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Obesity as a Public Health Issue and the Effects of Amino Acid Supplementation as a Prevention Mechanism

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Abstract

This manuscript serves to examine the increasing obesity trend and the harmful medical conditions such as the chronic diseases that can develop as a result of obesity. Probable causes of obesity are discussed, along with suggestions of how to combat the epidemic. Past and present attempts to resolve the issue are compared with further suggestions that could potentially be effective in the future. This manuscript will review several treatment recommendations including the use of amino acid therapy, along with decreased daily caloric intake and increased daily activity. Additionally, there is an emphasis to take preventative measures while simultaneously helping already obese individuals. By implementing new strategies, the increasing obesity trends may be slowed and eventually reversed. If the number of obese individuals decreases, the chronic diseases associated with them will likely decline as well.

Keywords: Obesity; Public health; Amino acids; Body mass index

Obesity and Public Health

Obesity in the United States is an ever-emerging public health issue that affects approximately 35.7% of adults and over one-third of children [1,2]. It is important to examine the factors that have lead obesity to become a major public health problem. If this issue is not addressed, it is likely that the number of overweight and obese individuals will continue rising to even higher numbers, leading to an increasing number of negative health outcomes and high healthcare costs. Despite minimal government and individual efforts, the primary problem lies in our environment, which is not easily changed. The two factors that influence obesity directly are calorie intake and calorie expenditure. In order to lose weight, caloric intake must be decreased while calorie expenditure, such as physical activity, is increased. Unfortunately, this is not occurring for many Americans and the number of overweight and obese individuals in the United States is rapidly increasing (Table 1).

BMI	Category
<18.5 kg/m^2	Underweight
18.5-24.9 kg/m^2	Normal weight
25.0-29.9 kg/m^2	Overweight
30-34.9 kg/m^2	Class I obesity
35-39.9 kg/m^2	Class II obesity
≥40 kg/m^2	Clas III obesity (also referred to as severe, extreme, or morbid obesity)

Table 1: Categorization of body mass by body mass index [2].

Although the American Heart Association, American Cancer Society, and the National Institutes of Health, among many other government organizations, have tried to intervene, as a whole new programs and policies have been ineffective. Starting in 1980, the National Public Health Policy tried to implement a series of 10-year policies by which the government and the organizations listed above would "lead, catalyze, and provide strategic support," for starting these programs [3]. The focus was primarily obesity prevention, through the distribution of educational materials, supporting exercise plans, and encouraging obesity prevention research. These objectives were not successful for several reasons. Funding was limited and government control to change an individual lifestyle is difficult and limited. The ineffectiveness of these programs was seen in the continuous increasing obesity trends, which included little to no change in activity levels and an overall increased daily caloric intake.

Another problem that has helped fuel the obesity epidemic is high individual energy intake. While the Food and Drug Administration (FDA) has cautioned against high caloric intake and tried to emphasize daily nutritional guidelines, caloric intake remains very high. In 1970, the average daily adult caloric intake was 2,234, while in 2003 it was measured at approximately 2,757 calories per day [4,5]. Daily recommendations range from 2,400 to 2,800 calories for males, and 2,000 to 2,400 calories for females. It is also important to note that more than half of the 523-calorie increase from 1970 to 2003 was from fats, oils, and sugars. These increases among Americans can be attributed to unhealthy habits.

Due to increased daily caloric intake and ultimately greater weight gain, obesity can have a ripple effect. In the past, when obesity was less common, the rare sight of an obese individual repulsed people. Historically, obese individuals represented the higher socio-economic class, where as today obesity is more prevalent among lower socio-economic individuals [6]. Obesity used to represent wealth, as one who was able to afford more food would exhibit it by their weight. Today, however, healthier foods are more expensive and as a result people with lower incomes choose cheaper, unhealthier, options. As

the prevalence of obesity has increased, specifically over the last 50 years, obesity is such a common problem that it is seen on a daily basis and spreading not only among adults, but also children. The increased familiarity with obesity remains one hypothesis as to why the number of obese individuals has dramatically increased [7].

Increased calorie accessibility is one reason that caloric intake is increasing among individuals. Advertising, prices, and food availability all promote increased eating, rather than decreasing daily caloric intake. Weight tends to rise when food prices are cheaper at the grocery store and restaurants, and when a wider variety of foods are available. The food industry spends over 30 million dollars annually on advertising, food promotions and discounts [3]. As a result of mass advertising and the easy accessibility to food in fast-food or other restaurants, Americans spend approximately half of their food budget on food that is not prepared at home [3]. This too leads to greater caloric intake, as restaurants and food prepared outside the home typically contains more calories and fat than food that is made at home. In addition, healthy options at restaurants, such as salads tend to be more expensive than less healthy alternatives such as hamburgers and French fries, which lead people to choose the cheaper and sometimes tastier options.

As previously mentioned there are two factors that lead to weight gain; calorie intake and calorie expenditure. From the energy expenditure point of view of the obesity crisis, people are choosing to live more sedentary lifestyles due to many reasons. The increase in technology and white-collar labor as opposed to manual labor has resulted in people spending most of their days sitting at desks, often in front of a computer. Manual labor used to be part of daily work. The advances of the industrial revolution and technology, however, have made exercise a rare part of daily work. Instead of exercise being a part of regular work, it must now come from the limited leisure part of one's day, which is often already very short. This shift in the type of labor performed helps explain why energy expenditure for adults is lower, although it does not explain why energy expenditure is lower for children.

The decrease in energy expenditure among children can be explained by a few different reasons. These include the elimination of physical education classes in public schools due to decreased funding, and "junk-food" advertising that targets children particularly on television. Children also tend to follow the patterns of adult role models. Therefore, when parents' model sedentary lifestyles, children are likely to do so as well. Children's daily caloric intake has also increased due to the fact that children typically eat the same food that their parents eat.

While many suggestions have been made as to how to overcome the obesity epidemic, many have failed, primarily due to lack of funds. If more funds were allocated to promote obesity prevention, the health care costs of caring for obese individuals would ultimately decrease. The cost for caring for obese individuals is nearly 40% higher than the cost of caring for non-obese individuals [8]. Their costs are so much higher because of the fact that obesity increases their chance of many chronic diseases, and they typically require more doctor's visits, medications, and overall medical treatments than non-obese individuals. Despite increased short-term costs, in the long run preventing obesity would help decrease overall future medical costs. Currently the government is spending over $190 billion in annual medical costs as a result of obesity [9]. It is also more effective to implement preventative measures as opposed to correcting poor existing habits and their negative sequelae. Ultimately, an effective preventative strategy must be implemented in order to combat the obesity public health problem in the United States.

Obesity and Chronic Disease

Obesity is characterized by an excess of body fat and or adipose tissue, and can be defined by a BMI greater than 30 kg/m^2 [2]. As a result, excess fat and weight can have detrimental secondary effects on health such as increased risk for many life threatening diseases including diabetes mellitus type 2, cardiovascular disease, hypertension, stroke, arthritis, and many cancers. Research has shown that obesity increases the risk of death from cardiovascular disease by nearly nine fold and death from many cancers by three fold [3]. Since weight is one of the few health conditions over which one has control, it is important to make an attempt to focus on weight and attempt to control and/or prevent many diseases affected by obesity.

Recently, the distribution of excess body fat has been examined. Specific locations, such as waist circumference and waist-to-hip ratio have been shown as precursors for certain chronic diseases [3]. In fact, these excess fat locations may perhaps be a better indication of long-term health effects than BMI alone. The NIH considers a waist circumference of greater than 102 cm. for men, and 88 cm. for women as "high [3]." As a result of high waist circumference, such individuals have increased health risk for hypertension, diabetes mellitus type 2, and dislipidemia, when compared to people with the same BMI and "normal" waist circumferences. Similarly, the waist-to-hip ratio may too be a more significant indicator of Coronary Artery Disease (CAD), than BMI by itself.

Although body fat location is an interesting factor in prediction of certain chronic diseases, BMI is still well correlated with chronic diseases. When considering the correlation between obesity and cancer, malignancies are more common in obese individuals [3]. Overweight and obese patients potentially account for nearly 14% and 20% of all cancer-related deaths in men and women, respectively [3]. In addition to higher mortality risk from cancer, similar findings have been observed in obese patients with relation to diabetes mellitus type 2, dislipidemia, coronary artery disease, and many other health hazards as seen below (Table 2).

Morbidity	**Representative data on increased risk attributable to obesity as compared with individuals of normal weight**
Coronary Artery Disease	Adjusted relative risk of 36 for BMI ≥ 29 kg/m^2
Type II Diabetes mellitus and insulin resistance	Type II DM: adjusted relative risk of 61 for BMI ≥ 35 kg/m^2
Hypertension	Estimated to account for up to 26 percent of cases
Dysilipidemia	Reduction in serum high-density-lipoprotein cholestrol of about 5 percent

Venous thrombosis	Adjusted relative risk of 27 for a first episode of VTE for a BMI ≥ 40 kg/m^2
Cholelithiasis	Women 34-59 year old: annual incidence of greater than 1% for BMI ≥ 30kg/m^2
Gout	Adjuste relative risk of 30 for BMI 30-34.9 kg/m^2
Stroke	Adjusted relative risk of 22 for BMI ≥ 32 kg/m^2
Osteoarthritis	Adjusted odds ratio of 6-18 of radiographic OA at the knee for BMI ≥ 26 kg/m^2
Obstructive Sleep Apnea	Two to four fold increased
Nephrolithiasis	Doubling of the risk for BMI ≥ 30 kg/m^2
Heart Failure	Doubling of the risk for BMI ≥ 30 kg/m^2
Depression	Higher risk for younger women with poor body image

Table 2: Morbidities associated with obesity [2].

It is well documented that an obese individual's lifespan is typically shorter than that of a non-obese individual. Such evidence was found in patients who underwent bariatric surgery. In a study that followed 7,925 individuals post-bariatric surgery, with an approximate seven-year follow-up, the average mortality was 40% lower for the surgical group than the control group [10]. In addition, deaths resulting from chronic diseases were observed at a greater rate in the control group [11]. Post-surgery patients were more likely to die from causes other than chronic diseases, such as accidents.

Amino Acids and the Management of Obesity

While nearly 45 million Americans will attempt to follow some sort of diet each year, most will not experience long-term benefits and weight loss [12]. Many factors impact obesity including genetics, socioeconomic status, and behavioral and environmental issues. There are still, however, ways to help prevent obesity and the resulting chronic diseases. It is important to start preventative measures at a young age in order that children not develop into obese adults. The most effective ways to prevent obesity are decreased daily caloric intake, increased exercise, and appetite suppression medications; however, the most effective method may come from a combination of the three.

Decreasing daily caloric intake can be done many different ways. Portion control is a very effective way to decrease caloric intake. By reducing the portion size, you automatically reduce the number of calories you consume. Smaller portions and frequent snacking can also help to avoid over eating. Also, by choosing lower caloric foods and beverages than higher ones, overall caloric intake is also decreased. Drinking water is another great way to help promote satiety since it does not contain any calories.

Appetite suppressants have recently been found helpful to jumpstart weight loss and some have been shown to be a safe method of weight loss by health professionals [13]. Such suppressants work through the glands of the hypothalamus, which leads to a suppressed appetite, thereby leading to lower food consumption and ultimately weight loss [14]. "Appetite" as defined by the Miller-Keane Encyclopedia and Dictionary of Medicine, is "the psychological desire for food." Since appetite is a psychological factor, suppressant medications such as Phenylpropanolamine, Phentermine and Diethylpropion have been the most effective [14,15]. Obesity is often linked to over eating due to feelings of stress, anxiety, and sadness. By controlling these psychological feelings, appetite can be controlled. Suppressant medications are most effective when combined with a diet and exercise program under the supervision of a physician. Appetite suppressants can have mild side effects such as thirst, fatigue, and irritability. Rarely, people experience more severe side effects including cardiac arrhythmias, cerebral arthritis, and cerebral hemorrhage, which can ultimately lead to death.

Severe side effects such as those listed above are often a major deterrent to taking a medication. Recently a new phenomenon of "prescription medical foods" has emerged. According to the FDA, a medical food is defined as "a food which is formulated to be consumed or administered enterally under the supervision of a physician and which is intended for the specific dietary management of a disease or condition for which distinctive nutritional requirements, based on recognized scientific principles, are established by medical evaluation." People with chronic diseases have different nutritional needs than those without them. If these needs, such as neurotransmitter deficiencies, are not addressed, then oftentimes the overall health issue cannot be resolved.

Neurotransmitters control appetite, satiety, and carbohydrate cravings. It has been observed that obese patients have an increased need for these transmitters and neurotransmitter levels are often found to be depleted in these patients [16]. Thus, by increasing the amount and efficient turnover of neurotransmitter precursors, it is possible to increase the concentration and function of neurotransmitters, which as a result might help control obesity.

There are several amino acid precursors that produce the neurotransmitters that control appetite and satiety. Histidine functions as the amino acid precursor to the excitatory neurotransmitter and anorexigenic agent, histamine [8]. Histamine is an important regulator of food intake and body weight. This neurotransmitter functions in the posterior hypothalamus by stimulating effects on the central nervous system. During the appetite phase, histamine works by suppressing appetite by stimulating Corticotropin-Releasing Hormone (CRH) and Corticotropin-Releasing Factor (CRF), both of which limit the production of Neuropeptide Y (NPY). By inhibiting NPY, an energy regulator, increased food take is reduced and physical activity levels are increased. Thus by increasing the amount of histamine produced, there is an overall decrease in food intake.

Glutamate is an excitatory neurotransmitter that has been shown to have effects on appetite. Increased intake of glutamate leads to stimulation of brain nuclei that help to control appetite [17]. On the other hand, low levels of glutamate have been connected with imbalances of serotonin levels, another neurotransmitter that affects appetite.

Tryptophan functions as the neurotransmitter precursor for serotonin, an excitatory neurotransmitter that helps suppress appetite. Many obese patients have lower levels of serotonin than non-obese patients [18]. As a result, obese patients experience carbohydrate cravings and increased appetite. Another factor that influences serotonin levels is protein. For patients on a low calorie diet, if protein intake is also significantly decreased, a serotonin deficiency can arise. A serotonin deficiency as a result of low protein levels can occur because low protein levels limit the amount of tryptophan available for serotonin synthesis.

Tyrosine is the neurotransmitter precursor for the neurotransmitters norepinephrine and epinephrine, both of which function as appetite suppressants [18]. With a greater amount of tyrosine available the production of dopamine and norepinephrine are quicker. In addition, norepinephrine helps increase serotonin levels by increasing the tryptophan uptake by the brain, which as previously stated helps to suppress appetite. Lower norepinephrine levels have been reported in obese individuals.

Choline serves as the precursor to the both inhibitory and excitatory neurotransmitter, Acetylcholine, the main neurotransmitter of the autonomic nervous system. Acetylcholine regulates insulin and glucose levels in the blood. Additionally, Acetylcholine is involved in food intake by controlling activity in the sympathetic nervous system [19]. One way it does this is by binding to receptors on postganglionic neurons, which triggers the release of norepinephrine. This in turn activates the sympathetic nervous system, which might be one way to explain the increase in leptin, the hormone which regulates energy intake and expenditure.

Lastly, L-serine activates the neurotransmitter D-serine, which is the precursor for the production of a few amino acids, including tryptophan. Ultimately, the production of serine is vitally important to the production of serotonin and appetite suppression [20].

Medical foods and the treatment of obesity focus on treating the dietary deficiencies that is present in a disease state by correcting neurotransmitter deficiencies and restoring the homeostatic mechanisms that work to control appetite. By controlling appetite, satiety is increased, leading to decreased caloric intake. This may be achieved by providing the neurotransmitter precursors which have been noted to be involved in the neural pathway that controls appetite, specifically tyrosine, tryptophan, choline, glutamate and histidine.

Recent research has noted nutritional deficiencies in obese patients requiring more amino acids and minerals than are obtained in a normal daily diet [21]. The systemic supplementation of certain amino acids may facilitate the regulation of the obese patient's appetite. Flavonoids may also have therapeutic benefits, as they are found in all vascular plants, and are responsible for some of the health benefits associated with naturally brightly colored foods.

As previously discussed, neurotransmitters are intimately involved in the feedback mechanisms that regulate appetite and satiety and subsequently body weight. These neurotransmitters are made of amino acids precursors. Some of the amino acids are non-essential and some are essential, meaning the essential amino acids must be derived from our diet. When there is a depletion of these key amino acids the result is often times insatiable cravings. The most common cravings are for sugars, sweets and carbohydrates. One recent study demonstrated that supplementation with glutamine reduced sugar cravings and resulted in a loss of body fat [22] therefore, firmly establishing glutamate as a primary neurotransmitter that mediates body weight regulation.

If there is an imbalance of these neurotransmitters there will be a disruption in weight, appetite and satiety. Imbalances in neurotransmitters may occur for several reasons such as genetics, metabolic disorders, nutritional deficiency, digestive imbalances or medication use. It has also been noted that obese individuals had fewer neurotransmitter for certain receptors than normal weight subjects [23]. The lack of receptors may also play a role in the disruption of signaling that is present in obese individuals.

It is often an imbalance of serotonin and catecholamine, which include dopamine, norepinephine and epinephrine that can cause inappropriate hunger, cravings and binging behavior. Interestingly, these amino acids levels are low in obese individuals despite excessive calorie intake and could not be corrected with administration of a protein rich supplementation. This nutrient deficiency points to a possible metabolic problem that is also present in obese populations [24].

When normal serotonin levels are present, satiety normally occurs. A serotonin deficiency has been associated with carbohydrate binging that result in weight gain. As serotonin is derived from tryptophan, low blood levels of tryptophan have been found in obese individuals, which indicate that their overeating patterns may be related to a serotonin deficiency [25].

These findings illustrate that the cause and treatment of obesity is a complex matter. Further understanding of the amino acid deficiencies and the metabolic pathways are keys to understanding the treatment of the distinct nutritional needs that are present in obese subjects.

Implications for the Future

Since obesity already affects a major part of the United States' population and is considered a major public health issue, it is critical for the government to get involved. Past policies and programs sponsored by the US Department of Agriculture, US Department of Health and Human Services, and other government organizations were not successful for various reasons [26]. To date, educational programs, exercise programs, and fad diets, have had little to no effect due to lack of funds and difficulty getting the public involved. Future suggestions to control the obesity epidemic range from increased education and promotion of physical activity, to "junk food" taxation and fast food regulations.

Again, it is important to consider the benefits and drawbacks to each proposed suggestion in order to spend time and money on the plan that will be the most likely to be effective. Education will likely be one of the most critical ways to help prevent obesity. By educating people with food labels, calorie counts on restaurant and fast-food menus and media advertising warning about the negative effects of obesity, people will hopefully increase their personal awareness of obesity and consider the harmful effects before pursuing unhealthy behavior. Some have proposed an increase in general education instead of specifically nutritional education, since uneducated

individuals are less aware of health risks, and do not have as great an incentive to invest in their health as educated individuals. Nevertheless, nutritional and general education has limited effects, and is difficult to implement.

Taxation on foods that lead to obesity is often suggested but never fully executed. While a tax on certain types of foods, certain ingredients, or objects that may lead to obesity, such as televisions and junk food, might have an effect on obesity, it would be a very costly effort and a difficult one to enforce. Likewise, although it would be ideal to restrict access to fast food restaurants and advertising, it is not realistic, and efforts should be made in areas that are more likely to have a positive outcome.

The ultimate goal is to reduce and prevent obesity on a personal and global scale. The controversial question of how to do this remains unsolved, but nonetheless, we will not know which measures will be effective until they are tried. That being said, a combination of the most cost-effective and previously successful programs, policies, and medications should be implemented and supported. Educational programs, specifically those targeted at children, including physical education classes and anti-obesity advertisements should continue [20]. Exercise programs for overweight and obese individuals should be encouraged, along with a decreased daily caloric intake. As previously stated, these two measures will likely have the most potential when accompanied by an appetite suppressant medication under physician supervision. While many appetite suppressants are available today, amino acid therapy may be the most successful, as the side effects are virtually non-existent. By combining these three preventative measures, we may be able to start controlling the obesity epidemic.

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