

Based On Satiety Mechanism: The Effect of Dietary Therapy in Terms of Substitute Meal in Overweight and Diabetic Patients

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Abstract. Obesity is a widespread public health concern that poses a threat to global well-being. Effective dietary management stands out as a key component in the care of obesity and diabetes. It not only aids in regulating body fat and blood glucose levels but also demonstrates significant prowess in reducing fasting blood glucose and postprandial 2-hour blood glucose levels. Furthermore, it proves useful in assisting diabetic patients in achieving glycemic index targets and formulating tailored diet plans. However, not all patients possess the knowledge to establish a balanced diet. This is where meal substitutes step in, offering a convenient, pre-made solution. A well-balanced meal substitute can deliver ample satiety while ensuring essential nutrients, thus preventing overindulgence. Satiety, the sensation that increases fullness and reduces unnecessary food intake, plays a pivotal role in weight loss and overall health maintenance. It arises from the stomach's response to food ingestion, signaling to a person that they are comfortably full and no longer in need of further sustenance. Consequently, the exploration of meal substitutes as a novel form of diabetes intervention therapy has gained increasing attention in recent years.

Keywords: Satiety, diabetes, obesity, appetite control, meal substitute.

1. Introduction

When it comes to the issue of obesity, it is inevitable to facing a global epidemic that affects practically every culture and ethnic civilization, putting a huge strain on current healthcare systems. Obesity will not only affect personal image, but also induce some complications, such as hypertension, diabetes, fatty liver, etc., threatening human physical and mental health. The most common comorbidities associated with increased body fat include type 2 diabetes, cardiovascular disease, and certain types of cancer, primarily gastrointestinal cancer. Among the many factors that cause obesity, unreasonable diet dominates. People no longer rely on merely three meals a day, but eat many times as needed to meet the energy needs of the body, leading to the presence of words such as “brunch”, “afternoon tea”, “dessert”, and “night snack”. However, the massive intake of industrialized output of ultra-processed foods by the nearest ten generations to today is the root cause of many diseases [1]. The merchants are smart, they know what people concerned, notably in dieters and diabetic individuals. The meal supplement products catch people’s mental thoughts: eat but do not gain any weight. It is ubiquitous to see either zero-sugar or zero-calorie beverages in any tiny supermarkets, so the health awareness is increasingly arousing throughout the time.

After realizing the adverse effects of obesity and diabetes, people have turned their attention to finding food that can replace high calorie foods, and substitute food has emerged. The commonly known substitute food is a food that replaces some or all of the main meals to achieve weight and fat reduction. Substitute meals not only provide various necessary nutrients for the human body quickly and conveniently, but also have higher dietary fiber content and lower food calories, making it easy for people to achieve satiety. The feeling of fullness can also limit the total food intake to avoid the desired effect. Along with the development in recent years, the food substitutes tend to be rich in shape, such as meal substitutes, meal substitutes sticks, meal substitutes milkshakes.

Overall, this passage offers a well-rounded perspective on the challenges posed by obesity and the emergence of substitute foods as a potential solution.

2. Sugar Intake, Appetite and Obesity

People have long been dissatisfied with just three meals a day, and snacks have become an integral component of people's lives, for both the young and old generations. However, snacking already contributes to close to one-third of daily energy intake [2]. Some consume excessive amounts of unhealthy junk food with low nutritional value, leading to risks of diseases such as type-two diabetes, high blood pressure, obesity, and heart disease. Given that humans are generally susceptible to sugar addiction, food manufacturers cleverly exploit this vulnerability. To ensure consumers 'eat and want to buy again,' thus making repeat purchases of their products, manufacturers invest significant efforts in the research and development of their products. One of the most effective and common strategies is the heavy use of sugars and food additives to make it easier for people to become hooked on the taste and remain loyal to their products [1].

The root cause of modern obesity is not calories or fat, but rather sugar intake, meaning the consumption of carbohydrates. According to the recommendations of the WHO, as well as Chinese dietary guidelines, the preferred daily intake of added sugar should not exceed 25 grams, with an absolute maximum of 50 grams. Sugar addiction is associated with higher rates of cancer, heart attacks, stroke, and Alzheimer's disease, all exacerbated by obesity and diabetes. Once addicted to sugar, a hormone called leptin, produced by the satiety center in the brain, becomes less effective, a phenomenon known as leptin resistance [1]. In other words, the feeling of fullness diminishes, and people consistently crave food, often unconsciously. When leptin ceases to function, the brain sends a signal to 'keep eating and get fat.'

Obesity and diabetes fall under the category of lifestyle diseases; most patients with these conditions are accustomed to snacking on foods high in sugar, making it difficult for them to feel satisfied after a meal, thus leading to persistent cravings for snacks. Additionally, people may feel hungry again soon after consuming a substantial meal. These phenomena are closely related to blood glucose levels, which significantly influence moods. When blood sugar levels rise, individuals experience a surge of happiness, indicating that dopamine in the brain is active. However, this type of happiness is often brief and fleeting. The regulation of appetite is a complex process that involves intricate pathways of hormonal and neuronal signaling [3]. Energy homeostasis plays a crucial role in achieving glycemic control in people with type 2 diabetes mellitus (T2DM) [4]. Much research in the field of appetite has focused on identifying the key signals that trigger and inhibit food intake [5]. Additionally, other hormones such as insulin and glucagon can also impact appetite and the sensation of fullness [6].

3. Satiety Cascade

The satiety cascade is a process that occurs after a meal (Fig. 1). It is a biological mechanism that signals to people that they are no longer hungry and have consumed sufficient food.

The satiety cascade begins when humans start to eat. The sight and smell of food send signals to the brain, letting it know that food is on the way. However, someone with diabetes symptoms may eat when they are not hungry, possibly due to olfactory and visual stimuli. As the food is chewed and swallowed, signals are sent to the brain through the digestive system, responsible for creating the feeling of fullness.

As the food enters the stomach, it begins to expand and sends signals to the brain indicating it is full. These signals are responsible for feelings of fullness and satisfaction. After the food is digested, it enters the small intestine where nutrients are absorbed [6]. This absorption process takes time, which is why it usually takes approximately 20 minutes after finishing a meal to feel full. As nutrients are absorbed, hormones responsible for feelings of fullness are released into the bloodstream and sent to the brain. These hormones signal to the brain that the body has had enough to eat and it's time to stop eating.

Finally, as the meal concludes and the stomach empties, ghrelin helps to maintain the feeling of fullness and satisfaction after a meal. Ghrelin is a small polypeptide composed of 28 amino acids,

which can be divided into acylated ghrelin (AG) and non-acylated ghrelin (DAG) based on whether it can acylate serine residues. Ghrelin mainly exists in the latter form in the human body [3]. Some studies have found that ghrelin is closely related to obesity.

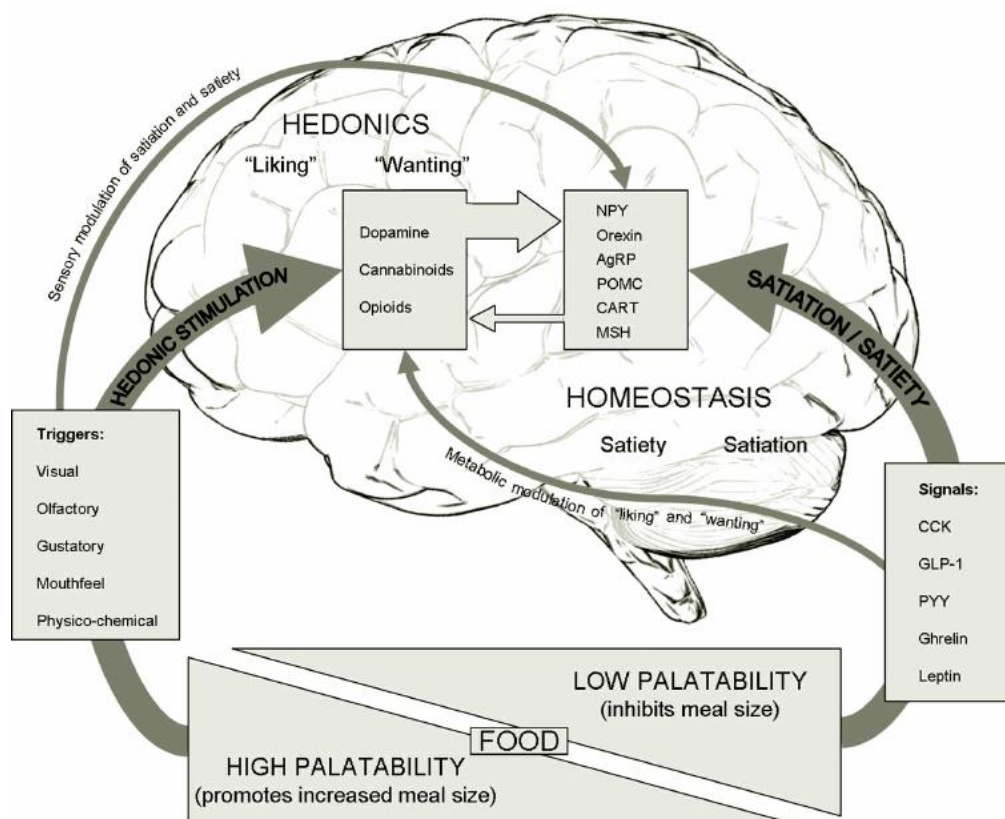


Figure 1. Diagram of satiety cascade [7].

4. External Factors Affecting Satiety

4.1. Personal Eating Habits and Behavior

Several studies have found that the more items available at a particular meal occasion, the more people will consume [6]. This impact appears to be mediated by a phenomenon known as sensory-specific satiety (SSS), in which people eat different types of food, taste and taste, and the appetite center produces distinct reactions, which influences satiety generation. This is why obese people tend to finish all the food on their plates, whilst thin people do not. The latter group stop eating when they feel full or no desire to continue eating. Also, studies have shown that the same food at a meal, eating vegetables and protein first, then eating carbohydrates, can better stabilize blood sugar. The recommended dining order is that "eat soup - eat vegetables - eat meat - lastly eat main food" [1]. Therefore, diabetic individuals eating in this way can enhance the sense of satiety to a certain extent.

4.2. Sleep

Getting adequate sleep helps increase satiety because sleep increases the body's production of leptin, which is a hormone that suppresses appetite [3]. Similarly, sleep reduces the production of ghrelin. On the other hand, epidemiological studies have linked a chronic lack of sleep to obesity, and it has been suggested that restricted sleep has an impact on the appetite hormones leptin and ghrelin [6].

4.3. Physical Activities

Lack of physical activity can reduce feelings of fullness, which can easily lead to increased hunger, which in turn increases food intake. Chronic inactivity can also lead to weight gain, as lack of exercise

affects the body's metabolism and energy expenditure, reducing feelings of fullness [4,6]. Therefore, maintaining moderate physical activity is crucial for improving satiety and maintaining good health.

4.4. Social Situations

Research shows that people generally eat more than others when they are with other people (mean 44%). In fact, there is a direct relationship between the number of eaters and the number of eaters, and the larger the number of eaters, the more energy consumption increases [6]. This is because if someone eats with a lot of people, others will imitate it and consume more things. The emotional effects of diet with other people promote energy intake, and the social interaction during meals stimulates control and ultimately means that group meals often eat longer.

5. Management Satiety

5.1. VAS

Inhibition of intake following a culinary event can be measured in a variety of ways. The Visual Analog Scale (VAS) is a basic technique that allows people to assess their level of hunger, fullness, or desire to eat [6]. The scale is normally composed of a line of 100- or 150-mm length, with extreme solutions to the question given at each end.

In a randomized controlled experiment, 108 T2DM patients aged 35-60 years were placed into three groups: aerobic, mixed (combining aerobic and resistance workouts), and control [4]. Subjective emotions of hunger and fullness were assessed using a 100 mm visual analogue scale in response to a normal breakfast meal (453 kcal). Long-term aerobic and mixed exercise clearly reduced hunger and calorie intake while enhancing fullness in people with T2DM. Exercise appears to have a significant effect on lowering energy intake regardless of energy expenditure. Combination exercises outperform aerobic exercise in terms of satiety and calorie intake in people with T2DM.

5.2. GI Value

The Glycemic Index (GI) serves as an effective indicator for observing and measuring changes in postprandial blood sugar levels resulting from food consumption [8]. These changes are closely linked to blood sugar fluctuations. When $GI < 55$, the food is considered to have a low GI. Opting for low GI foods can mitigate peak blood sugar levels and reduce the risk of cardiovascular disease and insulin resistance [9]. The higher the GI, the more pronounced the fluctuations in blood sugar induced by the food. High GI foods can lead to a rapid surge in blood sugar over a short period, followed by a swift decline, resulting in significant blood sugar swings. Conversely, foods with a low GI release energy gradually, helping maintain relatively stable blood sugar levels [1].

Under the same satiety condition, low GI foods will have better health effects. Hence, opting for foods with a low GI aid in sustaining stable blood sugar levels, providing enduring energy, and promoting overall health. Additionally, it's crucial to bear in mind that factors like cooking method, portion size, and individual physiological differences also influence digestive time and GI values [6]. Therefore, the information provided above is intended for reference only, and actual digestion times and GI values may vary.

6. Effects of Nutrients on Satiety

6.1. Nutrition-Allocated Proportion

Nutritional balance must take priority over satiety. Studies have shown that the energy supply ratio of fat, which is more conducive to weight loss, should be controlled within 30%. For example, diabetics choose foods with low GI and high dietary fiber content, which can account for up to 60% of the energy supply, which will help better improve the blood sugar level of adult patients with type 2 diabetes [10]. Under the premise of the same intake of energy, more choices to replace

carbohydrates and saturated fatty acids with monounsaturated fatty acids in the diet can not only improve glucose and lipid metabolism in diabetic patients, but also reduce body mass.

6.2. Fiber

Dietary fiber is an essential substance for the human body, and as a non-nutritional component, it holds significant importance for human health. Meals with dietary fiber replacement, for instance, can substitute some or all of the main meal, prolong gastrointestinal emptying time and transportation speed, increase satiety, and slow down the sensation of hunger [8].

In a study conducted by Shen Chunfeng et al., a total of 90 cases of type 2 diabetes mellitus patients were selected as research subjects to observe the clinical effect of predominantly providing sub-dietary fiber meal substitutes combined with low glycemic index foods based on conventional diabetic dietary guidance [9]. The results showed that the energy, fat, and carbohydrate intake of the observation group were lower than the control group, while protein intake was higher than the control group. Various indicators of blood glucose and blood lipid levels in the observation group were lower than those in the control group. This demonstrates that dietary management involving dietary fiber meal substitutes combined with low glycemic index foods can improve the intake of energy substances and blood glucose and lipid levels in type 2 diabetic individuals, without affecting the intestinal flora.

6.3. Micronutrient

Additionally, some minerals and vitamins are also linked to feelings of fullness. Zinc, for example, promotes the release of appetite hormones, while vitamin D increases leptin production [11]. Therefore, getting enough minerals and vitamins is very important for maintaining a normal appetite and feeling full [6, 11].

7. Food Substitute for Diabetics in Medical Treatment

In recent years, studies have demonstrated that meal substitute diets can effectively improve the blood glucose and lipid levels of overweight or obese individuals with type 2 diabetes, reduce body mass, decrease waist circumference, facilitate the achievement of glycated hemoglobin targets, enhance patient compliance, satisfaction rates, and bring about intervention and treatment effects across various aspects [12]. Scholarly research has indicated that partial meal substitute programs can assist type 2 diabetes patients in losing weight and enhancing the overall quality of their diets [10]. Meal substitutions not only reduce the energy intake of a specific meal but also provide essential nutrients that are often lacking during weight loss, ensuring that the meal's energy content remains moderate and meets basic nutritional requirements [8]. Moreover, since dietary fiber is not directly absorbed by the human body, it can bind to some fatty substances during intestinal transit, reducing energy absorption. Consequently, the dietary fiber content plays a crucial role in determining the satiety of substitute foods.

However, the effectiveness of substitute foods can vary among individuals with different constitutions, and improper consumption can even yield adverse effects [8]. These foods should not be combined haphazardly or consumed blindly, as doing so may lead to unfavorable reactions. Many individuals might harbor unrealistic expectations when using substitute foods, mistakenly believing that consuming a certain amount can offset excessive calorie intake, which could result in overeating and jeopardize physical health [13]. Conversely, relying solely on substitute foods may lead to inadequate nutrient intake, harming overall health. Therefore, when utilizing substitute foods to enhance one's physical fitness, it's essential to seek medical guidance and tailor the approach to individual needs.

In conclusion, the effectiveness of dietary fiber meal substitute, combined with low glycemic index medical food management, in the context of type 2 diabetes mellitus, is substantial and warrants further promotion and utilization.

8. Conclusion

In effective appetite control, the sequential occurrences of hunger, satiation, and satiety allow for the adjustment of energy intake in accordance with energy requirements. The prevailing obesity epidemic underscores that when potent and pervasive stimuli outweigh inhibitory mechanisms, appetite control can be overridden, leading to a phenomenon where people consume food even when they are not genuinely hungry. Substantial evidence indicates that enhancing satiety through the selection of appropriate foods—those rich in fiber, high in protein, and/or containing functional ingredients that promote satiety—can assist in sustaining long-term weight loss and stabilizing blood glucose levels. This approach is particularly viable for individuals dealing with obesity and diabetes. In the clinical management of diabetes mellitus, alongside medication, diet, exercise, and self-monitoring of blood glucose all play pivotal roles in determining success or failure. Among these components, dietary control stands as the linchpin, forming the foundation of all diabetes treatments. A body of research outlined in various studies suggests that meal substitute foods have the capacity to reduce blood sugar levels, improve metabolic profiles, and play a medically significant role that should not be underestimated. Therefore, meal substitute foods characterized by low calorie counts, high fiber content, and strong satiety-inducing properties are poised for broader future market prosperity.

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