UNITS: meters

ID = 0

UNITS: dmnl

Initial_BMI = INIT(Body_Mass_Index)

UNITS: kg/square meters

Initial_BW = INIT(Body_Mass.Body_Weight)

UNITS: g

Low_Carbs_Diet = 0

UNITS: Dimensionless

Normal_replenishment = 40

UNITS: WP

PA_adaptation = ((Regular_PA+PA_Gap)/Regular_PA)

UNITS: dmnl

PA_cost = IF Effect_of_PA_on_WP_cost=1 THEN (Regular_PA_cost*Effect_of_PA_on_WP_cost) ELSE (Regular_PA_cost*Effect_of_cabs_stored_on_PA*Effect_of_PA_on_WP_cost)

UNITS: WP

PA_Gap = IF Physical_Activity[a_quarter] THEN 11-Adaptive_PA ELSE IF Physical_Activity[half_hour] THEN 12-Adaptive_PA ELSE IF Physical_Activity[an_hour] THEN 14-Adaptive_PA ELSE IF Physical_Activity[one_and_a_half] THEN 16-Adaptive_PA ELSE IF Physical_Activity[two_hours] THEN 18-Adaptive_PA ELSE (10-Adaptive_PA)

UNITS: dmnl

Physical_Activity[half_hour] = 0 + STEP(1, 9)*0-STEP(1, 77)*0+STEP(1, 39)*0

UNITS: dmnl

Physical_Activity[an_hour] = 0 + STEP(1, 77)*0-STEP(1, 144)*0

UNITS: dmnl

Physical_Activity[one_and_a_half] = 0 + STEP(1, 144)*0-STEP(1, 210)*0

UNITS: dmnl

Physical_Activity[two_hours] = 0 + STEP(1, 39)*0

UNITS: dmnl

Physical_Activity[a_quarter] = 0-STEP(1, 39)*0

UNITS: dmnl

UNITS: dmnl

play_bottom = IF TIME<7 THEN 1 ELSE 0

UNITS: dmnl

promedio = IF TIME=STOPTIME THEN MEAN(SStot) ELSE 0

UNITS: kg

r = SAFEDIV(sum_square_d, sum_square_tot)

UNITS: dmnl

r2 = (1-r)*100

UNITS: dmnl

recovery = (Normal_replenishment*effect_of_change_in_weight_on_WP_replenishment*effect_of_energy_balance_on_WP_replenishment*WP_effect_on_replenish)

UNITS: WP

Regular_diet_cost = 9

UNITS: WP

Regular_PA = 10

UNITS: dmnl

Regular_PA_cost = 3

UNITS: WP

replenish_counter = IF (TIME) MOD 7 = 0 THEN 1 ELSE 0

UNITS: dmnl

SD[SD_XP] = 0

UNITS: dmnl

Sex[sex_definition] = 0

UNITS: dmnl

square_d[weeks] = IF weeks=Week_number THEN Difference^2 ELSE PREVIOUS(SELF, 0)

UNITS: kilograms^2

square_tot[weeks] = (SStot[weeks]-promedio)^2

UNITS: Kilograms^2

SStot[weeks] = IF weeks=Week_number THEN BW ELSE PREVIOUS(SELF, 0)

UNITS: kg

sum_of_difference = PREVIOUS(SELF, 0)+ABS(Difference)

UNITS: kg

sum_square_d = IF TIME=STOPTIME THEN SUM(square_d[*]) ELSE 0

UNITS: kilograms^2

sum_square_tot = IF TIME=STOPTIME THEN SUM(square_tot[*]) ELSE 0

UNITS: Kilograms^2

Survey = SUM(Age[*])*SUM(Sex[*])*SUM(Diet[*])*SUM(SD[*])

UNITS: dmnl

survey_message = IF Survey THEN 0 ELSE 1

UNITS: dmnl

T1 = IF G = 1 THEN 1 ELSE 0

UNITS: dmnl

T2 = IF G = 2 THEN 1 ELSE 0

UNITS: dmnl

T3 = IF G = 3 THEN 1 ELSE 0

UNITS: dmnl

T4 = IF G = 4 THEN 1 ELSE 0

UNITS: dmnl

time_to_adapt_to_calorie_deficit = 300

UNITS: days

time_to_adapt_to_PA = 270

UNITS: days

Total_Intake = 3000.43714878 - (STEP(398.5, 8) + STEP(280, 97)+ STEP(280, 187))*0 -STEP(1000, 9)*0+STEP(2000, 9)*0

UNITS: kcal/day

Week_number = IF Evaluation_counter AND TIME<17 THEN 1 ELSE IF Evaluation_counter AND TIME<24 THEN 2 ELSE IF Evaluation_counter AND TIME<31 THEN 3 ELSE IF Evaluation_counter AND TIME<38 THEN 4 ELSE IF Evaluation_counter AND TIME<45 THEN 5 ELSE IF Evaluation_counter AND TIME<52 THEN 6 ELSE IF Evaluation_counter AND TIME<59 THEN 7 ELSE IF Evaluation_counter AND TIME<66 THEN 8 ELSE IF Evaluation_counter AND TIME<73 THEN 9 ELSE IF Evaluation_counter AND TIME<80 THEN 10 ELSE IF Evaluation_counter AND TIME<87 THEN 11 ELSE IF Evaluation_counter AND TIME<94 THEN 12 ELSE IF Evaluation_counter AND TIME<101 THEN 13 ELSE IF Evaluation_counter AND TIME<108 THEN 14 ELSE IF Evaluation_counter AND TIME<115 THEN 15 ELSE IF Evaluation_counter AND TIME<122 THEN 16 ELSE IF Evaluation_counter AND TIME<129 THEN 17 ELSE IF Evaluation_counter AND TIME<136 THEN 18 ELSE IF Evaluation_counter AND TIME<143 THEN 19 ELSE IF Evaluation_counter AND TIME<150 THEN 20 ELSE IF Evaluation_counter AND TIME<157 THEN 21 ELSE IF Evaluation_counter AND TIME<164 THEN 22 ELSE IF Evaluation_counter AND TIME<171 THEN 23 ELSE IF Evaluation_counter AND TIME<178 THEN 24 ELSE IF Evaluation_counter AND TIME<185 THEN 25 ELSE IF Evaluation_counter AND TIME<192 THEN 26 ELSE IF Evaluation_counter AND TIME<199 THEN 27 ELSE IF Evaluation_counter AND TIME<206 THEN 28 ELSE IF Evaluation_counter AND TIME<213 THEN 29 ELSE IF Evaluation_counter AND TIME<220 THEN 30 ELSE IF Evaluation_counter AND TIME<227 THEN 31 ELSE IF Evaluation_counter AND TIME<234 THEN 32 ELSE IF Evaluation_counter AND TIME<241 THEN 33 ELSE IF Evaluation_counter AND TIME<248 THEN 34 ELSE IF Evaluation_counter AND TIME<255 THEN 35 ELSE 0

UNITS: dmnl

weekday_counter = IF (TIME-0.75) MOD 7 = 0 THEN 1 ELSE 0

UNITS: dmnl

WEEKS_LEFT = PREVIOUS(SELF, ((STOPTIME-1)/7))-weekday_counter

UNITS: dmnl

Weight_a_week_ago = HISTORY(Body_Mass.Body_Weight, TIME-7)
UNITS: Grams
Weight_lost_in_a_week = IF weekday_counter THEN BW_a_week_ago-Body_Mass.Body_Weight ELSE 0
UNITS: Grams
WP_adjustment_time = 1*DT
UNITS: day
WP_effect_on_replenish = GRAPH(Will_Power)
(70.00, 1.000), (76.00, 0.676), (82.00, 0.461), (88.00, 0.300), (94.00, 0.118), (100.00, 0.000)
UNITS: dmnl
WP_message = IF WP_Restriction THEN 0 ELSE 1
UNITS: dmnl
WP_Restriction = IF (Will_Power+recovery*0)-(Cost_for_the_week) >=0 THEN 1 ELSE 0
UNITS: dmnl
WP_total_cost = (Diet_Cost+PA_cost)
UNITS: WP
x = IF Body_Mass_Index>=25 THEN ((Body_Mass_Index-25)*20) ELSE ((Body_Mass_Index-25)*15.38)
UNITS: kg/square meters
y = 0
UNITS: dmnl

Body:
Adaptive_Thermogenesis(t) = Adaptive_Thermogenesis(t - dt) + (Change_in_AT) * dt
INIT Adaptive_Thermogenesis = 0
UNITS: unitless
INFLOWS:
Change_in_AT = ((AT_constant*(Delta_MEI/MEI_b))-Adaptive_Thermogenesis)/adjustment_time_for_AT
UNITS: Per Day
AT_effect_on_phi(t) = AT_effect_on_phi(t - dt) + (Change_in_AT_for_phi) * dt
INIT AT_effect_on_phi = 0

UNITS: unitless

INFLOWS:

Change_in_AT_for_phi = ((AT_phi_constant*(Delta_MEI/MEI_b))-AT_effect_on_phi)/adjustment_time_for_AT_phi

UNITS: Per Day

Carbs(t) = Carbs(t - dt) + (GNG_Fat + Carbs_Intake + GNG_Protein - "DNL_+_G3P" - CarbsOx) * dt

INIT Carbs = Basal_Carbs

UNITS: kcal

INFLOWS:

GNG_Fat = ((Fat_Intake*(Energy_Density[Carbs]/Energy_Density[Fat]))+(D_F_C.Fat_Conversion *Energy_Density[Carbs]))*(Mg/Mtg)

UNITS: Kcal/day

Carbs_Intake = Carbs_Intake_Diet

UNITS: Kcal/day

GNG_Protein = Basal_GNG_Protein*((Protein_Conversion/Baseline_Protein_Conversion)-(Tc*(Carbs_Intake_Change/Basal_Carbs_Intake))+(Tp*(Protein_Intake_Change/Basal _Protein_Intake)))

UNITS: Kcal/day

OUTFLOWS:

"DNL_+_G3P" = DNL+G3P

UNITS: Kcal/day

CarbsOx = Desired_CarbsOx*Eff_of_Carbs_Suff_on_CarbsOx

UNITS: Kcal/day

Energy_Balance(t) = Energy_Balance(t - dt) + (Intake - Expenditure - body_regulation) * dt

INIT Energy_Balance = 0

UNITS: kcal

INFLOWS:

Intake = MEI

UNITS: kcal/days

OUTFLOWS:

```
        Expenditure = TEE
            UNITS: kcal/days
        body_regulation = Energy_Balance/body_adjustment_time
            UNITS: kcal/days
Fat(t) = Fat(t - dt) + (Fat_Intake + "DNL_+_G3P" - FatOx - GNG_Fat) * dt
    INIT Fat = Basal_Fat
    UNITS: kcal
    INFLOWS:
        Fat_Intake = Fat_Intake_Diet
            UNITS: Kcal/day
        "DNL_+_G3P" = DNL+G3P
            UNITS: Kcal/day
    OUTFLOWS:
        FatOx = Desired_FatOx*Eff_of_Fat_Suff_on_FatOx
            UNITS: Kcal/day
        GNG_Fat                                                              =
((Fat_Intake*(Energy_Density[Carbs]/Energy_Density[Fat]))+(D_F_C.Fat_Conversion
*Energy_Density[Carbs]))*(Mg/Mtg)
            UNITS: Kcal/day
Protein(t) = Protein(t - dt) + (Protein_Intake - GNG_Protein - ProteinOx) * dt
    INIT Protein = Basal_Protein
    UNITS: kcal
    INFLOWS:
        Protein_Intake = Protein_Intake_Diet
            UNITS: Kcal/day
    OUTFLOWS:
        GNG_Protein                                                          =
Basal_GNG_Protein*((Protein_Conversion/Baseline_Protein_Conversion)-
(Tc*(Carbs_Intake_Change/Basal_Carbs_Intake))+(Tp*(Protein_Intake_Change/Basal
_Protein_Intake)))
            UNITS: Kcal/day
        ProteinOx = (Oxidation.f[Prot]*(TEE-(GNG_Fat+GNG_Protein))) + FatOx_Gap
+ (Gap_CarbsOx*0.6)
            UNITS: Kcal/day
```

Recent_Carbs(t) = Recent_Carbs(t - dt) + (Carbs_Change - Recent_Carbs_Change) * dt

INIT Recent_Carbs = Basal_Carbs*0

UNITS: kcal

INFLOWS:

Carbs_Change = Net_Carbs_Change

UNITS: kcal/days

OUTFLOWS:

Recent_Carbs_Change = Recent_Carbs/Delay_Time

UNITS: kcal/days

Recent_Fat(t) = Recent_Fat(t - dt) + (Fat_Change - Recent_Fat_Change) * dt

INIT Recent_Fat = Basal_Fat*0

UNITS: Kcal

INFLOWS:

Fat_Change = Net_Fat_Change

UNITS: kcal/days

OUTFLOWS:

Recent_Fat_Change = Recent_Fat/Delay_Time

UNITS: kcal/days

Recent_Protein(t) = Recent_Protein(t - dt) + (Protein_Change - Recent_Protein_Change) * dt

INIT Recent_Protein = Basal_Protein*0

UNITS: Kcal

INFLOWS:

Protein_Change = Net_Protein_Change

UNITS: kcal/days

OUTFLOWS:

Recent_Protein_Change = Recent_Protein/Delay_Time

UNITS: kcal/days

adjustment_time_for_AT = 7

UNITS: days

DOCUMENT: literature says 7

best fit 30

adjustment_time_for_AT_phi = 300

UNITS: days

DOCUMENT: literature says 7

best fit 30

AT_allocation = 0.6

UNITS: Dimensionless

DOCUMENT: Percentage of adaptive thermogenesis allocated to PAE vs RMR

AT_constant = 0.8

UNITS: Dimensionless

AT_phi_constant = 1.45

UNITS: Dimensionless

Basal_Carbs = 400*4.18

UNITS: kcal

Basal_Carbs_Intake = INIT(Carbs_Intake)

UNITS: Kcal/day

Basal_Carbs_Mass = INIT(Carbs_Mass)

UNITS: g

Basal_Fat = 24000*9.44

UNITS: kcal

Basal_Fat_Intake = INIT(Fat_Intake)

UNITS: Kcal/day

Basal_GNG_Protein = 100

UNITS: kcal/days

DOCUMENT: estimated that the net basal gluconeogenic rate from amino acids (GNGP b) was 100 kcal/day.

Basal_Intake[Fat] = Basal_Fat_Intake

UNITS: kcal/days

Basal_Intake[Carbs] = Basal_Carbs_Intake

UNITS: kcal/days

Basal_Intake[Prot] = Basal_Protein_Intake

UNITS: kcal/days

UNITS: kcal/days

Basal_Phi = Initial_Phi*(1+AT_effect_on_phi)

UNITS: kcal/g/day

Basal_Protein = 13050*4.7

UNITS: kcal

Basal_Protein_Intake = INIT(Protein_Intake)

UNITS: Kcal/day

Basal_Protein_Mass = INIT(Protein_Mass)

UNITS: g

Baseline_Carbs_Conversion = 180

UNITS: g/day

Baseline_Daily_Average_Conversion[Fat] = Baseline_Fat_Conversion

UNITS: g/day

Baseline_Daily_Average_Conversion[Carbs] = Baseline_Carbs_Conversion

UNITS: g/day

Baseline_Daily_Average_Conversion[Prot] = Baseline_Protein_Conversion

UNITS: g/day

UNITS: g/day

Baseline_Fat_Conversion = 140

UNITS: g/day

Baseline_Protein_Conversion = 300

UNITS: g/day

body_adjustment_time = 1

UNITS: day

Carbs_Conversion = Baseline_Carbs_Conversion*(Carbs_Mass/Basal_Carbs_Mass)

UNITS: g/day

Carbs_Intake_Change = Carbs_Intake-Basal_Carbs_Intake

UNITS: Kcal/day

Carbs_Intake_Diet = .Current_Carbs_Intake*1 + Initial_Carbs_Intake*0

UNITS: kcal/day

Carbs_Mass = Carbs/Energy_Density[Carbs]

UNITS: g

Carbs_Sufficiency = Carbs/Desired_CarbsOx

UNITS: day

Change_of_F = ((3*Mffa*Fat_Intake/Mtg)+DNL-FatOx)*0 + Recent_Fat_Change

UNITS: Kcal/day

Choice_of_PAL = IF .Physical_Activity[half_hour] THEN 1.2 ELSE IF .Physical_Activity[an_hour] THEN 1.35 ELSE IF .Physical_Activity[one_and_a_half]

THEN 1.45 ELSE IF .Physical_Activity[two_hours] THEN 1.55 ELSE IF .Physical_Activity[a_quarter] THEN 1.1 ELSE 0

UNITS: dmnl

Delay_Time = DT*0 + 0.25

UNITS: Days

Delta_MEI = MEI-MEI_b

UNITS: kcal/day

Desired_CarbsOx = (GNG_Fat+GNG_Protein)+(Oxidation.f[Carbs]*(TEE-(GNG_Fat+GNG_Protein)))

UNITS: kcal/days

Desired_FatOx = Oxidation.f[Fat]*(TEE-(GNG_Fat+GNG_Protein)) + Gap_CarbsOx*0.4

UNITS: kcal/days

DNL = ((Carbs_Intake*((Carbs/Basal_Carbs)^4))/(Kdln+((Carbs/Basal_Carbs)^4)))*0 + (MIN(Carbs/DT, (Carbs_Intake*((Carbs/Basal_Carbs)^4))/(Kdln+((Carbs/Basal_Carbs)^4))))*1

UNITS: kcal/days

DOCUMENT: Rate of de novo lipogenesis in kcal/day

Eff_of_Carbs_Suff_on_CarbsOx = GRAPH(Carbs_Sufficiency)

(0.000, 0.000), (0.100, 0.600), (0.200, 0.850), (0.300, 0.950), (0.400, 1.000), (1.000, 1.000)

UNITS: dmnl

Eff_of_Fat_Suff_on_FatOx = GRAPH(Possible_FatOx/Desired_FatOx)

(0.000, 0.000), (0.400, 0.400), (0.7982, 0.6272), (1.303, 0.8246), (2.000, 0.950), (3.000, 1.000)

UNITS: Unitless

Effect_of_PAL_on_Physical_Activity_Coefficient = GRAPH(Choice_of_PAL)

(0.000, 1.000), (0.200, 1.000), (0.400, 1.000), (0.600, 1.000), (0.800, 1.000), (1.000, 1.000), (1.200, 1.180), (1.400, 1.320), (1.600, 1.460), (1.800, 1.580), (2.000, 1.680), (2.200, 1.680), (2.400, 1.680), (2.600, 1.680)

UNITS: Unitless

Energy_Density[Fat] = 9.44

UNITS: kcal/g

Energy_Density[Carbs] = 4.18

UNITS: kcal/g

Energy_Density[Prot] = 4.7

UNITS: kcal/g

UNITS: kcal/g

Fat_Intake_Change = Fat_Intake-Basal_Fat_Intake

UNITS: kcal/day

Fat_Intake_Diet = .Current_Fat_Intake*1 + Initial_Fat_Intake*0

UNITS: kcal/day

Fat_Mass = Fat/Energy_Density[Fat]

UNITS: g

FatOx_Gap = Desired_FatOx-FatOx

UNITS: kcal/day

G3P = (MIN(Carbs/(16*DT), (Energy_Density[Carbs]*Sythesis_Rate_F*(Mg/Mtg))))*0 + (Energy_Density[Carbs]*Sythesis_Rate_F*(Mg/Mtg))*0 + (MIN(Carbs_Intake/1.2, (Energy_Density[Carbs]*Sythesis_Rate_F*(Mg/Mtg))))*1

UNITS: kcal/day

DOCUMENT: Glycerol 3-Phosphate Production

Because adipose tissue lacks glycerol kinase, the glycerol 3-phosphate backbone of adipose TG is derived primarily from glucose. Thus, the TG synthesis rate (SynthF) determined the rate of G3P

Gap_CarbsOx = Desired_CarbsOx-CarbsOx

UNITS: kcal/days

Initial_Carbs_Intake = 1461.50549889

UNITS: kcal/day

Initial_Fat_Intake = 1064.84589968

UNITS: kcal/day

Initial_Phi = 0.009345

UNITS: kcal/g/day

Initial_Protein_Intake = 432.796701418

UNITS: kcal/day

Kdln = 16

UNITS: Dimensionless

DOCUMENT: KDNL 2 and d 4 such that the computed DNL rate corresponded with measured in vivo DNL rates for experimentally determined carbohydrate intakes and estimated glycogen levels (1, 2, 33, 57).

MEI = Fat_Intake+Carbs_Intake+Protein_Intake

UNITS: kcal/day

DOCUMENT: metabolizable energy intake

MEI_b = Basal_Fat_Intake+Basal_Carbs_Intake+Basal_Protein_Intake

UNITS: kcal/day

DOCUMENT: baseline metabolizable energy intake

Mffa = 273

UNITS: g/mol

DOCUMENT: Molecular mass of the free fatty acids

Mg = 92

UNITS: g/mol

Mtg = 860

UNITS: g/mol

Net_Carbs_Change = Carbs_Intake+GNG_Fat+GNG_Protein-"DNL_+_G3P"-CarbsOx

UNITS: kcal/days

Net_energy_change = Intake-Expenditure

UNITS: kcal/days

Net_Fat_Change = Fat_Intake+"DNL_+_G3P"-FatOx-GNG_Fat

UNITS: kcal/days

Net_Protein_Change = Protein_Intake-GNG_Protein-ProteinOx

UNITS: kcal/days

PAE = (Phi)*(1+(AT_allocation*Adaptive_Thermogenesis))*Body_Mass.Body_Weight

UNITS: kcal/days

DOCUMENT: Physical Activity Expenditure

Phi = Basal_Phi*Effect_of_PAL_on_Physical_Activity_Coefficient

UNITS: kcal/g/day

Possible_FatOx = (Fat-00000)/DT

UNITS: kcal/day

Protein_Conversion = Baseline_Protein_Conversion*(Protein_Mass/Basal_Protein_Mass)

UNITS: g/day

Protein_Intake_Change = Protein_Intake-Basal_Protein_Intake

UNITS: Kcal/day

Protein_Intake_Diet = .Current_Protein_Intake*1 + Initial_Protein_Intake*0

UNITS: kcal/day

Protein_Mass = Protein/Energy_Density[Prot]

UNITS: g

Sythesis_Rate_F = (D_F_C.Fat_Conversion+(Change_of_F/Energy_Density[Fat]))

UNITS: g/days

Tc = 0.5

UNITS: Dimensionless

TEE = TEF+PAE+Metabolism.RMR

UNITS: kcal/days

DOCUMENT: Total Energy Expenditure

TEF = (0.025*Fat_Intake)+(0.25*Protein_Intake)+(0.075*Carbs_Intake)

UNITS: kcal/days

DOCUMENT: Thermal Effect of Feeding

Feeding induces a rise of metabolic rate associated with the digestion, absorption, and short-term storage of macronutrients where □F □ 0.025, □P □ 0.25, and □C □ 0.075 defined the short-term thermic effect of fat, protein, and carbohydrate feeding.

Tp = 0.3

UNITS: Dimensionless

Body_Mass:

BCM = ICW+(Body.Protein/Body.Energy_Density[Prot])+(Body.Carbs/Body.Energy_Density[Carbs])+ICS

UNITS: g

DOCUMENT: Body Cell Mass

BM = 3250

UNITS: g

DOCUMENT: Bone Mass

- Average weight for a person 1.8m tall

Body_Weight = Lean_Body_Mass+(Body.Fat/Body.Energy_Density[Fat])

UNITS: g

ECW = 21000

UNITS: g

DOCUMENT: Extracellular Water

7/10 * 3/8 * BW Nuhoglu 2009

ICS = 3970

UNITS: g

DOCUMENT: Intracellular solids

Nuhoglu 2009

ICW = ICW_b+(2*Body.Protein/Body.Energy_Density[Prot])+(2.7*Body.Carbs/Body.Energy_Density[Carbs])

UNITS: g

DOCUMENT: Total Intracellular water

ICW_b = 2164

UNITS: g

DOCUMENT: Intracellular water constant

Lean_Body_Mass = BM+ECW+BCM

UNITS: g

D_F_C:

A_l = 3.1

UNITS: Dimensionless

DOCUMENT: as computed by dividing the glycerol rate of appearance (Ra) after a 60-h fast (12) by the daily average glycerol Ra (34).

B_l = 0.9

UNITS: Dimensionless

Basal_Fat_Mass = INIT(Body.Fat_Mass)

UNITS: g

Fat_Conversion = (Body.Baseline_Fat_Conversion*(Body.Fat_Mass/Basal_Fat_Mass)^(2/3))* ((((A_l-B_l)*EXP(-K_l*Body.Carbs_Intake/Body.Basal_Carbs_Intake)+B_l-1)/MAX(1,(Body.Fat_Mass/Basal_Fat_Mass)^(2/3)))+1)

UNITS: g/day

K_l = LN((A_l-B_l)/(1-B_l))

UNITS: Dimensionless

Metabolism:

E_c = -100

UNITS: kcal/day

DOCUMENT: Constant energy expenditure

On the paper has a negative sign

5*age

E_d = 0.8

UNITS: Dimensionless

DOCUMENT: Efficiency of the Novo Lipogenesis

E_g = 0.8

UNITS: Dimensionless

DOCUMENT: Efficiency of Gluconeogenesis

E_p = 0.17

UNITS: kcal/g

DOCUMENT: Efficiency of the Proteolysis

M_b = 1400

UNITS: g

DOCUMENT: Brain mass

MR_b = 0.240

UNITS: kcal/g/day

DOCUMENT: Brain Metabolic Rate

MR_bcm = MR_bcm_prime*(1+((1-Body.AT_allocation)*Body.Adaptive_Thermogenesis))

UNITS: kcal/g/day

DOCUMENT: Metabolic Rate of Body cell mass

MR_bcm_prime = 0.024

UNITS: kcal/g/day

DOCUMENT: Prime Metabolic Rate of Body cell mass

MR_fat = 0.0045

UNITS: kcal/g/day

DOCUMENT: Metabolic Rate of Fat

N[Fat] = 0.18

UNITS: kcal/g

DOCUMENT: Percentage cost for Fat Synthesis

Percentage cost for Glycogen Synthesis

Percentage cost for Protein Synthesis

N[Carbs] = 0.21

UNITS: kcal/g

DOCUMENT: Percentage cost for Fat Synthesis

Percentage cost for Glycogen Synthesis

Percentage cost for Protein Synthesis

N[Prot] = 0.86

UNITS: kcal/g

DOCUMENT: Percentage cost for Fat Synthesis

Percentage cost for Glycogen Synthesis

Percentage cost for Protein Synthesis

UNITS: kcal/g

DOCUMENT: Percentage cost for Fat Synthesis

Percentage cost for Glycogen Synthesis

Percentage cost for Protein Synthesis

Net_change[Fat] = Body.Recent_Fat_Change

UNITS: kcal/day

Net_change[Carbs] = Body.Recent_Carbs_Change
UNITS: kcal/day
Net_change[Prot] = Body.Recent_Protein_Change
UNITS: kcal/day
UNITS: kcal/day

RMR = (E_c+(MR_b*M_b)+(MR_bcm*(Body_Mass.BCM-M_b))+(MR_fat*Body.Fat/Body.Energy_Density[Fat])+(Body.DNL*(1-E_d))+((1-E_g)*(Body.GNG_Fat+Body.GNG_Protein))+(Body.Protein_Conversion*(N[Prot]+E_p))+(D_F_C.Fat_Conversion*N[Fat])+(Body.Carbs_Conversion*N[Carbs])+SUM(N[*]*Net_change[*]/Body.Energy_Density[*]))
UNITS: kcal/days
DOCUMENT: Resting Metabolic Rate

Oxidation:
Daily_Average_Conversion[Fat] = D_F_C.Fat_Conversion
UNITS: g/days
DOCUMENT: Daily Average Lipolysis
Daily Average Glycogenolysis
Daily Average Proteolysis
Daily_Average_Conversion[Carbs] = Body.Carbs_Conversion
UNITS: g/days
DOCUMENT: Daily Average Lipolysis
Daily Average Glycogenolysis
Daily Average Proteolysis
Daily_Average_Conversion[Prot] = Body.Protein_Conversion
UNITS: g/days
DOCUMENT: Daily Average Lipolysis
Daily Average Glycogenolysis
Daily Average Proteolysis
UNITS: g/days
DOCUMENT: Daily Average Lipolysis
Daily Average Glycogenolysis
Daily Average Proteolysis
f[Macronutrient] = fn[Macronutrient]/Z

UNITS: Dimensionless

fn[Fat] = (W[Fat]*(Daily_Average_Conversion[Fat]/Body.Baseline_Daily_Average_Conversion [Fat]))

UNITS: Dimensionless

fn[Carbs] = (Wg*(Daily_Average_Conversion[Carbs]/Body.Baseline_Daily_Average_Conversion[Carbs]))+(W[Carbs]*(MAX(0, (1+(S[Carbs]*Intake_Change[Carbs]/Body.Basal_Intake[Carbs])))))*(Body.Carbs/(Gmi n+Body.Carbs)))

UNITS: Dimensionless

fn[Prot] = ((Daily_Average_Conversion[Prot]/Body.Baseline_Daily_Average_Conversion[Prot]) +(W[Prot]*MAX(0, (1+(S[Prot]*Intake_Change[Prot]/Body.Basal_Intake[Prot])))))*Sa*EXP(- Ka*(Body.Phi)/Phi_b)

UNITS: Dimensionless

UNITS: Dimensionless

Gmin = 4.2

UNITS: kcal

Intake_Change[Fat] = Body.Fat_Intake_Change

UNITS: kcal/days

Intake_Change[Carbs] = Body.Carbs_Intake_Change

UNITS: kcal/days

Intake_Change[Prot] = Body.Protein_Intake_Change

UNITS: kcal/days

UNITS: kcal/days

Ka = LN(Sa)

UNITS: Dimensionless

Phi_b = INIT(Body.Phi)

UNITS: kcal/g/day

S[Fat] = 0

UNITS: Dimensionless

S[Carbs] = 1

UNITS: Dimensionless

S[Prot] = 7

UNITS: Dimensionless

UNITS: Dimensionless

Sa = 4.6

UNITS: Dimensionless

DOCUMENT: Paper suggest 4.6

W[Fat] = 4.1

UNITS: Dimensionless

W[Carbs] = 3.2

UNITS: Dimensionless

W[Prot] = 0.24

UNITS: Dimensionless

UNITS: Dimensionless

Wg = 1.7

UNITS: Dimensionless

Z = SUM(fn[*])

UNITS: Dimensionless

{ The model has 275 (425) variables (array expansion in parens).

In root model and 5 additional modules with 1 sectors.

Stocks: 12 (12) Flows: 24 (24) Converters: 239 (389)

Constants: 64 (84) Equations: 199 (329) Graphicals: 9 (9)

}