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Nonnutritive Sweetener and Weight Management: A Potential Paradox in Modern Dieting

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NONNUTRITIVE SWEETENER AND WEIGHT MANAGEMENT: A POTENTIAL PARADOX IN MODERN DIETING

by

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Dedication

This thesis is dedicated to my family and friends for always being there for me and being so supportive and understanding while I go through this program. Thanks, specifically, to Mary, Robert, Kimberly, Harmony, Miranda, Avy, Monroe, John, Teresa, and Wendy for their unconditional love. Thanks also to Oz for the laughter, and Merietta, LorAda, Alan, and Cathy for always reminding me of who I am.

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Abstract

Obesity is a serious health concern in modern society. One way to reduce caloric intake is with nonnutritive sweeteners (NNS). However, recent research suggests they may be compounding the obesity problem. Nonnutritive sweeteners have been linked to increased body mass in a few studies and may be a barrier to effective weight management for some individuals.

Under the framework of the health belief model, the research question was: Does this pattern of NNS-BMI covariance exist in young adults at the University of North Florida and, if so, are there other dietary or activity differences that might partially explain this relationship? A sample of 113 students completed an online survey based on the Youth Risk Behavior Surveillance Survey to answer this question. Their responses quantified BMI, activity level estimates, NNS intake, and produce consumption. There was a no trend of covariance between BMI and NNS intake overall. However, there was a significant relationship between length of NNS usage and both BMI ($p<0.01$) and NNS intake ($p<0.05$). A positive correlation also existed between NNS usage and fruit and vegetable intake ($p<.005$). Weight variability was positively related to NNS due to the maintenance of previous weight loss ($p<0.005$). There was no correlation between NNS and activity. There is a tendency to have a higher BMI the longer NNS is consumed. This pattern does not appear to be explained by nutrient intake or activity. However, it may be due to increased tolerance towards sweets over time. Nurse practitioners can make recommendations that facilitate healthy behaviors amongst their patients. Therefore, this is an important issue for advanced practice nursing.

Chapter One: Introduction

The Centers for Disease Control and Prevention (CDC) has identified obesity as a priority public health issue (CDC, 2005). With obesity rates of 35% in the United States (CDC, 2012), the obesity problem is truly reaching epidemic proportions. Many negative physiological and psychosocial consequences arise from excess body fat making it essential that healthcare practitioners are equipped with the tools and information necessary to assist individuals in their weight loss efforts. Nurses and nurse practitioners play an important role in many efforts to counteract this problem. Most importantly, they can work with patients to identify potential barriers to weight loss, propose alternatives, and guide patients around common obstacles to their success.

Obesity is linked to many chronic diseases including hypertension, diabetes, and hyperlipidemia (Crawford et al., 2010). Increased body mass, circulating blood glucose, and lipids interact to create undue stress on the heart as it attempts to compensate for the added workload. Therefore, obesity is one of the most modifiable risk factors affecting quality of life and longevity.

In addition to the physiologic costs, obesity is related to psychosocial and economic issues. Financially, obesity can lead to an increased expenditure in terms of healthcare dollars and use of weight loss products, and may even reduce employment options (Tsai, Williamson, & Glick, 2011). Financial implications can be present at both the individual and societal level (Department of Health Policy, 2010). These potential economic strains can be significant sources of stress for the obese individual and this stress can further complicate their condition. Socially, an obese person may feel alienated by the thin-obsessed media and discriminated against in their social encounters. This alienation and its impact on their social support network is also a potential stressor. Emotionally, obesity may cause an individual to feel inferior or unsuccessful and may lead to depression and social anxiety. From a holistic perspective, obesity is clearly a multifaceted disease. Education regarding obesity prevention and management is a priority during patient care encounters culminating in a mutually acceptable plan of care.

Contemporary methods of weight loss and weight loss maintenance in those who are overweight or obese may include pharmacologic management of hunger or nutrient absorption, various dietary strategies, exercise, and surgical interventions. The goal of any intervention is to safely create an imbalance between energy expenditure and intake forcing the body to breakdown its own fat cells as fuel. Bish et al. (2005) polled 184,450 Americans and found that 46% of women and 33% of men were trying to lose weight. Many people do not succeed with their weight loss efforts (Finley et al., 2007; Bacon & Aphramor, 2011). Furthermore, those who are successful often regain a substantial portion of the weight lost within one year (Curioni & Lourenco, 2005; Wing & Phelan, 2005; Turk et al., 2009).

When dietary efforts fail, many people blame themselves for their lack of willpower. However, this abstract construct is poorly defined, difficult to manipulate, and represents a relatively fatalistic resignation to being overweight. Identifying potential barriers to successful dieting and recommending alternatives is a potentially constructive role that primary health care practitioners can play in combating this process. A survey of young adult women found that a number of perceived barriers interfere with their weight loss efforts including time, motivation, cost, and lack of social support (Andajani-Sutjahjo, Ball, Warren, Inglis, & Crawford, 2004). Other studies have found that sleep deprivation (Landis, Parker, & Dunbar, 2009), lack of knowledge and feelings of control (Welsh et al., 2011), and hunger (Adberg, Edman, & Rossner, 2008) are also implicated.

In an effort to reduce caloric intake, many people turn to nonnutritive sweeteners (NNS), the primary source of which is often diet soft drinks. Approximately 17.5% of American adults consume diet soda (Duffey & Popkin, 2006). Researchers hypothesize that artificially sweetened food and beverage intake may be counterproductive. Two studies found a relationship between consumption of these products and weight gain (Bouchard, Ross, & Janssen, 2010; Colditz et al., 1990). While causation has not been determined, these findings suggest that the common dietary strategy of substituting sugar with nonnutritive alternatives may undermine dietary efforts in some individuals, thus creating a cycle whereby those efforts may perpetuate the problem.

The reasons for the relationship between NNS intake and body mass index (BMI) are unclear. At first glance, it appears that the association is due to overweight individuals attempting to lose weight. One prospective longitudinal study revealed that NNS consumption can precede weight gain (Fowler et al., 2008). The next presumption might be that a propensity to gain weight, whatever the cause, leads individuals to use NNS in an attempt to offset such predispositions. Randomized controlled trials to assess these theories may not be feasible with human subjects. Research findings using rodents suggests that those who are randomly assigned to NNS conditions gain more weight than their peers (Martinez et al., 2010). This finding prompted a few researchers to speculate about possible mechanisms of this phenomenon. Theories ranging from effects on nutrient absorption to alterations in brain response secondary to a Pavlovian decoupling of sweet tastes to recognition of caloric intake have emerged. To confound matters, many studies have found that NNS is a useful tool for short term dieting related to calorie restriction (Hendriksen, Mariken, Fransen, Verhagen, & Hoekstra, 2011). Upon consideration of these findings, it is useful to take a practical approach and ask a simple question: Do long-term, frequent users of NNS differ from infrequent users of these products in other ways that might partially explain the BMI-NNS covariance?

Purpose Statement

The current research aims to determine whether consumption of NNS and length of NNS use are related to BMI amongst young adults at the University of North Florida. Moreover, the study examines whether frequent and infrequent users of NNS differ in terms of BMI, activity, and intake of fruits of vegetables. If activity and nutrient intake are different between these groups it might partially explain why BMI is often higher with increased NNS use.

Hypothesis

Based on previous findings, it is expected that frequent NNS users will be higher in BMI than infrequent users. Furthermore, we expect that this difference is mirrored by differences in activity level and nutrient intake between these groups. The null hypothesis states that differences in NNS intake or length of use will be unrelated to BMI, activity, or nutrient intake.

The Health Belief Model

The health belief model was chosen as a conceptual framework for the current research. This model focuses on the various factors that influence the likelihood that an individual will engage in preventative health behaviors (see Figure 1.1). The purpose of the model is to clarify the cognitive processes that result in behavior so that targeted interventions can be developed to encourage desired behavior adoption. The model focuses on perceptions that are mediated by personal characteristics and experiences to result in a likelihood of engaging in the behavior of interest (Rosenstock, 1966).

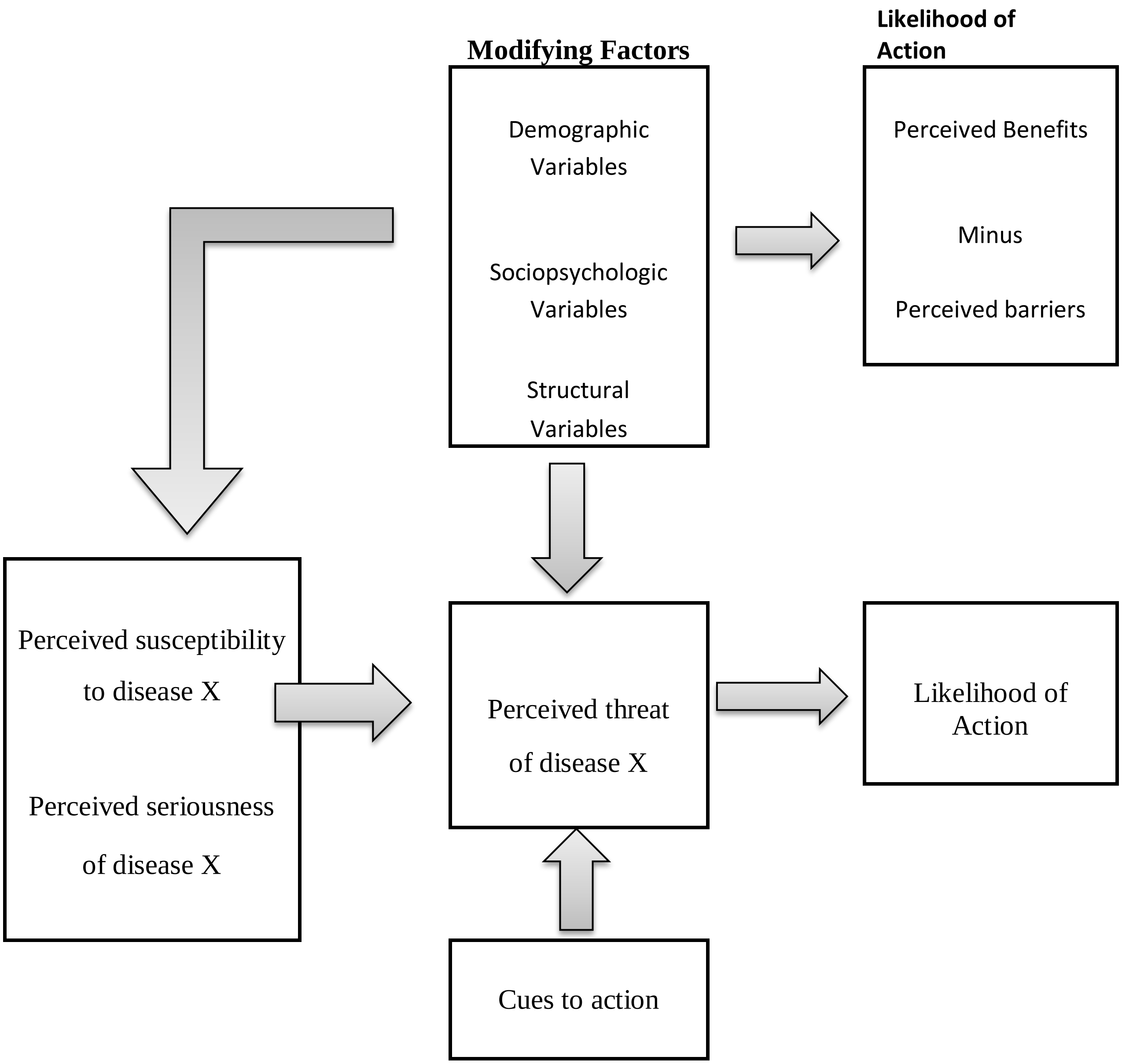

Figure 1.1. A pictorial representation of the health belief model. Information obtained from *Theoretical Basis for Nursing* (pp.274-299), by M. McEwen and E.M. Willis, 2011, Philadelphia, PA: Lipincott Williams and Wilkins. Copyright (2011) by Lipincott Williams and Wilkins.

Perceptions

According to the health belief model, a variety of perceptions inform an individual's decision to adopt a healthy behavior (Rosenstock, 1966). The central perception is that of perceived threat. Perceived threat is actually a combination of an individual's perceptions concerning their own susceptibility to the disease and beliefs about the severity of the disease. Severity of the disease includes a perception of not only the physical toll of the disease but also the psychosocial and economic consequences of disease development. However, perceived threat does not always lead to adoption of the preventative behavior. This is because other perceptions are involved. When deciding whether to engage in the behavior, the individual weighs their perception of the benefits of engaging in the behavior against the barriers or obstacles to that behavior. The individual essentially calculates a perception of the net benefits of that behavior by subtracting perceived barriers from benefits (Rosenstock, 1966).

Modifying Factors

Modifying factors are those factors that mediate the effects of the individual's perceptions. They include both individual factors and cues to action. Individual factors include demographics such as age and sex, sociopsychologic constructs such as personality, peer pressure, and social class, and structural variables such as past experience and academic knowledge. Cues to action are the key experiences that inspire a behavior change. They can be as simple as the receipt of an educational pamphlet or as dramatic as the death of a loved one (Rosenstock, 1966).

Likelihood of Action

All of these perceptions, through the mediation of the modifying factors, culminate in a likelihood of engaging in the desired behavior. This is termed the likelihood of action (Rosenstock, 1966).

The Health Belief Model as a Conceptual Framework

In this study, the ultimate goal is to identify any factors that might explain the inconsistently demonstrated efficacy of NNS in weight management in undergraduate university students. It is possible that NNS use provides a false sense of security leading to a reduction in other weight management tactics. In this manner, NNS may be unintentionally reducing the perceived threat of weight gain leading to inactivity and poor dietary choices. Since individuals with a propensity for weight gain are likely consumers of these products, it is important to establish whether this is actually the case. Although the reason for this phenomenon is undoubtedly multifactorial, identifying one of the variables at work enables NPs to preempt that tendency with anticipatory guidance in proper NNS usage.

Definition of Terms

In order to ensure a common language, certain terms are in need of definition. The following is a brief examination of the meanings of commonly used terms within this manuscript.

Body Mass Index (BMI)

The BMI is a construct that is often used to estimate body fat percentage. Mathematically, it is defined as the person's weight in kilograms (kg) divided by the height in meters squared or $BMI = \frac{kg}{(m)2}$. This enables clinicians to relate weight and height in order to approximate degree of body fat. Under this measurement, a BMI of 25 or higher is classified as overweight and a BMI of 30 or higher is termed obese. Since factors such as muscle mass can also impact weight, this is merely a screening tool which, under average circumstances, serves as a useful indicator of body fat percentage (World Health Organization, 1997).

Adult Weight Variability

Participants were asked about their highest and lowest adult weight in order to determine how consistent their weight was over time. From this information, their adult weight range was calculated.

Youth Risk Behavior Surveillance Survey

The Youth Risk Behavior Surveillance Survey (YRBSS) is a national survey developed by the CDC and administered via the educational system that assays risk behaviors in adolescent high school students (CDC, 2013). Questions concerning substance abuse, risk taking, sexuality, diet, and exercise are included. The majority of the items on the survey have been demonstrated to be reliable via test-retest methodology in adolescents grades nine thru twelve ($\kappa>60\%$). The CDC reports that establishing validity is problematic with this data as responses to many questions are effected by situational factors that may interfere with the honesty of responses. However, it has been determined that self-reports of height tend to be embellished in this age group (CDC, 2013). This survey provided many of the questions for the NNS questionnaire. Furthermore, many additional questions were adaptations of those from the YRBSS.

Nonnutritive Sweetener

Nonnutritive sweeteners (NNS), also termed artificial sweeteners or sugar substitutes, include any drink or product that contains aspartame (Equal; Nutrasweet), sucralose (Splenda), stevia, neotame, acesulfame potassium (Sweet One) or saccharin (Sweet’N Low).

Sweetener Intake

Intake of NNS is defined as the number of servings of ingested NNS per week. This will be acquired from self-reported survey results. The survey, based upon the Youth Risk Behavior Surveillance System (YRBSS) survey (CDC, 2013), provides a selection of ranges indicating number of servings in a seven-day period. These categories represent weekly intake amounts of zero, one to three, four to six, seven, fourteen, twenty one, and twenty eight or more. Participants were asked about NNS beverages, gums, foods, and sweetener packets separately. For example, the question for beverages stated “During the past 7 days, how many times did you drink a can, bottle, or glass of a diet beverage such as diet soda, low-calorie juice, crystal light, or diet sweet tea?.” Answer choices are “I did not drink diet beverages during the last 7 days”, “1 to 3 times during the past 7 days”, “4 to 6 times during the past 7 days”, “1 time per day”, “2 times per day”, “3 times per day”, and “4 or more times per day.” In order to make the data more usable, we counted each response as the lowest possible number from that category. Therefore, one to three servings was recorded as at least one serving.

Fruit and Vegetable Intake

The United States Department of Agriculture (USDA) recommends two and a half cups of fruits and vegetables daily (USDA, 2010). However, many Americans do not meet these requirements. In order to determine whether these participants have adequate intake, questions from the YRBSS were again utilized. Students were asked about the number of servings of fruit, green salad, potatoes, carrots, and “other vegetables” consumed in the last seven days. The response categories and style of analysis were equivalent to the questions regarding NNS use.

Length of Use

Students stated their current age and the age at which they began consuming NNS products. Via subtraction, this produced a number quantifying their length of use of these products.

Frequent Users of NNS

We arbitrarily defined frequent users as those who report at least daily usage of NNS products. Thus, students who reported seven or more servings in a week were classified in this group.

Infrequent Users of NNS

By default, infrequent users were defined as participants who consumed less than seven servings of NNS in a week.

Activity Level

Several questions were selected from the YRBSS to estimate activity level. Participants were asked how many days per week they exercised at a gym for at least 30 minutes or exercised anywhere for more than 60 minutes. Available responses included zero through seven days. They were also asked how many hours per day they watched television and how many hours per day they used a computer for purposes unrelated to work or school. Answer choices for these questions were “less than 1 hour per day”, “1 hour per day”, “2 hours per day”, “3 hours per day”, “4 hours per day”, and “5 or more hours per day.”

Weight Perception

A question regarding weight perception was selected from the YRBSS. Students were asked how they describe their weight. Answer choices were “very underweight”, “slightly underweight”, “about the right weight”, “slightly overweight”, and “very overweight”. This was done to determine whether perceptions about weight are related to NNS usage.

Perceived NNS Efficacy

Participants were asked a yes/no question about whether they believed that NNS helped them manage their weight. This was to determine whether they were correctly or incorrectly perceiving its effects.

Dietary Goals

Taken from the Youth Risk Behavior Survey, students were asked what they were trying to do about their weight. The answer choices were “lose weight”, “gain weight”, “stay the same weight”, and “I am not trying to do anything about my weight.” This question was posed in order to determine if those who use NNS are more likely to be trying to lose or maintain their weight.

Summary

The positive correlation between NNS intake and BMI in some individuals is a topic for debate in modern society. Many factors may be involved in creating this finding. Within the framework of the health belief model, NNS use might reduce the perceived risk of weight gain leading to increased participation in less healthy eating and activity patterns. In order to analyze the relationship between BMI and NNS intake, an online survey was developed to obtain answers about BMI, NNS intake, length of NNS use, produce intake, and activity level in a sample of students at a university.

Chapter Two: Review of Literature

In this chapter, the incidence, prevalence, impact, biology, etiology, and treatment of obesity are discussed. This is followed by a brief overview of the use of nonnutritive sweeteners (NNS) and the health risks and benefits that have been ascribed to them. Finally, a review of the available literature concerning the relationship between BMI and NNS use is provided.

Epidemiology of Obesity

Obesity is becoming an alarmingly common phenomenon in our society. Evidence from the National Health and Examination Survey reveals that the average BMI is increasing and that approximately one third of the current population in the United States is overweight (Kramer et al., 2010). As of 2006, the average BMI is well into the overweight category at 28.1 kg/m^2 (Kramer et al., 2010). Americans self-report their obesity at 26.7% (CDC, 2009). These numbers were even higher in certain ethnic groups. More specifically, 36.8% of blacks and 30.7% of Hispanics are obese. Obesity also increases with age and is negatively associated with education (CDC, 2009).

Healthy People Initiative

The United States Department of Health and Human Services (USDHHS) developed the healthy people initiatives to set clear, attainable goals aimed at health promotion (Koh, Piotrowski, Kumanyika, & Fielding, 2011). Each decade for the past 30 years, they have established health goals for that decade. Healthy People 2010 made obesity reduction in adults and children a priority and established goals targeting this indicator (USDHHS, 2012). These goals included increasing accessibility to nutritious food and education. Unfortunately, in spite of efforts to achieve these goals, obesity rates are continuing to rise. Healthy People 2020 reinforces the need to reduce obesity by establishing a goal of a 10% reduction in obesity by 2020 for both children and adults (USDHHS, 2012). Armed with a new social determinants approach, this initiative aims to take a multifaceted approach to goal achievement (Koh et al., 2011).

Impact of Obesity

Morbidity

Obesity is associated with a variety of chronic diseases. Bays, Chapman, and Grandy (2007) found that 50.9-59.2 % of patients with diabetes, 45.7-54.6% of patients with hypertension, and 37.9-51.9% of patients with hyperlipidemia are obese. These findings were replicated by analysis of the GE centricity electronic medical records database (Crawford et al., 2010). End stage renal disease (Hsu, McCulloch, Iribarren, Darbinian, & Go, 2006), fatty liver disease (Ong & Younossi, 2004) and sleep apnea (Shaw et al., 2008) are also commonly associated with elevated BMI. Due to these consistently dramatic associations, obesity is considered to be an important modifiable risk factor for these diseases. Furthermore, the American Medical Association (AMA) has recently classified obesity itself as a disease (Farouk, 2013).

Mortality

Due to the role it plays in so many life-threatening illnesses, obesity is associated with a relatively high mortality rate. One meta-analysis of prospective studies found that for every 5 mg/kg^2 over a BMI of 25, there is an approximately 30% increase in overall mortality

(Prospective Studies Collaboration, 2009). The biggest contributors to obesity-related mortality were diabetes, and renal, hepatic, and vascular disease.

Economic

In addition to the serious health ramifications, obesity can negatively impact many other areas of an individual’s life. In the financial sector, obesity impacts both public and private economics. A systematic review of the literature estimated that between five and ten percent of healthcare dollars in the United States are spent directly on obesity (Tsai et al., 2011). An obese individual was found to spend an average of $1,723 in additional funds per year on health care when compared with normal weight counterparts. Clearly, excess fat and its associated complications and treatments are expensive. Counter-intuitively, this review found that bariatric surgery might be the most cost-effective treatment for obesity (Tsai et al., 2011). However, many people are intimidated by the costs and risks of surgical interventions and continue to seek alternatives. In the public realm, these costs are translated into increased insurance premiums and affect the financial wellbeing of businesses via lost productive time (Ricci & Chee, 2005). To complicate matters further, obesity discrimination has been found in occupational hiring decisions (Agerstrom & Rooth, 2011).

Psychosocial

However, obesity is much more than an economic and physical burden. In a ten-year longitudinal study, 33% of severely obese individuals reported perceptions of discrimination such as being treated as inferior, threatened or harassed, or given poor service because of their weight (Schafer & Ferraro, 2011). Such negative perceptions are associated with negative health outcomes (Muennig, Haomiao, Rufina, & Lubetkin, 2008), and can lead to overeating or other detrimental behaviors (Puhl & Brownell, 2006). Obesity has also been found to affect the quality of an individual's social support network (Carr & Friedman, 2006) and psychological well-being (Carr & Friedman, 2005).

Biology and Etiology of Obesity

In simplistic terms, every pound of excess fat that an individual possesses corresponds to 3500 kilocalories that the body absorbed, processed, and yet did not utilize for basic metabolic functions. From this perspective, weight loss is a simple endeavor that merely requires a restriction of caloric intake through diet or an increase in caloric expenditure via exercise. However, the clinical picture is much more complex. Many different biological factors can impact this calories-in/calories-out paradigm. Hormones, genetics, environmental factors, stress, sleep cycles, and many medications can modify the effects of diet and activity level on weight.

Environment

When people discuss the obesity problem from a community health perspective, they often assess the toxicity of the surrounding environment. The modern environment is constructed in such a way as to discourage physical activity and encourage the consumption of convenient, high calorie, processed foods (Kanasaki & Koya, 2011). Zoning ordinances result in lengthy commutes between homes and work, discouraging walking or bicycling in favor of automotive alternatives. Long work hours lead to less time for healthy food preparation and a reliance on processed, pre-packaged foods. Lack of sleep is another common result of these increased work hours and commute times. Technology reduces the amount of exertion required for basic activities both at work and at home. These circumstances distance us from those of our ancestors who often had to exert substantial energy in pursuit of sustenance (Kanasaki & Koya, 2011).

Genetics

Perhaps due to the increased efforts of our predecessors, certain genes have been identified that impact food intake, hunger, and nutrient utilization. The evolutionary perspective touts that individuals who lived in environments where food was scarce were more likely to survive long enough to pass on their genes if they possessed certain genes that maintained their weight (Kanasaki & Koya, 2011). These genes were then selected to be passed on to their progeny. Many genes have been identified that impact hormonal regulation of body weight (Herrera & Lindgren, 2010; see Table 2.1). While these genes do not doom a person to obesity,

Table 2.1. Obesity Genetics

Gene	Chromosomal Position	Phenotype Association
NEGR1	1p31	BMI, weight
SEC16B, RASAL2	1q25	BMI, weight
LYPLAL1, ZC3H11B	1q41	Waist-to-Hip ratio
SDCCAG8	1q43-q44	BMI
TMEM18	2p25	BMI
Near ETVS	3q27	BMI, weight
Near GNPDA2	4p13	BMI
TFAP28	6p12	BMI, waist circumference
NCR3, AIF1, and BAT2	6p21	Weight
PRL	6p22.2-p21.3	BMI
MSRA	8p23.1	BMI, waist circumference
PTER	10p12	BMI
MTCH2	11p11.2	BMI
BDNF region	11p14	BMI
C12orf51/PTPN11	12q24	Waist-to-Hip ratio
FAIM2, BCDIN3D	12q13	BMI, weight
NRXN3	14q31	BMI, waist circumference
SH2B1 region	16p11.2	BMI
MAF	16q22-q23	BMI
FTO	16q22.2	BMI
NPC1	18q11.2	BMI
MC4R	18q22	BMI
KCTD15	19q13.11	BMI, weight

Note. The data in this table are from “The genetics of obesity” by B.M. Herrera and C.M. Lindgren, 2010, *Current Diabetes Reports*, *10*, pp. 498-505. Copyright 2010 by the authors.

they increase the impact of a toxic, obese-promoting environment on an individual’s propensity for weight gain (Bellar, Jarosz, & Bellar, 2008). Most likely, it is a multi-gene mechanism that actually contributes to this process (Kanasaki & Koya, 2011).

Hormones

Hormones and other biological lipoproteins play an essential role in the regulation of food intake and act via a number of mechanisms (Bellar et al., 2008). Ideally, they interact to produce homeostasis within the body at a healthy body weight. Some of the most metabolically influential chemicals in the body include hypothalamic neuropeptides, leptin, insulin, endocannabinoids, cortisol, grehlin, and cholecystokinin.

Hypothalamic neuropeptides. The hypothalamus plays a significant role in the short-term regulation of appetite and metabolism. In the healthy, normal-weight body, anabolic processes activate the anabolic neurological pathways resulting in the hypothalamic production of neuropeptides that encourage food intake and slow the body’s metabolism resulting in storage of nutrients as fat. Alternatively, catabolic processes stimulate the opposing processes of increased metabolism and diminished food consumption. These complementary processes function to maintain homeostasis within the body. However, various mechanisms can impact the effectiveness of this system (Bellar et al., 2008).

Leptin. One of the mediators of the hypothalamic neuropeptides is leptin. Released by adipocytes, leptin stimulates the release of anabolic neuropeptides (Bellar et al., 2008). Circulating levels of leptin are found to be proportional to amount of body fat. This mechanism functions to reduce food consumption and increase energy utilization in response to adequate fat stores. However, many obese individuals continue to overeat in spite of this increase in leptin. While exact mechanisms are unclear, two factors have been identified that may contribute to this inconsistency. Firstly, adipose tissue located within the abdomen releases less leptin. Therefore, central obesity is associated with less circulating leptin. In addition, it has been suggested that obese individuals become leptin resistant and, therefore, no longer produce proportional amounts of neuropeptides in response (Bellar et al., 2008).

Insulin. Insulin is a hormone that is synthesized in the pancreatic beta cells and secreted in response to elevated blood glucose (Brashers & Jones, 2010). It acts to facilitate cellular glucose uptake and utilization. In this manner, it helps remove excess glucose from the blood so that it may be broken down for energy or turned into proteins, nucleic acids, or lipids (Brashers & Jones, 2010).

By assisting the cells with glucose absorption and storage as lipids, insulin becomes another important regulator of body weight. It also circulates at higher levels in individuals with obesity. Like leptin, long-term elevation of insulin levels can lead to insulin resistance, a tendency that is heightened in individuals with central adiposity. This insulin resistance is likely related to the down-regulation of Glucose Transporter Type-4 (GLUT-4) in adipocytes and the resulting up-regulation of factors that enhance insulin resistance (Bellar et al., 2008).

Endocannabinoids. The endocannabinoid system (ECS) links the hypothalamic neuropeptides with the dopamine-mediated reward centers of the brain causing pleasure in response to eating (Bellar et al., 2008). Endocannabinoids also increase adipocyte production and insulin sensitivity. This system is activated by decreased leptin or glucose and increased hunger or stress. The ECS has been found to be hyperactive in obese individuals (Bellar et al., 2008).

Grehlin and cholecystokinin. The ECS collaborates with grehlin to encourage food intake. Grehlin is released by cells lining the gastric mucosa in response to low nutrient levels resulting in increased release of anabolic neuropeptides. Cholecystokinin is also released from the gastrointestinal tract and acts to reduce consumption in response to nutrient adequacy. All of these hormones normally interact to produce body weight adequacy and homeostasis and disruptions in this process can lead to both anorexia and obesity (Bellar et al., 2008).

Cortisol. Cortisol is a glucocorticoid primarily secreted by the adrenal cortex that functions to protect the body during stress (Brashers & Jones, 2010). This hormone has many physiological effects including the stimulation of gluconeogenesis in the liver and the inhibition of glucose absorption and utilization by the cells of the body. The overall result is the elevation of blood glucose. However, cortisol also promotes redistribution of body fat by inciting lipid breakdown in the periphery of the body and lipid synthesis in the abdomen, trunk, and face (Forshee, Clayton, & McCance, 2010).

Unfortunately, this process becomes self-perpetuating. Cortisone is released by abdominal adipose tissue. This chemical is then converted to cortisol leading to additional central adipose hypertrophy. Since adipose tissue releases cortisol, obesity can cause stress to the body leading to a chronic cycle of weight gain and the stress response (Foss & Dyrstad, 2011).

Sleep

Inadequate sleep patterns are associated with impaired leptin production and increased grehlin. Individuals who did not regularly get eight hours of sleep a night were found to have lower leptin and increased grehlin levels. Furthermore, their BMIs were negatively associated with amount of sleep (Taheri, Lin, Austin, Young, & Mignot, 2004).

Metabolic Mediators

Many other factors can cause weight gain including medications such as atypical antipsychotics (Citrome, Holt, Walker, & Hoffmann, 2011) and medical conditions such as hypothyroidism (Reinehr, 2010). Clearly, the solution to specific cases such as these involves correction of the obesity-promoting factor and is outside of the scope of this analysis.

All of these factors interact to produce a clinically complex portrait of a superficially simple phenomenon. While the math of calories-in/calories-out is relatively steady, the determinants of each component are exceedingly complicated. Many of these factors seem to be working against the obese individual, impeding their progress in the attainment of weight loss. It is often necessary to provide support for these individuals as they attempt to conquer the odds, identify, and amend the barriers to their success.

Treatment for Obesity

The various causes of obesity contain implicit suggestions about their solutions and treatments. At the heart of every weight loss attempt is usually an attempt to create a caloric deficit. In order to lose a pound of fat, an individual must create an approximately 3,500-calorie deficit between the caloric requirements of the body and their intake (Hall, 2008). This can be achieved either by increasing metabolic demand through exercise or by decreasing caloric intake. However, most individuals choose to use a combination approach.

Diet

Many diets are popular in modern society. However, commonly chosen dietary interventions usually include either a low-carbohydrate/high protein or a low-fat/low-calorie strategy (Miljokovic & Mostad, 2007). Low-carbohydrate diets have become highly popular recently. They tend to reduce caloric intake by limiting food options. However, they have been associated with many serious health consequences. Low-fat diets work by reducing caloric intake by removing the biggest source of caloric density, which is fat. However, the additional food options can make food intake control more difficult (Miljokovic & Mostad, 2007). Current research suggests that, while short-term high-protein/low-carbohydrate approaches may be more successful, longer-term results tend to favor low-fat approaches. When combined with the health consequences of the low-carbohydrate approach, most research indicates that low-fat diets are still the best dietary approach for sustainable weight loss (Kirschenbaum, 2005). One variation of these dietary strategies that has gained popularity in recent years is intermittent fasting whereby the window during which food is consumed is narrowed during the day. Preliminary research reveals that this is an effective strategy for short-term reduction in caloric intake (Harvie et al., 2011). However, much more research is necessary in this area. Evidence also suggests that slow weight loss is less likely to stimulate homeostatic mechanisms that oppose weight loss leading to a greater likelihood of weight maintenance. Consumption of vegetables, fruit, lean meats, dairy, and whole grain are recommended in order to ensure nutritional adequacy of the meals (Burke & Wang, 2011).

Exercise

Exercise can result in weight reduction by increasing caloric expenditure and metabolism. The American College of Sports Medicine (ACSM) recommends cardiovascular exercise three to five days of the week for 20-60 minutes per session. However, simply choosing more active options such as taking the stairs instead of the elevator can be beneficial. Exercise helps increase the caloric requirements of the body resulting in weight loss while also promoting cardiovascular health (Burke & Wang, 2011).

Pharmacology

Pharmacologic interventions are usually only considered in extreme cases where dietary and activity interventions were unsuccessful. The primary medication prescribed for obesity is orlistat, which reduces the gastrointestinal absorption of fat. Weight loss medications are most effective in conjunction with lifestyle modification (Burke & Wang, 2011). Sibutramine, a medication that blocks serotonin and noradrenaline reuptake reducing the urge to eat, has recently been removed from the market due to evidence of cardiovascular risk. Qsymia, an extended release of combination phentermine and topiramate shows promise as a new FDA approved medication that is currently undergoing longterm trials (Shin & Gadde, 2013). It acts both by improving metabolism and reducing appetite. Belviq, another recently approved drug, is a serotonin receptor antagonist that also acts as an appetite suppressant (Fala, 2012).

Surgery

Bariatric surgery is becoming an increasingly common method of weight loss. This term encompasses both gastric banding which reduces the capacity of the stomach and Roux-en Y procedures, which impact absorption, as well as capacity. These procedures are especially effective at weight reduction and, in the higher obesity categories, the benefits often outweigh the potential risks of the procedure (Burke & Wang, 2011).

Adjunctive Strategies

Other important methods of weight loss include counseling, stress management, adequate sleep, cognitive restructuring and problem solving through counseling, behavioral goal setting, and self-monitoring. These function as important supplementary tools (Burke & Wang, 2011).

Barriers to Treatment

Regardless of the chosen intervention, many people find it difficult to lose weight. Amongst those who are successful, it is not uncommon to regain the weight within a year (Curioni & Lourenco, 2005). The reasons for this difficulty are often unclear. However, many barriers including genetics (Nagai et al., 2011), time, motivation, cost, poor social support network (Andajani-Sutjahjo et al., 2004), fatigue (Landis et al., 2009), hunger (Adberg et al., 2008), knowledge deficit, poor perceptions of control (Welsh et al., 2011), and low self-efficacy (Shin et al., 2011) are implicated. There are likely many additional barriers to weight loss that have yet to be identified or sufficiently addressed. Nonnutritive sweetener (NNS) has the potential to be a barrier as well as an instrument for success depending on how it is used.

Nonnutritive Sweeteners

Since reducing caloric intake is the foundation of any successful diet, one logical strategy is to substitute sucrose with a lower calorie alternative. The first NNS, saccharin, was discovered in 1879 by Constantine Fahlberg when he was experimenting with coal tar derivatives (De la Pena, 2010). For much of the early 20th century, this sweetener was regarded as inferior to normal sugar and was used only by diabetics. However, during the late 1940s, the scarcity of sugar and a newfound societal obsession with thinness led to an increase in its popularity (De la Pena, 2010). In 1965, aspartame was discovered and quickly became popular. Sucralose was discovered in 1976. All of these substances have been criticized as potentially detrimental to health (Tandel, 2011). Yet many individuals believe that the health benefits of weight reduction outweigh the potential for toxicity with these chemicals (De la Pena, 2010). The US Food and Drug Administration (FDA) currently classifies six NNS as generally recognized as safe. These chemicals are saccharin, aspartame, sucralose, neotame, stevia and acesulfame potassium (Tandel, 2011).

Safety

In spite of the formal declarations of the FDA, the safety of these chemicals continues to be debated. Aspartame and its metabolites have been touted to cause allergic reactions, brain damage, seizures, and exacerbation of mood disorders. Perhaps the most disturbing accusations were a potential link between aspartame and certain cancers (Lim et al., 2006; Fitch & Keim, 2012). However, these accusations were determined to be unsubstantiated. Saccharin has also been labeled as potentially carcinogenic. Specifically, saccharin was revealed to be associated with bladder cancer in rodents (Lim et al., 2006). However, the mechanisms whereby this occurs were not found in humans. Sucralose is the most heat-stable of the NNS. However, some concern has arisen due to its classification as an organic chloride. While some organic chlorides have been linked to cancer, the conditions of sucralose degradation into carcinogenic compounds do not appear to be present within the human body (Tandel, 2011).

Usefulness as a Dietary Tool

Some research reveals that artificial sweetener can be an effective tool for weight loss and maintenance. A study of young, Dutch adults found that substituting sugar-laden beverages with their artificial counterparts led to a significant decrease in BMI (Hendriksen et al., 2011). Other research has shown that NNS are a key component of the diets of many successful weight loss maintainers. However, these same products are not utilized as frequently amongst individuals who have always maintained a healthy weight (Phelan, Lang, Jordan, & Wing, 2009). One study found that when rats were fed aspartame for 14 weeks they had a lower weight and fat percentage than those who were fed pure water despite no differences in food intake (Beck, Burlet, Max, & Stricker-Krongrad, 2002). However, other research in the rodent population contradicts this finding.

Epidemiologic Trends

While the aforementioned research supports the assumption that NNS products are useful tools for weight loss, there is a growing body of evidence suggesting that the reverse may be accurate in some long-term users. Correlational studies have uncovered a positive relationship between BMI and NNS consumption (Bouchard et al., 2010; Colditz et al., 1990). Similar patterns have been noted in children (Forshee & Storey, 2003; Wollitzer, Jovanovic, & Petitt, 2004). In general, the more overweight an individual is, the more likely they are to consume NNS. However, these findings do not suggest any particular direction to this relationship. It is likely that those who have a susceptibility to weight gain, whether due to genetic or behavioral tendency, are more likely to consume diet products.

Interestingly, this in vivo association between BMI and NNS consumption appears to occur despite apparently healthy food choices amongst those consumers. A study by the American Cancer Society found that NNS users ate significantly more lean poultry, fish, and vegetables and significantly less simple carbohydrates and fatty foods than those who did not consume these products (Stellman & Garfinkel, 1988). One problem with this study is that it relied on dietary recall, which is not necessarily an accurate depiction of actual intake. A grocery purchase pattern analysis found that diet soda purchases were significantly correlated with better nutrition choices (Binkley & Golub, 2007). However, this finding did not incorporate food choices made outside of the grocery store. It is likely that individuals on a diet are more likely to purchase both diet beverages and healthier food selections.

Experimental and Prospective Evidence

More convincing research utilizing a rodent model has suggested a causal relationship between these variables. The majority of research where rats have been fed nonnutritive sweeteners reveals weight gain and increased food intake when compared with a sucrose control (Swithers, Martin, & Davidson, 2010; Roy, Davidson, & Swithers, 2007). However, the generalizability of these findings is lacking. Humans appear to process NNS differently from rodents as evidenced by the differences in bladder cancer risks between rodents and humans with saccharin (Lim et al., 2006). More relevant are the results of the prospective San Antonio Heart Study which found that baseline NNS consumption was associated with a twofold likelihood of overweight or obesity over a nine-year period (Fowler et al., 2008). This effect was found in spite of normal weights at the start of the study.

Potential Mechanisms

Many potential mechanisms have been proposed to account for these findings. They include the role of NNS in glucose absorption, hunger and satiety, and cortical response and desensitization.

Glucose absorption. Some researchers suggest that increased NNS intake is associated with an increased uptake of glucose by the gastrointestinal tract. When rats were regularly fed sucrose solutions, aspartame solutions, or sucralose solutions as an adjunct to their normal ad libitum diet, they experienced differential body masses depending on their experimental condition (Martinez et al., 2010). More specifically, those that consumed aspartame and sucralose had a significantly higher final body mass than those in the sucrose condition. Interestingly, the sucrose fed rats had a lower body mass than rats that were given pure water. What makes these findings even more intriguing is that they occurred in spite of increased overall caloric intake amongst rats in the sucrose condition (Martinez et al., 2010). Mace, Affleck, Patel, and Kellett (2007) identified the glucose transporter-2 as the likely site of this increased absorption. However, research in humans has failed to produce a similar effect. When individuals were fed intra-duodenal glucose subsequent to either a sucralose or saline preload, they did not demonstrate differences in serum glucose concentrations (Ma et al., 2010).

Hunger and satiety. Some research suggests that there is a decreased release of satiety peptides such as glucagon-like peptide-1 by the intestines in response to NNS compared to sucrose. This leads to a decrease in satiety and an increase in hunger amongst NNS consumers (Steinert, Frey, & Topfer, 2011; Fujita et al., 2009). However, these findings have been challenged by others that have not found this effect (Brown, Walter, & Rother, 2009; Geraedts, Troost, & Saris, 2011).

Other studies have found that NNS consumers at least partially compensate for the calorie reduction with an increase in food intake. For example, one experimental study found that when people were given sucrose-sweetened beverages, they consumed significantly less carbohydrates, fat, and protein than those who were given NNS beverages over a four-week period (Reid, Hammersley, & Hill, 2007). However, those in the sucrose condition gained slightly more weight suggesting that, while the weight differences were not significant, dietary compensation was not sufficient to overcome the energy savings (Reid, Hammersley, & Hill, 2007).

Another study supplied overweight individuals with sweetened beverages that were either sucrose sweetened or aspartame sweetened (Reida, Hammersely, & Duffy, 2010). Food intake and hunger were monitored over a four-week period. Findings suggest that while net energy intake increased in the sucrose group during the first week, this effect was not sustained. Intake differences were not apparent by week four suggesting complete caloric compensation over time (Reida, Hammersley, & Duffy, 2010).

These findings suggest that there is a satiating effect of sugar consumption from which NNS consumers fail to benefit. However, research findings are far from conclusive and same-day experimental studies have failed to produce increased hunger or food intake in response to sucralose when compared to sucrose (Brown, Bohan, Onken, & Beitz, 2011; Anton et al., 2010). This suggests that such an effect is time sensitive and requires physiological adjustment before it is evident.

Cortical response and desensitization. Some research suggests that differences in cortical response to NNS compared to regular sugar may account for these differences. Magnetic resonance imaging (MRIs) of individuals consuming sucrose found that regular NNS users experience a lesser activation of the amygdala than those who regularly use sugar (Rudengaa & Small, 2011). Another MRI study found that sucrose elicits greater stimulation of multiple sections of the brain associated with the experience of pleasure when compared to sucralose (Frank et al., 2008). These findings have led scientists to propose that there is a Pavlovian decoupling of sweet sensations to caloric intake when non-caloric sweets are regularly consumed. The result is a decreased response to sweets by the brain and therefore a reduction in satiety when these sensations are experienced.

There is evidence that frequent consumers of NNS are less perceptually responsive to sweet tastes than low habitual consumers. One study found that people who do not regularly consume NNS experience increased appetite in response to a small, sweetened preload. This effect was not found in regular consumers of these products (Appleton & Blundell, 2007). However, another study found that it was the level of sweetness that a person was accustomed to regardless of artificial or natural origin that determined perceptions of sweets (Mahar & Duizer, 2007). It is possible that, as an individual becomes accustomed to sweeter foods, they essentially develop a tolerance so that a larger intake is required in order to achieve the same cortical effect.

Summary and Conclusion

Obesity is a serious health concern that affects all aspects of health and influences many deadly disease processes. Both biology and environment converge in the creation of this obesogenic atmosphere. Many methods of weight loss are prescribed including exercise, dietary interventions, pharmacotherapy, and surgery. NNS is frequently suggested as a useful and effective substitute for higher calorie alternatives. However, NNS use is also associated with BMI in correlational, prospective, and experimental research. Many theories for these findings have been proposed. Perhaps most disconcerting is the possibility that NNS intake may be contributing to the obesity problem for some individuals. The current research examines whether NNS intake and length of use are associated with BMI amongst UNF undergraduate students. It also examines whether any differences in activity or produce consumption might partially explain these patterns.

Chapter Three: Methodology

This chapter describes the research design of a descriptive, evidence level III, pilot study to examine the relationship between BMI and degree and length of NNS use. The chapter begins with a description of the research sample, setting, and procedures. Following this is a discussion of the measures employed for the protection of human subjects.

Sample

This study drew its participants from a convenience sample of University of North Florida (UNF) students enrolled in the introductory nutrition courses HUN1001 and HUN2201. Most health majors have these courses as a requirement. Thus, the sample included a selection of individuals from across the spectrum of health fields as well as students who are using nutrition as an elective. There were two sections of HUN1001 and thirteen sections of HUN2201 whose professors were approached concerning participation. Professors in both sections of HUN1001 and four sections of HUN2201 agreed to open the survey to their students, making 173 possible participants.

Inclusion Criteria

Individuals over the age of 18 who are enrolled in HUN1001 or CRN# 11469, 11532, 11583, and 12918 of HUN 2201 were eligible for inclusion. There were no exclusion criteria.

Setting

According to the UNF handbook (UNF, 2011), UNF has over 16,000 students. The UNF Brooks College of Health regularly offers up to 15 sections of introductory nutrition classes in the spring term. Total enrollment for these classes can approach 462 students.

Procedures

Professors who agreed to open the survey to their students were sent a link to a secure, online website which they, in turn, sent to their students offering extra credit for participation. When students clicked on the link, they were taken to an electronic informed consent form (see Appendix A). If they agreed to participate, the students were given a choice about how extra credit would be granted (see Appendix B). The choices were to (a) participate in the study by completing an online survey or (b) read an article about NNS and weight management (Gardner et. al, 2012) and write a short, 200-word summary. Upon completion of the survey, participants were given a link to a separate survey where they could enter identifying information to receive course credit without affecting their anonymity. If they chose the article, they were instead given a link to the full text along with a text box with a 200-word minimum to enter their summary. Due to the anonymous nature of the study, it was not possible to determine who wrote the essays. Therefore, essay adequacy was determined solely on exceeding the minimum word requirements. Once this requirement was met, they were given the link to the same identifying information survey as the other group. Students were not obligated to receive extra credit and did not have to provide information on the second survey.

Instrumentation

The survey was comprised of 24 questions in multiple choice and short answer format (see Appendix C). The majority of the questions were adapted from the Youth Risk Behavior Surveillance Survey (CDC, 2013). This is a national survey with predetermined test-retest reliability. Validity for this survey has not been formally established.

Fruit and Vegetable Intake

In order to obtain an indicator about the nutritional adequacy of their diet, participants were asked about fruit, corn, potatoes, carrots, green salad, and other vegetable intake. These questions were selected from the Youth Risk Behavior Survey (CDC, 2013). Answer choices were “I did not eat [fruit] during the last 7 days”, “1 to 3 times during the past 7 days”, “4 to 6 times during the past 7 days”, “1 time per day”, “2 times per day”, “3 times per day”, and “4 or more times per day.”

Activity Level

Participants were asked about the number of days per week that they went to the gym, the number of days they got at least 30 minutes of exercise, the number of hours per day that they watch television, and the number of hours per day that they play video games or use the computer for non-work or school related purposes. All of these questions were taken from the Youth Risk Behavior Survey and were ways of estimating activity level.

Nonnutritive Sweetener Intake

Nonnutritive sweetener (NNS) was divided into NNS beverages, gums, foods, and sweetener packets. Participants were asked about how many servings of that item they had consumed in the last seven days. Answer choices were “I did not [drink diet beverages] during the last 7 days”, “1 to 3 times during the past 7 days”, “4 to 6 times during the past 7 days”, “1 time per day”, “2 times per day”, “3 times per day”, and “4 or more times per day.” Please refer to Appendix C for the complete list and format of questions.

Length of Use

Participants were asked what age they started using NNS products in order to calculate length of use.

Body Mass Index and Weight Variability

Body Mass Index (BMI) was calculated from the weights and heights provided by the participants. This calculation was performed using the equation $BMI = \frac{lb\ x\ 703}{(in)2}$. They also provided a lowest and highest adult weight so that their weight variability range could be calculated.

Demographic Variables

Demographic information was collected to describe the sample and determine its generalizability to the student body of UNF. Information regarding age, gender, and college major were collected for this purpose.

Protection of Human Subjects

All students in the classes had an equal opportunity of obtaining extra credit even if they did not want to take the survey. Furthermore, informed consent was obtained electronically. This study was classified as exempt by the UNF institutional review board. All participants were over 18 years of age and able to exit out of the survey at any time.

Summary

An online survey was administered to 113 students enrolled in introductory nutrition classes. These students chose between reading an article about NNS and writing a short essay on the topic and completing a questionnaire inquiring about demographics, BMI, weight variability, activity levels, length of NNS use, and fruit, vegetable, and NNS intake. Compensation was provided in the form of extra credit for their class. Student anonymity was maintained and students were able to withdraw from the study at any time.

Chapter Four: Results

This chapter provides a recount of the statistical findings of this pilot study. Demographic information is first summarized with descriptive statistics and compared against those of UNF and the US overall. Following this description of the sample is the correlation and non-parametric t-test results examining relationships between the variables. The data were analyzed using Statistical Product and Service Solutions (SPSS) software and the statistical significance was set at the $p \leq .05$ level.

Response Rate

From the sections of nutrition classes whose professors agreed to collaborate, there were 173 potential participants. Of these students, 119 logged on to the Qualtrics survey site (68.79% response rate). All 119 consented to the survey and did not elect to read and summarize the article. Four participants did not complete the survey in its entirety. Two additional students provided information that was clearly incorrect, one stating her lowest adult weight was 10 pounds and one stating that he was "6'57 inches" tall, and their responses were dropped from final analyses. Therefore, the final sample size was 113 students.

Characteristics of the Sample

Participants were 18-42 years old (M=20.23, SD=2.9). The majority were female and roughly one-third were majoring or intending to major in fields within the Brooks College of Health (see Table 4.1).

The height ranged from 60-81 inches, weight from 106-265 pounds, BMI from 17-40 kg/m^2, and weight variability from 0-220 pounds (see Table 4.2). The person with

Table 4.1. Description of the Sample (n=113)

Characteristic	N	%
Gender		
Female	74	65.5
Male	39	34.5
College Major		
College of Arts and Sciences	41	36.3
Brooks College of Health	39	34.5
Coggin College of Business	20	17.7
College of Education and Human Services	5	4.4
College of Computing, Engineering, and Construction	2	1.8
Undecided	8	5.3

Table 4.2. Anthropometric Data

Variable	Minimum	Maximum	Mean	Std Dev
Height in inches	60	81	67.36	4.04
Weight in pounds	106	265	155.5	35.89
BMI	16.6	42.43	23.98	4.5
Weight Variability	0	220	25.16	27.42

the 220 pound range was an outlier whose maximum weight was 300 and minimum was 80 pounds. Although these values were extreme, they were not outside the realm of possibility. Therefore, this individual was included in the data set. The majority of the participants rated themselves as "about the right weight" and as having a weight goal of losing weight (see Table 4.3).

Only 37 (32.7%) of the participants believed that NNS helped them manage their weight. The most heavily consumed source of NNS was gum. Total NNS intake during the week ranged from 0-50 servings, while fruit and vegetable consumption ranged from 1-84 (see Table 4.4).

Table 4.3. Weight Perception and Goals

Variable	N	%
Weight Perception		
About the right weight	60	53.1
Slightly overweight	33	29.2
Slightly underweight	14	12.4
Very overweight	5	4.4
Very underweight	1	0.9
Weight Goals		
Lose weight	58	51.3
Stay the same weight	28	24.8
Gain weight	16	14.2
Not trying to do anything about weight	11	9.7

Table 4.4. Consumption of NNS, Fruits, and Vegetables per Week

Variable	Mean	Median	Std Dev
Nonnutritive Sweetener			
Diet beverages	2.27	0	5.196
Diet foods	1.71	0	4.321
Sugar free gum	3.12	1	5.899
Sweetener packets	1.36	0	3.541
Fruits and Vegetables			
Fruit	6.75	4	6.948
Salad	3.7	1	4.635
Potatoes	1.8	1	2.723
Carrots	2.08	1	3.257
Other vegetables	5.46	4	6.439

There was wide variation in the amount of exercise with most students reporting three or less days of active exercise (see Table 4.5). The majority of the students watched television for less than one hour per day and participated more in computer activities such as Xbox, Playstation, an iPod, an iPad or other tablet, a smartphone, YouTube, Facebook, or other social networking tools, and the Internet for recreational purposes (see Table 4.6).

Table 4.5. Exercise

Exercise Levels	Mean	Median	Mode	Std Dev
Exercise				
# days with ≥ 60 minutes exercise/week	3.52	3	3	2.053
# days with ≥ 30 minutes gym exercise/week	3.04	3	3	2.089

Table 4.6. Sedentary Activity

Activity	N	%
Watching television		
None	21	18.6
< 1 hour per day	27	23.9
1 hour per day	19	16.8
2 hours per day	21	18.6
3 hours per day	17	15
4 hours per day	4	3.5
5 or more hours per day	4	3.5
Recreational computer use		
None	7	6.2
< 1 hour per day	17	15
1 hour per day	23	20.4
2 hours per day	26	23
3 hours per day	21	18.6
4 hours per day	5	4.4
5 or more hours per day	14	12.4

Efficacy, Weight Goals, and Intake Differences

Those trying to lose weight consumed significantly more NNS ($t=2.008$, $p<0.05$). Those who perceived that they helped them manage their weight also had a higher consumption pattern ($t=2.383$, $p<0.05$).

Relationships

Body Mass Index and Lifestyle

Body mass index (BMI) was not significantly related to fruit/vegetable intake ($r=-0.04$), exercising more than 60 minutes ($r= -0.098$), going to the gym ($r=-0.066$), or recreational computer use ($r= -0.073$). However, BMI was significantly positively related to hours of television per day ($r=0.232$, $p<0.05$). This implies that individuals with higher BMIs engage in more sedentary activities during the day.

NNS Intake, BMI, and Lifestyle

Nonnutritive sweetener (NNS) intake was significantly related to fruit and vegetable intake ($r=0.26$, $p<0.005$). The more NNS consumed, the more fruits and vegetables they reported consuming. There was a small, but not significant correlation between NNS beverages and BMI ($r=0.17$, $p=0.06$). NNS consumption was not significantly related to BMI ($r=0.025$), gym visits ($r=0.064$), days of exercise ($r= 0.084$), recreational computing ($r= 0.065$), or television watching ($r=0.009$).

Weight Variability and NNS Consumption

There was a statistically significant relationship between adult weight variation and NNS intake ($r=0.31$, $p<0.005$). The more the participant's weight varied over time, the more NNS he or she consumed.

Length of Use, Quantity of Use, and BMI

Length of use was significantly positively correlated with NNS intake ($r=0.23$, $p< 0.05$) and BMI ($r=0.24$, $p<0.01$). The longer NNS was used, the higher their BMI. It was not, however, related to fruit/vegetable intake ($r= -0.038$), exercise ($r=0.077$), gym visits ($r= -0.032$), recreational computing ($r=0.143$), or television watching ($r=0.157$).

Group Comparisons

Since the continuum of NNS use was relatively uniform, there was no clear distinction between frequent and infrequent users. Also, since the majority of individuals reported only two or less servings per week, the resultant groups were highly disproportionate. Therefore, these computations were deemed inappropriate and not performed.

Summary

Significant findings included a tendency to use NNS more in those with an intention to lose weight as well as a perception that NNS facilitates weight management. NNS intake was also positively related to produce intake, adult weight variability, and length of use. There was also a positive correlation between BMI and both hours of television watching and length of NNS use.

Chapter Five: Discussion

This chapter provides a discussion of the results regarding the association between NNS use, fruit and vegetable intake, activity, and BMI among students at the University of North Florida. Following this analysis, the limitations of the study will be examined. Implications for practice and recommendations for future research are also provided.

Sample Characteristics

Only 35 % of the participants were male and 65% were female. This is in contrast to the university overall which reports a 44%-56% male-female distribution (UNF, 2012). This is also in contrast to the United States overall where females make up 50.8% and males 49.2% (United States Census Bureau, 2012). The gender differences likely reflect an increased interest in nutrition among women as well as an elevated representation of women within health related fields. The average age in the sample was 20 years old compared to 24.78 in UNF overall (UNF, 2012). The younger age of the sample is likely due to the fact that this is a freshman level course. Of the participants, 32% were enrolled or intended to enroll in the Brooks College of Health compared to 14.5% of the student body overall. The high prevalence of College of Health enrollees likely reflects the fact that many majors in this college require this course.

Clearly, the data obtained from this sample represents a very specific group that is not generalizable to UNF overall. Therefore, it is not clear whether the relationships found between the variables in this study exist within the general population of the university. Similarly, these results are not generalizable to young adults throughout the United States.

BMI and Nutrition

The average BMI for this group was 24. The American College Health Association (ACHA, 2012) reports a similar mean of 24.23. This BMI is on the upper end of a healthy range. However, fewer students in this sample have unhealthy BMIs when compared to other college students. Among the participants, 27% had BMIs > 25 kg/m^2. ACHA reports that the national rate of overweight and obesity amongst college students is 32.5%. However, since these students were younger than average, a better comparison might be the results of the Youth Risk Behavior Surveillance Survey itself where the rate of overweight and obesity in adolescence was found to be 28.2% (CDC, 2012). Similarly, the average number of servings of fruits and vegetables that this sample reported consuming within a week was 20 or 2.9 servings per day. According to ACHA (2012), this is better than 67.7% of college students nationwide. These differences may be due to more individuals interested in health and nutrition enrolling in a nutrition course.

Activity Level

Of the respondents, 69% reported exercising at least 60 minutes a day less than five days out of the week. This is in comparison to the YRBSS (CDC, 2013) which reports that 55.2% of 12th graders fell into this category. Thus, the students in this sample are less active than seniors in high school. According to the ACHA (2012), 30.4% of high school seniors admitted to watching three or more hours of television per day. In the current study, this number was reduced to 22.1%. However, recreational computing time was elevated at 35.4% compared to 28.8% for high school seniors. No comparison data were found for gym attendance. It appears that the UNF students in this sample are more sedentary than the national averages for high school seniors and, although they watch less television, they make up for it in recreational computer use.

NNS Use

No use of NNS in the past seven days was reported by 22.1% of respondents. However, with the inclusion of individuals who consume these products less than daily, the results increase to 63.7%. Very little data exists regarding consumption of NNS products other than diet beverages. However, 17.5% of American adults report drinking diet soda (Duffey & Popkin, 2006). Frequencies of consumption were not specified with that data. Of the students who responded to the survey, 12.4% reported daily consumption of diet soda.

Relationships

Body Mass Index and Lifestyle

There does not appear to be a relationship between BMI, fruit/vegetable intake, gym attendance, or recreational computer use. There was also no significant relationship between BMI and number of days exercising more than 60 minutes. However, there appeared to be a slight negative association between these last two variables that might have become significant with a larger sample size. Body mass index was positively associated with hours of television watched per day suggesting that, although their time devoted to exercise is not significantly different from their thinner counterparts, higher BMI individuals are more sedentary during leisure time in this sample population.

NNS Intake, BMI, and Lifestyle

Nonnutritive sweetener intake was not associated with BMI, gym visits, exercise frequency, recreational computing, or television watching. Although not associated with BMI overall, NNS beverage intake had a slight but not significant association with BMI. This is interesting considering much of the research demonstrating a relationship between NNS and BMI has quantified NNS use through diet beverages alone. However, the American Heart

Association and American Diabetes Association also found that NNS was least likely to be compensated when consumed in beverages (Gardner et al., 2012). Clearly, the clinical picture is complex. Nonnutritive sweetener intake was also positively associated with fruit and vegetable intake, although the reasons for this association are unclear. It may be because individuals using NNS are more likely to be dieting and are therefore paying more attention to the health of their diet. If this were true, both NNS use and fruit/vegetable intake would be higher in those trying to lose weight. A post-hoc analysis of the data, however, revealed that while NNS use was different between those trying to lose weight and those who were not ($p<0.05$), fruit/vegetable intake was not significantly different between these groups($p=0.67$). Another potential explanation is that people are making fruits more palatable with NNS. However, the correlation between NNS intake and fruit intake alone was lower ($r=0.237$, $p<0.05$) suggesting that this does not completely explain the relationship. More likely, those that are using NNS to control sucrose intake independent of weight loss motives are also cognizant of other healthful aspects of their diet.

Weight Variability and NNS Consumption

Weight variability in adulthood was positively related to NNS consumption. It is possible that this is due to successful weight loss amongst NNS users. When analyzed post-hoc for associations between NNS intake and the difference between highest weight and current weight, the findings were significant ($r=0.43$, $p<0.01$). There was no association between length of use and weight variation ($r=0.07$, $p=0.464$) implying that longer use of NNS does not lead to decreased control over weight or increased success at weight loss.

Length of Use, Quantity of Use, and BMI

The longer the students reported having used NNS, the higher their intake. This is a very interesting finding because there is some indication that frequent NNS users have less brain activity in response to sweets (Rudengaa & Small, 2011). It is possible that longer use has led them to develop a type of tolerance to sweet tastes requiring more sweetness in order to be satisfied. The finding that BMI is significantly related to length of use mirrors that of the San Antonio Heart Study where participants who regularly consumed NNS were found to gain more weight over an eight-year period than those who did not (Fowler et al., 2008). It is possible, that the lack of a relationship between BMI and NNS intake is due to the fact that this sample is composed of quite young individuals who have not used NNS for a significant enough length of time. Of course, those individuals who were raised in families with a genetic or behavioral predisposition to weight gain are more likely to be exposed to NNS at an earlier age also potentially explaining the BMI-length of use covariance. No other variables appeared to be related to length of use.

Implications for Practice

It appears that NNS does not affect BMI negatively and may even facilitate weight loss in the short term. This is consistent with the research that shows it is useful for short-term weight loss. However, as an individual continues to use NNS over time, their BMI and their consumption amounts tend to increase. The reasons for this distinction are unclear and do not appear to be related to nutritional adequacy of the diet or activity level. Ideally, NNS substances are used as substitutes for sugar-sweetened ones and not simply as additional sources of sweetness. It is possible that over time, some individuals may begin to use more sugar-sweetened products in addition to NNS leading to weight gain. If so, these individuals may develop tolerance to NNS.

As practitioners, it might be helpful to counsel non-diabetic patients that NNS use is a short-term solution as the patient actively works to changing their palate. Encouraging patients to be aware of the potential for increasing reliance on NNS may be an intervention to limit this tendency. Patients should also be reminded periodically that NNS are meant to replace sugar-sweetened alternatives. Furthermore, informing them about the potential development of tolerance to sweets and the importance of maintaining portion control when indulging in sugar-sweetened products might help to eliminate this pattern.

Implications for Research

Perhaps the most interesting finding that warrants further exploration is the idea that consumption of NNS in some individuals increases over time. Verifying this pattern in a more heterogenous and generalizable sample would be an important step. If these consumption patterns are determined to be universal, then tolerance to sweet tastes may be a factor. Similarly, administering this survey overall to a more diverse group could help to give more external validity to the results. Research concerning sugar-sweetened product consumption in NNS users vs nonusers might help determine whether sweets in general are more highly consumed in these users. Frequent and infrequent users could be asked to weigh all foods and document them in a food diary over the course of one week. This case-control approach could provide greater insight into dietary differences between these groups. From a scientific perspective, longer-term randomized controlled trials in human beings are needed in order to determine the effects of NNS products. However, practically, this is often neither feasible nor ethical. One interesting study might involve giving education about the potential addictiveness of sweets to frequent users of NNS and then comparing their success on a weight loss program with that of frequent users who were not given this education. This study could be conducted in quasi-experimental fashion.

Limitations

Clearly, there are many limitations to the current research. Primarily, the study sample was highly homogenous and not representative of either UNF or the United States. Therefore, no generalizations can be made. A larger sample size would also increase the generalizability of the findings. Some respondents might have easier access to the internet than others making them more likely to complete the survey. This may have created a self-selection bias. This study employed a descriptive, survey design. No causality can be attributed to the findings and the results rely not only on the students' honesty but also their ability to correctly gauge and recall serving sizes, intake patterns, and activity. Serving sizes were not well defined in the survey. Another weakness of this study is that the answer choices to intake questions were in uneven ranges causing inexact estimates of actual consumption patterns. The assumption of continuous data was somewhat erroneous. Also, the survey did not have established validity or reliability and, although it was based on the nationally recognized YRBSS, this too has not been validated nor has reliability been established in individuals over the age of 18. Finally, although there were statistically significant associations found, these associations were still quite small due to the multivariate nature of these issues. Therefore, the clinical significance of this data may be lacking.

Summary and Conclusion

The original research premise queried whether NNS reduced the perceived threat of weight gain leading to poorer lifestyle choices and paradoxical weight gain. After consideration of the current findings, it is possible that NNS contributes to overweight via a different mechanism by indirectly increasing perceived barriers to obtaining portion control with sweets. Educating patients about this potential effect may be enough to offset this tendency.

Appendix A: Electronic Informed Consent

Hello class! I am a nurse practitioner student at the University of North Florida who is doing research on non-nutritive sweetener use and weight management. I have obtained permission from your instructor to offer you extra credit in exchange for completion of a survey. Your responses will not be tied to your names and you will be provided with a separate suvey that is unlinked to the first where you can provide identifying information to give you credit for your participation. Please be honest in your answers. You are not obligated to participate in this study and your participation is completely voluntary. You are welcome to withdraw from the study at any time without penalty by simply closing the survey or article window. However, in order to receive credit for your participation, it is expected that you will provide an answer to all of the questions. The survey is expected to take approximately 10 minutes to complete. While we do not anticipate any risks involved in participation in this study, it is possible that some students may become uncomfortable answering questions about their body weight, dietary habits, or activity level. Your responses will not be tied to your names and you will remain anonymous.

If you prefer not to participate in the survey but do want extra credit, you are welcome to choose the option of reading a short article and writing a one paragraph summary. By submitting this summary, you can qualify for the same number of extra credit points.

Both of these options are available by selecting the box "I consent to participate". Clicking on this box represents your informed, electronic consent to participate in this research. If you choose the survey option, you are agreeing to allow your anonymous responses to basic questions about your weight and health behaviors to be used for research purposes.

If at any point you should decide that you would prefer to do the other option, you are able to begin again by simply closing the survey or article window, clicking on the blackboard link, and restarting. However, you will not receive additional points for completing both options.

If you have any questions, please contact Kat Wright at or call her at . If you have any questions about your rights as a research participant, please call the UNF Institutional Review Board

Please print a copy of this informed consent for your records by one of the following methods:

• Click on the printer icon in the upper right-hand corner of your screen

• Select file in the upper left-hand corner of the screen and choose "print" from the dropdown menu

• Push the print screen button on your keyboard or

• Right click with a mouse and choosing "print" from the available options

Thank you for your time!

Katharine Wright

O I consent to participate

O I do not consent to participate

Appendix B: Options

Thank you for your interest in this opportunity. You are being given the option of obtaining extra credit in exchange for either completion of a ten minute survey or reading a short article and writing a one paragraph (200-400 word) summary of the article. However you can only receive credit for one extra credit option.

Both of these options are concerning non-nutritive sweeteners. These are defined as sweeteners that do not have substantial caloric or nutritional value. They are present in many diet foods, drinks, gums, and are also available in sweetener packets. Products such as Equal, Splenda, Stevia, and Sweet n Low are all examples of non-nutritive sweeteners.

If you are not pregnant, do not have diabetes, are over the age of 18, and would like to complete a 10 minute survey about your weight history, health habits, and use of non-nutritively sweetened products, please select the survey option. By selecting the survey option you are consenting to allow the use of your anonymous responses in a research study.

If you would rather read a short article about non-nutritive sweeteners and write a 200-400 word summary of the article, please select the article option.

Thank you again for your time!

O Survey [takes them to the Survey]

O Article **Please click on the following link to read the article:**

Article

Once you have read the article, please write an essay that is at least 900-1800 characters (approximately 200-400 words) summarizing what you have learned.

Appendix C: Nonnutritive Sweetener Questionnaire

Non-Nutritive Sweetener Questionnaire

Non-nutritive sweeteners, previous known as artificial sweeteners, are substances that provide a sweet taste without significant calories. Examples of non-nutritive sweeteners include Splenda, Equal, Sweet Ones, Stevia, and Nutrasweet.

If you are over the age of 18 and are not pregnant or diabetic please complete the following questionnaire.

1. Age:________
2. Sex (circle one): M/F
3. Height:_____
4. Weight:_____
5. Highest adult weight:_____
6. Lowest adult weight:_____

7. How do **you** describe your weight?*
__ Very underweight
__ Slightly underweight
__ About the right weight
__ Slightly overweight
__ Very overweight

8. Which of the following are you trying to do about your weight?*
__ **Lose** weight
__ **Gain** weight
__ **Stay** the same weight
__ I am **not trying to do anything** about my weight

9. Are you a nutrition major (circle one)?
___Yes
___No

10. During the past 7 days, how many times did you drink **a can, bottle, or glass of a diet beverage** such as diet soda**,** low-calorie juice, crystal light, or diet sweet tea?*
__ I did not drink diet beverages during the past 7 days
__ 1 to 3 times during the past 7 days
__ 4 to 6 times during the past 7 days
__ 1 time per day
__ 2 times per day
__ 3 times per day
__ 4 or more times per day

11. During the past 7 days, how many times did you eat a **serving of sugar-free or reduced-sugar foods** such as Snackwells products, Smart Ones desserts, sugar-free jello, or light yogurt?*
__ I did not eat sugar-free or reduced-sugar foods during the past 7 days
__ 1 to 3 times during the past 7 days
__ 4 to 6 times during the past 7 days
__ 1 time per day
__ 2 times per day
__ 3 times per day
__ 4 or more times per day

12. During the past 7 days, how many times did you chew **sugar-free gum**?*
__ I did not chew sugar-free gum during the past 7 days
__ 1 to 3 times during the past 7 days
__ 4 to 6 times during the past 7 days
__ 1 time per day
__ 2 times per day
__ 3 times per day
__ 4 or more times per day

13. During the past 7 days, how many times did you use **a packet of non-nutritive sweetener** such as Equal, Splenda, Stevia, Sweet Ones, or Nutrasweet?*
__ I did not use non-nutritive sweeteners during the past 7 days
__ 1 to 3 times during the past 7 days
__ 4 to 6 times during the past 7 days
__ 1 time per day
__ 2 times per day
__ 3 times per day
__ 4 or more times per day

14. How old were you when you started using non-nutritive sweeteners for the first time?*
______ years old

15. Do you perceive that non-nutritive sweeteners and diet or sugar-free products help you manage your weight?
___Yes
___No

16. During the past 7 days, how many times did you eat **fruit**? (Do **not** count fruit juice.)*
__ I did not eat fruit during the past 7 days
__ 1 to 3 times during the past 7 days
__ 4 to 6 times during the past 7 days
__ 1 time per day
__ 2 times per day
__ 3 times per day

__ 4 or more times per day

17. During the past 7 days, how many times did you eat **green salad**?*
__ I did not eat green salad during the past 7 days
__ 1 to 3 times during the past 7 days
__ 4 to 6 times during the past 7 days
__ 1 time per day
__ 2 times per day
__ 3 times per day
__ 4 or more times per day

18. During the past 7 days, how many times did you eat **potatoes**?*
__ I did not eat potatoes during the past 7 days
__ 1 to 3 times during the past 7 days
__ 4 to 6 times during the past 7 days
__ 1 time per day
__ 2 times per day
__ 3 times per day
__ 4 or more times per day

19. During the past 7 days, how many times did you eat **carrots**?*
__ I did not eat carrots during the past 7 days
__ 1 to 3 times during the past 7 days
__ 4 to 6 times during the past 7 days
__ 1 time per day
__ 2 times per day
__ 3 times per day
__ 4 or more times per day

20. During the past 7 days, how many times did you eat **other vegetables**? (Do **not** count green salad, potatoes, or carrots.)*
__ I did not eat other vegetables during the past 7 days
__ 1 to 3 times during the past 7 days
__ 4 to 6 times during the past 7 days
__ 1 time per day
__ 2 times per day
__ 3 times per day
__ 4 or more times per day

21. During the past 7 days, on how many days were you physically active for a total of **at least 60 minutes per day**? (Add up all the time you spent in any kind of physical activity that increased your heart rate and made you breathe hard some of the time.)*
__ 0 days
__ 1 day
__ 2 days
__ 3 days
__ 4 days
__ 5 days
__ 6 days
__ 7 days

22. On an average day, how many hours do you watch TV?*
__ I do not watch TV on an average day
__ Less than 1 hour per day
__ 1 hour per day
__ 2 hours per day
__ 3 hours per day
__ 4 hours per day
__ 5 or more hours per day

23. On an average day, how many hours do you play video or computer games or use a computer for something that is not school or job work? (Count time spent on things such as Xbox, PlayStation, an iPod, an iPad or other tablet, a smartphone, YouTube, Facebook, or other social networking tools, and the Internet.)*
__ I do not play video or computer games or use a computer for something that is not school or job work
__ Less than 1 hour per day
__ 1 hour per day
__ 2 hours per day
__ 3 hours per day
__ 4 hours per day
__ 5 or more hours per day

24. In an average week, on how many days do you go to the gym and exercise for at least 30 minutes?*
__ 0 days
__ 1 day
__ 2 days
__ 3 days
__ 4 days
__ 5 days
__ 6 days
__ 7 days

*These questions have been adapted from the 2013 State and Local Youth Risk Behavior Survey

Thank you for taking the time to complete this survey!

References

Adberg, G., Edman, G., & Rossner, S. (2008). Perceived hunger, palatability, and adherence: A comparison of high- and low-fat diets. *Obesity Research and Clinical Practice, 2,* 101-110. doi: 10.1016/j.orcp.2008.03.001

Agerstrom, J., & Rooth, D. (2011). The role of automatic obesity stereotypes in real hiring discrimination. *Journal of Applied Psychology*, *96*, 790-805. doi: 10.1037/a0021594

American College Health Association (2012). *National College Health Assessment: Fall 2012 Reference Group Executive Summary.* Retrieved from www.acha-ncha.org

Andajani-Sutjahjo, S., Ball, K., Warren, N., Inglis, V., & Crawford, D. (2004). Perceived personal social and environmental barriers to weight maintenance among young women: a community survey. *International Journal of Behavioral Nutrition and Physical Activity*, *1*, 15-21. doi: 10.1186/1479-5868-1-15

Anton, S.D., Martin, C.K., Han, H., Coulon, S., Cefalu, W.T., Geiselman, P., & Williamson, D.A. (2010). Effects of stevia, aspartame, and sucrose on food intake, satiety, and postprandial glucose and insulin levels. *Appetite*, *55*, 37-43. doi: 10.1016/j.appet.2010.03.009

Appleton, K.M., & Blundell, J.E. (2007). Habitual high and low consumers of artificially sweetened beverages: Effects of sweet taste and energy on short-term appetite. *Physiology & Behavior*, *92*, 479-486. doi: 10.1016/j.physbeh.2007.04.027

Bacon, L., & Aphramor, L. (2011). Weight science: Evaluating the evidence for a paradigm shift. *Nutrition Journal*, 10, 1-13. doi: 10.10.1186/1475-2891-10-9

Bays, H.E., Chapman, R.H., & Grandy, S. (2007). The relationship of body mass index to diabetes mellitus, hypertension, and dyslipidaemia: comparison of data from two national surveys. *International Journal of Clinical Practice*, *61*, 737-747. doi:10.1038/sj.ijo.0803015

Beck, B., Burlet, A., Max, J.P., & Stricker-Krongrad, A. (2002). Effects of long-term ingestion of aspartame on hypothalamic neuropeptide Y, plasma lepti and body weight gain and composition. *Physiology & Behavior, 75*, 41-47. doi: 10.1016/S0031-9384(01)00654-0

Bellar, A., Jarosz, P.A., & Bellar, D. (2008). Implications of the biology of weight regulation and obesity on the treatment of obesity. *Journal of the American Academy of Nurse Practitioners, 20,* 128-135. doi: 10.1111/j.1745-7599.2007.00299.x

Binkley, J., & Golub, A. (2007). Research report: Comparison of grocery purchase patterns of diet soda buyers to those of regular soda buyers. *Appetite*, *49*, 561-571. doi: 10.1016/j.appet.2007.03.225

Bish, C.L., Blanck, H.M., Serdula, M.K., Marcus, M., Kohl, H.W., & Khan, L.K. (2005). Diet and physical activity behaviors among Americans trying to lose weight: 2000 Behavioral Risk Factor Surveillance System, *Obesity Research*, *13*, 596-607. doi:10.1038/oby.2005.64

Bouchard, D.R., Ross, R., & Janssen, I. (2010). Coffee, tea and their additives: Association with BMI and waist circumference. *European Journal of Obesity*, *3*, 345-352. doi: 10.1159/000322915

Brashers, V.L., & Jones, R.E. (2010). Mechanisms of Hormonal Regulation. In K.L. McCance & S.E. Huether (Eds.), *Pathophysiology: The Biologic Basis for Disease in Adults and Children* (6th ed., pp. 696-726). St. Louis, MO: Mosby-Elsevier

Brown, A.W., Bohan, M.M., Onken, K.L., & Beitz, D.C. (2011). Short-term consumption of sucralose, a nonnutritive sweetener, is similar to water with regard to select markers of hunger signaling and short-term glucose homeostasis in women. *Nutrition Research*, *31*, 882-888. doi: 10.1016/j.nutres.2011.10.004

Brown, R.J., Walter, M., & Rother, K.I. (2009). Ingestion of diet soda before a glucose load augments glucagon-like peptide-1 secretion. *Diabetes Care*, *32*, 2184-2186. doi: 10.2337/dc09-1185

Burke, L.E., & Wang, J. (2011). Treatment strategies for overweight and obesity. *Journal of Nursing Scholarship*, *43*, 368-375. Doi: 10.1111/j.1547-5069.2011.01424.x

Carr, D., & Friedman, M.A. (2005). Is obesity stigmatizing? Body weight, perceived discrimination, and psychological well-being in the United States. *Journal of Health and Social Behavior*, *46*, 244-259. doi: 10.1177/002214650504600303

Carr, D., & Friedman, M.A. (2006). Body weight and the quality of interpersonal relationships. *Social Psychology Quarterly*, *69*, 127-149. doi: 10.1177/019027250606900202

Centers for Disease Control and Prevention (2005). *MMWR recommendations and reports: Public health strategies for preventing and controlling overweight and obesity in school and worksite settings*. Retrieved from http://www.cdc.gov

Centers for Disease Control and Prevention (2009). *MMWR weekly: State-specific obesity prevalence among adults.* Retrieved from http://www.cdc.gov

Centers for Disease Control (2012). Prevalence of Obesity in the United States, 2009-2010. *NCHS Data Brief*, no. 82. Retrieved from www.cdc.gov

Centers for Disease Control (2013). *Youth Risk Behavior Surveillance System*. Retrieved from www.cdc.gov

Citrome, L., Holt, R.I., Walker, D.J., & Hoffmann, V.P. (2011). Weight gain and changes in metabolic variables following olanzapine treatment in schizophrenia and bipolar disorder. *Clinical Drug Investigation*, *31*, 455-482. doi: 10.2165/11589060-000000000-00000

Colditz, G.A., Willett, W.C., Stampfer, M.J, London, S.J., Segal, M.R., & Speizer, F.E. (1990). Patterns of weight change and their relation to diet in a cohort of healthy women. *American Journal of Clinical Nutrition*, *51*, 1100-1105. Retrieved from www.ajcn.org

Crawford, A.G., Cote, C., Couto, J., Daskiran, M., Gunnarson, C., Haas, K., … Schuette, R. (2010). Prevalence of obesity, type II diabetes mellitus, hyperlipidemia, and hypertension in the United States: Findings from the GE Centricity electronic medical record database. *Population Health Management*, *13*, 151-161. doi: 10.1089/pop.2009.0039

Curioni, C.C., & Lourenco, P.M. (2005). Long-term weight loss after diet and exercise: a systematic review. *International Journal of Obesity*, *29*, 1168-1174. doi: 10.1038/sj.ijo.0803015

De la Pena, C. (2010). Artificial sweetener as a historical window to culturally situated health. *Annals of the New York Academy of Sciences*, *1190*, 159-165. doi: 10.1111/j.1749-6632.2009.05253.x

Department of Health Policy (2010). *A Heavy Burden: The Individual Costs of Being Overweight and Obese in the United States*. Retrieved from www.sphhs.gwu.edu

Duffey, K.J., & Popkin, B.M. (2006). Adults with healthier dietary patterns have healthier beverage patterns. *Journal of Nutrition*, *136*, 2901-2907. Retrieved from http://jn.nutrition.org

Fala, L (2012). *Belviq: A New Prescription Weight-loss Treatment for Overweight or Obese Patients.* Retrieved from www.ahdbonline.com

Farouk, A. (2013). Obesity as a Disease State: It's About Patient Health. *American Medical Association President's Blog*. Retrieved from www.ama_assn.org

Finley, C.E., Barlow, C.E., Greenway, F.L., Rock, C.L., Rolls, B.J., & Blair, S.N. (2007). Retention rates and weight loss in a commercial weight loss program. *International Journal of Obesity*, *31*, 292-298.

Fitch, C., & Keim, K.S. (2012). Use of nutritive and nonnutritive sweeteners. *Journal of the Academy of Nutrition and Dietetics, 112*, 739-758. doi: 10.1016/j.jand.2012.03.009

Forshee, B.A., Clayton, M.F., & McCance, K.L. (2010). Stress and disease. In K.L. McCance & S.E. Huether (Eds.), *Pathophysiology: The Biologic Basis for Disease in Adults and Children* (6th ed., pp. 336-359). St. Louis, MO: Mosby-Elsevier

Forshee, R.A., & Storey, M.L. (2003). Total beverage consumption and beverage choices among children and adolescents. *International Journal of Food Sciences and Nutrition*, *54*, 297-307. Retrieved from http://informahealthcare.com/journal/ijf

Foss, B., & Dyrstad, S.M. (2011). Stress in obesity: cause or consequence? *Medical Hypotheses, 77,* 7-10. doi: 10.1016/j.mehy.2011.03.011

Fowler, S.P., Williams, K., Resendez, R.G., Hunt, K.J., Hazuda, H.P., & Stern, M.P. (2008). Fueling the obesity epidemic? Artificially sweetened beverage use and long-term weight gain. *Obesity, 16*, 1894-1900. doi: 10.1038/oby.2008.284

Frank, G.K., Oberndorfer, T.A., Simmons, A.N., Paulus, M.P., Fudge, J.L., Yang, T.T., & Kaye, W.H. (2008). Sucrose activates human taste pathways differently from artificial sweetener. *Neuroimage*, *39*, 1559-1569. doi: 10.1016/j.neuroimage.2007.10.061

Fujita, Y., Wideman,, R., Speck, M., Asadi, A., King, D., Webbert, T., … Kieffer, T.(2009). Incretin release from gut is acutely enhanced by sugar but not by sweeteners in vivo. *American Journal of Physiology-Endocrinology and Metabolism*, *296*, 473-479. doi: 10.1152/ajpendo.90636.2008

Gardner, C., Wylie-Rosett, J., Gidding, S.S., Steffen, L.M., Johnson, R.K., Reader, D., & Lichtenstein, A.H. (2012). Nonnutritive sweeteners: Current use and health perspectives. A scientific statement from the American Heart Association and the American Diabetes Association. *Circulation*, 126, 509-519. doi: 10.2337/dc12-9002

Geraedts, M.C., Troost, F.J., & Saris, W.H. (2011). Different tastants and low cal sweeteners induce differential effects on the release of satiety hormones. *Food Chemistry*, *129*, 731-738. doi: 10.1016/j.foodchem.2011.05.013

Hall, K.D. (2008). What is the required energy deficit per unit weight loss? *International Journal of Obesity*, *32,* 573-576. doi: 10.1038/sj.ijo.0803720

Harvie, M.N., Pegington, M., Mattson, M.P., Frystyk, J., Dillon, B., Evans, G., …Howell, A. (2011). The effects of intermittent or continuous energy restriction on weight loss and metabolic disease risk markers: a randomized trial in young overweight women. *International Journal of Obesity, 35*, 714-727. doi: 10.1038/ijo.2010.171

Hendriksen, M., Mariken, T., Fransen, H., Verhagen, H., & Hoekstra, J. (2011). Impact of substituting added sugar in carbonated soft drinks by intense sweeteners in young adults in the Netherlands: example of a benefit-risk approach. *European Journal of Nutrition, 50,* 41-51. doi: 10.1007/s00394-010-0113-z.

Herrera, B.M., & Lindgren, C.M. (2010). The genetics of obesity. *Current Diabetes Reports, 10*, 498-505. doi: 10.1007/s11892-010-0153-z

Hsu, C.Y., McCulloch, C.E., Iribarren, C., Darbinian, J., & Go, A.S. (2006). Body mass index and risk for end-stage renal disease. *Annals of Internal Medicine*, *144,* 21-28. Retrieved from www.annals.org

Kanasaki, K., & Koya, D. (2011). Biology of obesity: lessons from animal models of obesity. *Journal of Biomedicine and Biotechnology*, *2011*, 1-11. doi: 10.1155/2011/197636

Kirschenbaum, D.S. (2005). Very-low-fat diets are superior to low-carbohydrate diets. *Patient Care*, *39*(11), 47-55. Retrieved from www.patientcareonline.com

Koh, H.K., Piotrowski, J.J., Kumanyika, S., & Fielding, J.E. (2011). Healthy people: A 2020 vision for the social determinants approach. *Health Education & Behavior, 38,* 551-557. doi: 10.1177/1090198111428646

Kramer, H., Cao, G., Dugas, L., Luke, A., Cooper, R., & Durazo-Arvizu, R. (2010). Increasing BMI and waist circumference and prevalence of obesity among adults with type 2 diabetes: the national health and nutrition examination surveys. *Journal of Diabetes and Its Complications*, *24*, 368-374. Retrieved from http://jdcjournal.com/

Kuhns, M., & McEwen, M. (2011). Theories from the behavioral sciences. In M. McEwen & E.M. Wills (Eds.), *Theoretical Basis for Nursing (*3rd ed., pp. 274-299). Philadelphia, PA: Lipincott Williams & Wilkins.

Landis, A.M., Parker, K.P., & Dunbar, S.B. (2009). Sleep, hunger, satiety, food cravings, and caloric intake in adolescents. *Journal of Nursing Scholarship*, *41*, 115-123. doi: 10.1111/j.1547-5069.2009.01262.x

Lim, U., Subar, A.F., Mouw, T., Hartge, P., Morton, L.M., Stolzenberg-Solomon, R., … Schatzkin, A. (2006). Consumption of aspartame-containing beverages and incidence of hematopoietic and brain malignancies. *Cancer Epidemiology, Biomarkers & Prevention*, *15*, 1654-1659. doi:10.1158/1055-9965.EPI-06-0203

Ma, J.C., Checklin, J., Jing Ma, H.L., Chang, J., Checklin, H.L., Young, R.L., … Rayner, C.K. (2010). Effect of the artificial sweetener, sucralose, on small intestinal glucose absorption in healthy human subjects. *British Journal of Nutrition*, *104*, 803-806. doi: 10.1017/S0007114510001327.

Mace, O.J., Affleck, J., Patel, N., & Kellett, G.L. (2007). Sweet taste receptors in rat small intestine stimulate glucose absorption through apical GLUT2. *Journal of Physiology*, *582*, 379-392. doi: 10.1113/jphysiol.2007.130906

Mahar, A., & Duizer, L.M. (2007). The effect of frequency of consumption of artificial sweeteners on sweetness liking by women. *Journal of Food Science*, *72*, 714-718. doi: 10.1111/j.1750-3841.2007.00573.x

Martinez, C., Gonzalez, E., Garcia, R., Salas, G., Constantino-Casas, F., Macias, L., … Duran-de-Bazua, C. (2010). Effects on body mass of laboratory rats after ingestion of drinking water with sucrose, fructose, aspartame, and sucralose additives. *Open Obesity Journal*, *2*, 116-124. Retrieved from www.benthamscience.com

Miljkovic, D., & Mostad, D. (2007). Obesity and low-carb diets in the United States: a herd behavior model. *Agribusiness*, *23*, 421-434. doi: 10.1002/agr.20131

Muennig, P., Haomiao, J., Rufina, L., & Lubetkin, E. (2008). I think therefore I am: Perceived ideal weight as a determinant of health. *American Journal of Public Health*, *98*, 501-506. doi: 10.2105/AJPH.2007.114769

Nagai, N., Sakane, N., Kotani, K., Hamada, T., Tsuzaki, K., & Moritani, T. (2011). Uncoupling protein 1 gene-3825 A/G polymorphism is associated with weight loss on a short-term, controlled-energy diet in young women. *Nutrition Research*, *31*, 255-261. doi: 10.1016/j.nutres.2011.03.010

Ong, C.R., & Younossi, Z.M. (2004). Nonalcoholic fatty liver disease and the epidemic of obesity. *Cleveland Clinic Journal of Medicine*, *71*, 657-664. Retrieved from ccjm.org

Phelan, S., Lang, W., Jordan, D., & Wing, R.R. (2009). Use of artificial sweeteners and fat-modified foods in weight loss maintainers and always-normal weight individuals. *International Journal of Obesity*, *33*, 1183-1190. doi: 10.1038/ijo.2009.147

Prospective Studies Collaboration (2009). Body-mass index and cause-specific mortality in 900,000 adults: Collaborative analyses of 57 prospective studies. *Lancet*, *373*, 1083-1096. Retrieved from www.thelancet.com

Puhl, R., & Brownell, K.D. (2006). Confronting and coping with weight stigma: An investigation of overweight and obese individuals. *Obesity*, *14*, 1802-1815. doi: 10.1038/oby.2006.208

Reid, M., Hammersley, R., & Hill, A.J. (2007). Long-term dietary compensation for added sugar: effects of supplementary sucrose drinks over a 4-week period. *British Journal of Nutrition*, *97*, 193-203. doi: 10.1017/S0007114507252705.

Reida, M., Hammersley, R., & Duffyc, M. (2010). Research report: Effects of sucrose drinks on macronutrient intake, body weight, and mood state in overweight women over 4 weeks. *Appetite*, *55*, 130-136. doi: 10.1016/j.appet.2010.05.001

Reinehr, T. (2010). Obesity and thyroid function. *Molecular and Cellular Endocrinology*, *316*, 165-171. doi: 10.1016/j.mce.2009.06.005

Ricci, J.A., & Chee, E. (2005). Lost productive time associated with excess weight in the U.S. workforce. *Journal of Occupational and Environmental Medicine*, *47*, 1227-1234. doi: 10.1097/01.jom.0000184871.20901.c3

Rosenstock, I.M. (1966). Why people use health services. *Milbank Memorial Fund Quarterly*, *44*(3), 94-124. doi: 10.1111/j.1468-0009.2005.00425.x

Roy, S.L., Davidson, T.L., & Swithers, S.E. (2007). The effects of high intensity sweeteners (saccharin and acesulfame potassium) on food intake and body weight regulation in rats. *Appetite*, *49*, 325-325. doi: 10.1016/j.appet.2007.03.171

Rudengaa, K.J., & Small, D.M. (2011). Short communication: Amygdala response to sucrose consumption is inversely related to artificial sweetener use. *Appetite*, *58*, 504-507. doi: 10.1016/j.appet.2011.12.001

Schafer, M.H., & Ferraro, K.F. (2011). The stigma of obesity: Does perceived weight discrimination effect identity and physical health? *Social Psychology Quarterly*, *74*, 76-97. doi: 10.1177/0190272511398197

Shaw, J.E., Punjabi, N.M., Wilding, J.P., George, K., Alberti, M.M., & Zimmet, P.Z. (2008). Sleep-disordered breathing and type 2 diabetes: A report from the international diabetes federation taskforce on epidemiology and prevention. *Diabetes Research and Clinical Practice*, *81*, 2-12. doi: 10.1016/j.diabres.2008.04.025

Shin, J.H., & Gadde, K.M. (2013). Clinical utility of phentermine/topiramate (Qsymia™) combination for the treatment of obesity. *Diabetes, Metabolic Syndrome, and Obesity*, *6*, 131-139. doi: 10.2147/DMSO.S43403

Shin, H., Shin, J., Liu, P., Dutton, G.R., Abood, D.A., & Ilich, J.Z. (2011). Self-efficacy improves weight loss in overweight/obese postmenopausal women during a 6-month weight loss intervention. *Nutrition Research*, *31*, 822-828. doi: 10.1016/j.nutres.2011.09.022

Steinert, R.E., Frey, F., & Topfer, A. (2011). Effects of carbohydrate sugars and artificial sweeteners on appetite and the secretion of gastrointestinal satiety peptides. *British Journal of Nutrition*, *105*, 1320-1328. doi: 10.1017/S000711451000512X

Stellman, S.D., & Garfinkel, L. (1988). Patterns of artificial sweetener use and weight change in an American cancer society prospective study. *Appetite*, *11*, 85-91. doi: 10.1016/S0195-6663(88)80051-5

Swithers, S.E., Martin, A.A., & Davidson, T.L. (2010). High-intensity sweeteners and energy balance. *Physiology & Behavior*, *100*, 55-62. doi: 10.1016/j.physbeh.2009.12.021

Taheri, S., Lin, L., Austin, D., Young, T., & Mignot, E. (2004). Short sleep duration is associated with reduced leptin, elevated grehlin, and increased body mass index. *Public Library of Science Medicine*, *1*, 210-217. doi: 10.1371/journal.pmed.0010062

Tandel, K.R. (2011). Sugar substitutes: health controversy over perceived benefits. *Journal of Pharmacology and Pharmacotherapeutics*, *2*, 236-243. doi: 10.4103/0976-500x.85936

Tsai, A.G., Williamson, D.F., & Glick, H.A. (2011). Direct medical cost of overweight and obesity in the USA: a quantitative systematic review. *Obesity Reviews*, *12*, 50-61. doi: 10.1111/j.1467-789X.2009.00708.x

Turk, M.W., Yang, K., Hravnak, M., Sereika, S.M., Ewing, L.J., & Burke, L.E. (2009). Randomized clinical trials of weight-loss maintenance: A review. *Journal of Cardiovascular Nursing, 24*, 58-80. doi: 10.1097/01.JCN.0000317471.58048.32

United States Census Bureau (2012). *USA Quick Facts*. Retrieved from quickfacts.census.gov

United States Department of Agriculture (2010). *Dietary Guidelines for Americans*. Retrieved from www.health.gov

United States Department of Health and Human Services (2012). *Healthy People 2020*. Retrieved from www.healthypeople.gov.

University of North Florida (2011). *UNF Student Handbook 2011-2012*. Retrieved from www.unf.edu

University of North Florida (2012). *Fall 2012 Student Data*. Retrieved from www.unf.edu

Welsh, E.M., Jeffery, R.W., Levy, R.L., Langer, S.L., Flood, A.P., Jaeb, M.A., & Laqua, P.S. (2011). Measuring perceived barriers to healthful eating in obese, treatment-seeking adults. *Journal of Nutrition Education and Behavior*, 1-6. Advance online publication. doi:10.1016/j.jneb.2010.06.005

Wing, R.R., & Phelan, S. (2005). Long-term weight loss maintenance. *American Journal of Clinical Nutrition, 82*, 2225-2255. Retrieved from www.ajcn.nutrition.org

Wollitzer, A.O., Jovanovic, L., & Petitt, D.J. (2004). Adolescent obesity is associated with excess consumption of diet soda [Abstract]. *Diabetes, 53*, 599-600. Retrieved from http://professional.diabetes.org

World Health Organization (1997). *Obesity: Preventing and managing the global epidemic.* Retrieved from www.cdc.gov