THE EFFECTS OF EATING PERIODICITY ON WEIGHT LOSS

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BS, Pennsylvania State University, 1999

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Submitted to the Graduate Faculty of

The Department of Health and Physical Activity in partial fulfillment

of the requirements for the degree of

Doctor of Philosophy

University of Pittsburgh

2005

UNIVERSITY OF PITTSBURGH

FACULTY OF EDUCATION

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July 28th, 2005

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There is some evidence that eating periodicity is inversely associated with the onset of obesity. Eating periodicity in obese individuals engaging in weight loss efforts has not been well studied. The purpose of this study was to examine the pattern of eating periodicity in obese adults engaging in weight loss efforts, and to examine the relationship between eating periodicity and subsequent changes in body weight.

Seventy five sedentary overweight adults were recruited to participate in this study. Individuals were considered eligible if they were 18 to 55 years of age with a body mass index of 25.0 to 39.9 kg/m^2. The subjects for this study were part of a 20-week sub-investigation of an ongoing 18-month clinical weight loss trial. Subjects were weighed at 0, 12, and 20-weeks, and were instructed to complete daily food logs that included the frequency of eating episodes.

Analysis revealed significant weight loss of -6.3 ± 4.3 kg (-6.6 ± 4.2 %) from baseline to week 12 (n=63; $p < 0.01$), with weight loss of -8.6 ± 5.8 kg (-9.2 ± 5.8 %) observed from baseline to week 20 (N = 55; $p < 0.01$). Analyses indicated significant inverse correlations between total meals and snacks consumed and absolute body weight change at 12- and 20-weeks (-0.39 and -0.40, respectively, $p<0.05$), indicating that an increase in meal periodicity was associated with a lower body weight. However, eating periodicity was not significantly associated with absolute or relative magnitude of weight loss.

This study demonstrated a significant, inverse correlation between meal periodicity and absolute body weight. These findings may be important because they may suggest eating periodicity can influence body weight by allowing for the maintenance of a lower body weight.

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PREFACE

I would first like to thank my advisor, Dr. John Jakicic; without his guidance, this project would not have been possible. Dr. Jakicic generously shared his expertise and devoted endless hours in helping see this project through to completion in a timely manner. He never hesitates to put everything aside for the students he mentors, and is always there to provide the necessary guidance.

I would also like to thank my committee members, Dr. Bret Goodpaster, Dr. Betsy Nagle, and Dr. Amy Otto. The contributions they all made helped make this project what it is. Without their thoughts and ideas, I would still be searching for an endpoint to this project.

The entire staff at the Physical Activity and Weight Management Research Center also deserves a thank you for their assistance in carrying out this project. In particular, everyone who helped me enter the seemingly endless data; I may still be working on that if it was not for you. Mike McDermott also deserves a big thank you for compiling the data and setting up the necessary databases.

Thank you also to my friends who were always there to support me. Finally, I of course have to thank all of my family for their unconditional love. Especially my parents and brother who have always been there to support, push, and encourage me to follow my dreams. Thank you all for helping make me who I am.

1. INTRODUCTION

"Eating periodicity" is defined as an eating occasion that provides at least 50 kilocalories (kcals) and is separated by at least 15 minutes with a proceeding or follow up eating event (Gibney & Wolever, 1997). There is some evidence from animal studies and observational studies that eating periodicity is inversely associated with the onset of obesity. However, eating periodicity in obese individuals engaging in weight loss efforts has not been well studied. Therefore, the purpose of this study was to examine the pattern of eating periodicity in obese adults engaging in weight loss efforts, and to examine the relationship between eating periodicity and subsequent changes in body weight. This investigation was conducted as a sub-investigation of an ongoing, clinical weight loss trial conducted at the Physical Activity and Weight Management Research Center at the University of Pittsburgh.

Overweight and obesity are associated with the onset of significant health problems and have risen to epidemic levels over the past few decades (Hedley et al., 2004). The prevalence of overweight, defined as a body mass index (BMI) of 25 to 29.9 kg/m^2, has increased substantially to in excess of 65% of adults (Hedley et al., 2004). Obesity, defined as a BMI of $\geq 30.0\ kg/m^2$ now affects in excess of 30% of adults (Hedley et al., 2004). This is of concern because both overweight and obesity are precursors to numerous major health problems including, but not limited to, cardiovascular disease, type II diabetes mellitus, hypertension, sleep apnea, dyslipidemia, osteoarthritis, and many cancers (Kopelman, 2000). Therefore, it is important to better understand behavioral patterns which contribute to the development of overweight and obesity, and to examine the contribution of behaviors in the treatment of overweight and obesity.

Energy balance is an important aspect of a successful weight loss program (Prentice, 1996) and research has demonstrated that energy balance may be affected by eating behaviors such as increased eating periodicity (Drummond, Crombie, Cursiter, & Kirk, 1998; Speechly & Buffenstein, 1999; Speechly, Rogers, & Buffenstein, 1999). There is some evidence that this may impact the onset of overweight and obesity. While the exact mechanism(s) remain elusive, it has been suggested that this may be due to better appetite control, decreased binge eating, improved glucose regulation, and/or the thermic effect of feeding. However, little is known about the impact of eating periodicity on weight loss. Thus, the contribution of this 24-week sub-investigation was to observe the pattern of eating periodicity in overweight adults and the potential role of eating periodicity on short term weight loss. Furthermore, this investigation also sought to examine the relationship between eating periodicity and binge eating.

1.1. Rationale

There is a paucity of data regarding the effects of eating periodicity on weight loss in humans; however, the research that has been conducted is promising. Eating periodicity in humans during weight loss may be an interesting and important research question because of the potential of eating periodicity to impact energy intake, which can contribute to energy balance and body weight regulation. If shown to be effective for reducing energy intake and enhancing weight loss, this may impact intervention recommendations for the prevention and treatment of obesity.

Early studies of eating periodicity conducted by Fabry et al (Fabry, Hejl, Fodor, Braun, & Zvolankova, 1964) examined the relationship among eating frequency and body weight, serum cholesterol, and glucose-tolerance among 61 men. The researchers ascertained that body weight and blood cholesterol increased, and glucose tolerance decreased, with concurrent decreases in reported eating periodicity. This provides initial scientific support of the potential importance of eating periodicity on the regulation of body weight.

More recently, Ma et al examined data from the large, prospective Seasonal Variation of Blood Cholesterol Study (SEASONS) (Ma et al., 2003). From the cross-sectional data collected, the researchers examined the relationship between eating periodicity and obesity while controlling for both physical activity and energy intake. The results from this study demonstrated that subjects who consumed four or more eating episodes per day versus three or fewer eating episodes per day had a significant 45% lower risk of obesity. Furthermore, data from early animal studies have shown that the distribution of meals throughout a 24-hour period has a positive effect on weight stabilization, overall energy metabolism as well as several biochemical measures, such as glucose and fat absorption, and increased lipogenesis (Braun, Kohout, & Fabry, 1967; Fabry & Braun, 1967).

While there are published data to support the importance of eating periodicity on controlling body weight (Braun et al., 1967; Fabry et al., 1964; Ma et al., 2003), not all studies support these conclusions (Summerbell, Moody, Shanks, Stock, & Geissler, 1996; Verboeket-van de Venne & Westerterp, 1991). This may be a result of limitations in study design and the inability to control for confounding variables (Bellisle, McDevitt, & Prentice, 1997). For example, it is suggested that the results are difficult to interpret because of the lack of total energy intake and activity measurements among many of these studies (Willett, 1990).

There are several additional gaps in the literature regarding eating periodicity and weight management. No published study to our knowledge has attempted to examine the effects of eating periodicity on weight loss during a behavioral, weight loss intervention. Thus, the effects of eating periodicity, in a free-living environment, on weight loss and overall energy intake are not well understood. This study was conducted to address those gaps in the scientific literature by examining the pattern of eating periodicity in overweight and obese adults, and by examining the relationship of eating periodicity and weight loss during a behavioral weight loss intervention. These results may lead to modifications to intervention strategies to address the obesity epidemic.

1.2. Specific Aims

The primary aim of this study was to:

1. Examine the relationship between eating periodicity and weight loss in overweight and obese adults.

The secondary aims of this study were to:

2. Examine the relationship between eating periodicity and energy intake in free-living, overweight and obese individuals prior to and during weight loss.
3. Examine the relationship between eating periodicity and baseline binge eating in free-living overweight and obese adults.

1.3. Research Hypotheses

1.3.1. Primary Hypothesis:

1. Eating periodicity will be inversely related to weight loss during a 20-week intervention.

1.3.2. Secondary Hypotheses:

1. There will be an inverse relationship between eating periodicity and energy intake prior to and during weight loss in overweight and obese adults.
2. There will be an inverse relationship between eating periodicity and baseline binge eating and weight loss in overweight and obese adults.

1.4. Significance of the Study

Obesity is a significant public health problem with over 65% of the population overweight or obese (Hedley et al., 2004). It is recommended that behavioral interventions elicit weight loss through the combination of a decrease in energy intake and increase in energy expenditure (Jakicic et al., 2001). Changing eating and activity behaviors in individuals is challenging as evidenced by typical weight regain following initial weight loss (Phelan, Hill, Lang, Dibello, & Wing, 2003). Therefore, health professionals are continually trying to learn new behaviors that may facilitate positive behavior change.

Therefore, it is important to continue to examine strategies to enhance adoption and maintenance of behaviors that will impact weight management. However, evidence exists that increased eating periodicity may be associated with decreased body weight and lower BMI's (Braun et al., 1967; Fabry et al., 1964; Ma et al., 2003). However, this connection has yet to be investigated in overweight or obese humans actively trying to lose weight. Therefore, it is not known if eating periodicity is truly associated with weight loss over the short-term. Subsequently, if it is determined there is a link between eating periodicity and weight loss, interventions may be developed to incorporate this strategy into interventions to improve the prevention and treatment of overweight and obesity.

"Meal periodicity" is defined as an eating occasion that provides at least 50 kilocalories (kcals) and is separated by at least 15 minutes with a proceeding or follow up eating event (Gibney & Wolever, 1997). There is some evidence from animal studies and observational studies that meal periodicity is inversely associated with the onset of obesity. However, meal periodicity in obese individuals engaging in weight loss efforts has not been well studied. Therefore, the purpose of this study is to examine the pattern of meal periodicity in obese adults engaging in weight loss efforts, and to examine the relationship between meal periodicity and subsequent changes in body weight. This investigation is to be conducted as a sub-investigation of an ongoing, clinical weight loss trial being conducted at the Physical Activity and Weight Management Research Center at the University of Pittsburgh.

Overweight and obesity are associated with the onset of significant health problems and have risen to epidemic levels over the past few decades (Hedley et al., 2004). The prevalence of overweight, defined as a body mass index (BMI) of 25 to 29.9 $kg \bullet m^2$, has increased substantially to in excess of 65% of adults (Hedley et al., 2004). Obesity, defined as a BMI of ≥ 30.0 $kg \bullet m^2$ now affects in excess of 30% of adults (Hedley et al., 2004). This is of concern because both overweight and obesity are precursors to numerous major health problems including, but not limited to, cardiovascular disease, non-insulin dependent diabetes mellitus, hypertension, sleep apnea, dyslipidemia, osteoarthritis, and many cancers (Kopelman, 2000). Therefore, it is important to better understand behavioral patterns which contribute to the development of overweight and obesity, and to examine the contribution of behaviors to the treatment of overweight and obesity.

Energy balance is an important aspect of a successful weight loss program (Prentice, 1996) and research has demonstrated that energy balance may be affected by eating behaviors such as increased meal periodicity (Drummond et al., 1998; Speechly & Buffenstein, 1999; Speechly et al., 1999). There is some evidence that this may impact the onset of overweight and obesity. However, little is known about the impact of meal periodicity on weight loss. Thus, the contribution of this 12-week sub-investigation will be to provide an understanding of the pattern of meal periodicity in overweight adults and the potential role of meal periodicity on short term weight loss.

2. REVIEW OF THE LITERATURE

2.1. Introduction

The purpose of this study was to examine the pattern of eating periodicity in obese adults engaging in weight loss efforts, and to examine the relationship between eating periodicity and subsequent changes in body weight. There is little consistency among the literature regarding the effects of eating periodicity and weight loss. One primary reason for this confusion is the lack of consistency among researchers in differentiating between a "meal" and a "snack" (Gibney & Wolever, 1997).

Eating periodicity has been defined as increased snacking and increased meal consumption. Foltin (1992) attempted to differentiate between snacks and meals, and defined a snack as the between-meals consumption of any item contained within a box of food not requiring preparation time, whereas a meal was defined as the consumption of any of the items that required preparation time, including frozen foods and sandwiches, alone or in combination with any of the snack food items. More recently, researchers attempted to differentiate between the two with a more specific definition looking solely at energy provided from eating occasions rather than labeling meals or snacks (Gibney & Wolever, 1997). In this literature review, "meal periodicity" was defined as an eating occasion that provides at least 50 kilocalories (kcals) and is separated by at least 15 minutes with a proceeding or follow up eating event.

The term "eating periodicity" has been chosen for this review of the literature to reduce any confusion when differentiating between a meal and a snack since there is no standard definition. However, when referring to specific research studies, the term selected in the respective investigation will be used. This investigation was to be conducted as a sub-investigation of an ongoing clinical weight loss trial. The following literature provides support for the importance of this research question.

2.1.1. Prevalence of Obesity

Obesity is a major health concern. The most recent statistics from the National Health and Nutrition Examination Survey (NHANES) reveal that in 1999-2002, 65.1% of adult Americans were either overweight or obese and 30.4% were obese (Hedley et al., 2004). This increase in obesity was across the entire United States; men and women of all ages, races, and educational levels. The NHANES data set also showed that 33.0% of adults were at a healthy weight (BMI, 18.5-24.9 $kg \bullet m^2$), which is slightly above half of the Healthy People 2010 target goal for 60% of adults to be at a healthy weight (Hedley et al., 2004).

Obesity continues to be a major health concern and growing epidemic (Hedley et al., 2004). It is understood that certain behaviors must be modified to initiate and ultimately maintain weight loss (e.g., social support, goal setting, stimulus control, planning meals, etc) (Wing, 2002). In addition, these behavioral changes must be accompanied by shifts in energy balance (Jakicic et al., 2001).

Energy balance is achieved when energy intake matches energy expenditure. Weight loss can be achieved through a modest reduction in energy intake and an increase in energy expenditure (Jakicic et al., 2001). Behavioral weight loss programs, which have incorporated a balance-deficit diet into the intervention, are more effective in terms of overall weight loss (Jakicic, Winters, Lang, & Wing, 1999; Wadden, Foster, & Letizia, 1994; Wing et al., 1996). Energy reductions of 500 to 1000 kcal/day are common, as many behavioral weight loss interventions aim to reduce energy intake to 1000 to 1500 kcal/day among individuals averaging 200 pounds (Jakicic et al., 2001).

Studies have also demonstrated that much larger energy deficits (400-800 kcal/day) can produce double the weight loss of conventional 1200 kcal/day diets (Wadden et al., 1994). These very-low-calorie diets (VLCD) have also been shown to be safe when used under medical supervision. Wadden et al (1994) compared a balanced deficit diet (BDD) to a VLCD in a 78-week study. Subjects randomized to the BDD group consumed a 1200 kcal/day diet. The VLCD group consumed 1200 kcal/day for the first week, 420 kcal for weeks 2-17 using a liquid formula, 1000 kcal for weeks 18-23 while reintroducing more conventional foods, and 1200 kcal for weeks 24-52. All subjects received a 26-week (weeks 53 to 78) maintenance program where subjects were instructed to adjust their energy intake to match their weight loss goals, as long as they did not consume less than 1200 kcal. The results of this study demonstrated that during the initial 17-weeks, subjects in the VLCD lost approximately double the weight of those in the BDD (20.5 ± 7.3 kg vs. 9.1 ± 6.2 kg, respectively). However, because of weight regain, there was no significant difference in weight loss at week 52 between the groups (BDD = 14.4 ± 9.5 kg; VLCD = 17.3 ± 9.9 kg) or at week 78, after the 26-week maintenance program (BDD = 12.2 ± 8.2 kg; VLCD = 10.9 ± 10.0 kg).

The results of this study demonstrate that while there may be some short-term advantages to VLCD's, there does not appear to be long-term advantages to such large energy reductions because of weight regain. However, subjects in the BDD group also gained weight back during the maintenance component of this program. While the short-term differences between VLCD's and BDD's are apparent, there appears to be no significant differences with regards to long-term weight loss. This demonstrates the need to identify other behavioral strategies that may facilitate weight loss and prevent weight regain. Eating periodicity may be one component of a behavioral weight loss program that can play an important role in the treatment of overweight and obesity and the short-term patterns of eating periodicity during weight loss were examined in this study.

2.2. Eating Periodicity Overview

Literature has suggested that the pattern of eating periodicity may play a role in the overall treatment of overweight and obesity (Cross, Babicz, & Cushman, 1994; Jenkins et al., 1989; Ma et al., 2003; Schlundt, Hill, Sbrocco, Pope-Cordle, & Sharp, 1992). However, no study to date has prospectively measured the potential impact of eating periodicity in individuals currently engaging in weight loss efforts. If it is determined that eating periodicity is a determinant of success during weight loss efforts, interventions may be developed to impact this particular behavior.

Eating periodicity has attracted attention since the 1930's, when it was first investigated for its use in those with diabetes (Ellis, 1934). Follow-up studies have investigated the effects of eating periodicity on a number of other health outcomes, including overweight and obesity (Fabry et al., 1964). One study in the area measured the correlation among eating periodicity and bodyweight, hypercholesteremia and diminished glucose-tolerance in 61 men (Fabry et al., 1964).

Recruited subjects were interviewed by a dietitian regarding their meal habits. Subjects were subsequently divided according to their number of reported meals per day (Group I ate three meals or less per day; Group II at three to four meals; Group III ate three to four meals with snacks between them; Group IV ate three to four meals with an additional snack before bedtime; and group V ate 5 or more meals per day). The researchers concluded that each of the outcome measures (body weight, cholesterol and glucose) tended to increase as the frequency of meals decreases. Furthermore, the difference between body weight was significant among subjects in

Group I vs. Group III ($p < 0.02$), Group I vs. Group V ($p < 0.01$), and Group II vs. Group III ($p < 0.05$). While the differences in body weight were reported to be statistically significant, no specific data was provided from this early work limiting the ability to extrapolate these findings.

Another early study hypothesized that those who increased the frequency of eating episodes during a 24-hour period would be less overweight or obese compared to those who consumed the same total energy, but ate fewer, larger meals. Metzner and colleagues (1977) utilized data from a long-term epidemiological study of 948 males (79.7 ± 12.7 kg; 46.4 ± 10.4 year of age) and 1080 females (66.0 ± 13.7 kg; 45.6 ± 11.1 years of age) (Metzner, Lamphiear, Wheeler, & Larkin, 1977). All subjects completed a 24-hour dietary recall given by a trained interviewer. In addition, body weights and skinfolds were measured at the examination time. The main outcome variable in this study was the adiposity index (AI), which was calculated from the values obtained from the following calculations:

AI Males=34+22600 (kg/cm^2)+0.740*(sum of subscapular and triceps skinfolds in mm)

AI Females=34+24200(kg/cm^2)+0.571*(sum of subscapular and triceps skinfolds in mm)

This particular index was used because it "describes the observed weight relative to the median with an adjustment from skinfolds for body build and degree of musculature" (Metzner et al., 1977). The researchers found that when adjusting for energy intake, there was a significant negative correlation between AI and number of eating episodes. The AI was significantly reduced as the number of meals increased from two to six. This was true for both men and women. The researchers did note that the AI was lowest for both men and women who consumed only 1 meal per day; however, it was noted that few respondents reported eating only once per day (n =6), therefore it is unclear if this reflects a representative pattern or reflects random variation. The results from this epidemiological study provide further evidence that there is a potential connection between eating periodicity and body fatness.

In 1997, a workshop was held to discuss eating periodicity and human health. Within the confines of this workshop, numerous variables were explored with regards to current questions and controversies regarding this topic. Research presented at this workshop provided a review of eating periodicity and its effects on energy balance (Bellisle et al., 1997), while others discussed the cultural aspects of meal size and frequency (Chiva, 1997; de Castro, 1997), as well as the internal and external factors that relate to eating periodicity (Waterhouse, Minors, Atkinson, & Benton, 1997).

There was a unanimous conclusion by the co-chairs of the conference that much of the early work on eating periodicity and its relation to overweight and obesity must be questioned due to methodological flaws (Gibney & Wolever, 1997). For example, the trend of the overweight and obese is to underreport (Heymsfield et al., 1995; Lara, Scott, & Lean, 2004; Ortega et al., 1996); therefore, early studies that relied solely on self-report may not provide a true estimate of actual behaviors. However, while self-report has inherent errors, there is clear evidence of their importance in a weight loss program (Boutelle & Kirschenbaum, 1998; Jakicic et al., 2001) and thus self-report was one measure utilized in this protocol. However, for the purposes of this investigation, self-report was not used to calculate energy intake, but instead eating frequency. This may reduce the error since subjects will not be asked to report amounts of food consumed, but rather if they ate throughout the day. In addition, an eating periodicity questionnaire was utilized as a second measurement instrument to assess behaviors to better understand the eating patterns of subjects.

2.2.1. Effect of Eating Periodicity on Energy Intake

Energy balance is a crucial component of a weight loss regimen; if energy intake is less than energy expenditure, a person will lose weight. Similarly, if energy intake is greater than energy expenditure, a person will gain weight. There are a number of factors that may affect energy balance, such as temporal distribution of dietary intake, and researchers are investigating the impact of those factors (de Castro, 2004; Jenkins et al., 1989; Johnstone, Shannon, Whybrow, Reid, & Stubbs, 2000; Lawton, Delargy, Smith, Hamilton, & Blundell, 1998).

Some researchers suggest the availability of commercially available “snack foods” in addition to the social and cultural acceptance of snacking have both led to an increase in energy intake (Booth, 1988; Gatenby, 1997). On the contrary, several research studies have demonstrated that the temporal distribution of energy may lead to compensatory adjustments in eating behaviors, thereby reducing energy intake (Johnstone et al., 2000; Speechly & Buffenstein, 1999; Speechly et al., 1999; Westerterp-Plantenga, Wijckmans-Duysens, & ten Hoor, 1994).

Johnstone et al (2000) noted that there is little evidence that draws a definitive correlation between snacking and obesity. This recent study is one of the few prospective studies to specifically intervene in subjects with regards to meal periodicity. Eight healthy, non-smoking men (27.3 ± 6.4 years of age; 76.5 ± 10.2 kg) volunteered for this study. Resting metabolic rate was measured to determine baseline energy needs. In addition, body weights were obtained on all subjects each morning of the study and subjects completed visual analogue scales to assess changes in appetite, hunger, and satiety. Subjects were provided maintenance diets on days one and two. During the subsequent seven days (days three to nine), subjects were provided ad libitum access to foods to meet their energy needs. Subjects were randomized into either "snack" or "no-snack (NS)" conditions. In addition, snacking conditions were separated into high carbohydrate (HC), high protein (HP), or high fat (HF) to also determine if the composition of the snack affected any of the outcome measures. "High" in this case meant 70% of the food was comprised of the specific macronutrient. Snack in this study was defined as "a small inter-meal ingestive event." Those in the snacking group consumed 30% of total energy from snacks. There were no significant differences in body weights between days three and nine (gains of 0.5 kg ± 0.1 [HP] and 0.3 ± 0.1 kg [HC] and losses of 0.2 ± 0.1 kg [NS] and 0.03 ± 0.04 kg [HF]). On the contrary, there were significant differences in total energy intake among conditions (11.7 MJ [HP], 11.7 MJ [HC], 12.2 MJ [HF] and 13.9 MJ [NS], (p=0.007) (Note: 1 MJ = 239 kcal; therefore, HP = 2796 kcal, HC = 2796 kcal, HF = 2916 kcal, NS = 3322 kcal). Therefore, adding mandatory snacks decreased the total amount of food consumed at meals, although the composition of the snack did not significantly affect total energy intake. Longer research studies are necessary to ascertain this potential relationship since the short duration of this study and numerous experimental variables make it difficult to interpret the conclusions.

Contrary to the aforementioned study where normal weight individuals compensated for their between meal feedings, some researchers suggest that people who are overweight and particularly obese, tend to consume the same amount of energy at meals, regardless of between meal feedings, which would suggest that eating between meals may actually increase total energy intake (Drummond, Crombie, & Kirk, 1996; Johnstone et al., 2000). On the contrary, though, Speechly (1999) noted that obese men ate less at an ad libitum meal after consuming small, frequent meals (Speechly et al., 1999). There is clearly little consensus among scientists warranting more research in this area.

Speechly et al (1999) examined the effects of meal periodicity on appetite reduction in obese men (37.4 ±18.5 years of age; BMI = 40.02 ± 10.93 kg/m^2) (Speechly et al., 1999). Researchers provided subjects isoenergetic diets, divided into either one large meal or five smaller meals over a five hour period in a controlled environment. The men in the five-meal group consumed 27% less energy in a subsequent ad libitum meal than those in the single meal group. This provides evidence that obese individuals may also control their energy intake when energy is more evenly distributed on a daily basis. It is unclear, however, how obese men would react in an uncontrolled environment, filled with a variety of dietary options and other psychological factors and if this compensation would affect body weight.

An epidemiological study was recently published using data from the Seasonal Variation of Blood Cholesterol Study (SEASONS) (Ma et al., 2003). SEASONS was conducted to determine the effect of seasonal variations on blood lipids and determine the mediators of change. From the cross-sectional data collected, the researchers measured the relation between meal periodicity and obesity, while controlling for both physical activity and energy intake. Data from 499 men and women were utilized in this study. To reduce the inaccuracies often cited with dietary and physical activity recalls (Lara et al., 2004; Mela & Aaron, 1997) researchers increased the frequency of data collection (13.4 ± 1.5 dietary recalls per subject) during a one-year period and randomized the times of collection. Using the aforementioned definition of an eating occasion (Gibney & Wolever, 1997), researchers analyzed the dietary data to eliminate the variation among subjects who may classify their eating episode as either a "meal" or a "snack." Researchers determined the average number of eating episodes each day for subjects was 3.92 ± 0.8, with an average total energy intake of 2,259 ± 540 kcals for men and 1,641 ± 363 kcals for women. Data from this study showed that subjects who reported four or more eating episodes per day versus three or fewer eating episodes per day had a significant 45% lower risk of being obese. The authors chose three meals as a cutoff as this is the standard number of meals individuals consume.

In a cross-sectional study by Drummond et al (1998), it was determined that there may in fact be gender differences in eating frequency and energy intake (Drummond et al., 1998). Forty-eight men and 47 women (BMI: 18 to 30 kg/m^2) took part in this study. Men who snacked tended to compensate for their energy intake at meals, so there was no increase in energy intake. In addition, the researchers also found that men showed a negative correlation between eating frequency and body weight (the higher the frequency, the lower the body weight). On the contrary, women who ate the greatest number of meals each day also had the highest energy intake; women did not compensate for the increase in meal frequency like men. However, this did not correlate to any change in body weight. The authors concluded that the lack of correlation between meal periodicity and body weight was due to the fact that women who had a higher energy intake also had greater energy expenditure from physical activity to compensate for the additional energy intake.

A more recent investigation by Rolls et al (2004) and presented only in abstract form, suggested that varying the energy density and portion size of foods served over a specified time period influenced overall energy intake and satiety. Twenty four women ate an ad libitum diet consisting of breakfast, lunch, and dinner in a laboratory and were provided evening snacks to take home for two consecutive days over a four-week period. Although the same foods were provided each week, the foods varied in either energy density (standard or reduced by 30%) or portion size (standard or reduced by 25%). Results showed that reducing the energy density of foods led to a significant 23% reduction in energy intake (544 kcal). Similarly, by reducing the portion sizes of foods, subjects reduced their energy intake significantly by 12% (256 kcal). The authors concluded that when smaller portions of less energy dense foods were served, energy intake was approximately 800 kcal less during ad libitum feedings. This suggests that by eating smaller portions and less energy dense foods during eating episodes, individuals may be able to reduce their overall energy intake, subsequently assisting with weight loss.

It is understood that disturbances to the energy balance equation are ultimately the most important components of a weight loss program. Researchers are trying to determine what factors and behavioral mechanisms play a role in disrupting the energy balance equation. The above studies provide evidence that there may be a relationship between eating periodicity and the etiology of obesity, but the influence of eating patterns and the physiological aspects of obesity are not well understood.

2.2.2. Effects on Satiety

Humans do not eat solely to sustain energy needs. Factors such as stress, boredom, and social activities may also cause individuals to eat (Chiva, 1997; de Castro, 1997). Moreover, work with animals has demonstrated that declines in blood glucose concentrations may precede an eating episode (Campfield & Smith, 1986, 1990; Louis-Sylvestre & Le Magnen, 1980). Similar feeding pattern responses have been replicated in humans as well (Bernstein, Zimmerman, Czeisler, & Weitzman, 1981) and studies have also demonstrated that macronutrient intake and volume might effect subsequent food choices (Rolls et al., 1994; Rolls, Roe, & Meengs, 2004).

Rolls et al (1994) tested both obese and normal-weight, restrained and unrestrained individuals, to ascertain the satiating effects of a “preload” (snack before a meal) with different amounts of fat and carbohydrate (Rolls et al., 1994). The term “snack” was not specifically defined in this study, but provides less total energy than the "meals." There is also evidence that obese individuals consume higher intakes of dietary fat than normal weight individuals (Mela & Sacchetti, 1991). Therefore, including obese individuals in this study is of importance to determine if there is any difference with regards to the effects of macronutrients on satiety among humans of various BMI's. The subjects were provided with yogurts, which provided varying amounts of energy and macronutrients to determine if subjects would restrain their subsequent intake at the next meal after eating different amounts and types of foods. The yogurts provided the following energy and macronutrients: control (161.0 kcal), medium carbohydrate and medium fat (262.5 kcal each), and high carbohydrate and high fat (357.0 kcal each).

It was determined that for the normal weight unrestrained and obese unrestrained females, lunch intake in the no pre-load condition ate significantly more at the next meal (lunch) than the other conditions ($p < 0.05$). This finding was not the same in normal-weight, unrestrained males who adjusted their intakes down after the high-energy yogurts were consumed compared with the low-energy yogurts. In addition, when comparing the satiating efficiency of the different yogurt types (higher carbohydrate vs. higher fat), the yogurt with the greater amount of carbohydrate demonstrated a significantly greater satiating power. Similarly, it was determined that subjects who consumed the higher fat preload did not compensate by consuming less fat at the next meal. This suggests that lower-fat foods (or preloads) may assist with overall energy reduction since fat provides more energy per gram than carbohydrate or protein. These findings suggest that some individuals may compensate their energy intake after preloads (snacks) due to satiating power.

Another similar study measured the satiating effects of different liquid preloads before lunch (Rolls et al., 1998). Twenty, healthy, young males (28 ± 1.5 years of age; BMI 23.3 ± 0.3 kg/m^2) participated in a four-day study in which subjects were provided with three meals per day (breakfast, lunch and dinner) on each of the days. On three out of four days, subjects received a milk-based preload before lunch and on the fourth day, subjects received no preload.

The preloads varied in volume providing 300-, 450-, or 600-mL per drink, but were isoenergetic, to determine if the different volumes affected subsequent energy intake. There was a significant difference among the energy intake of lunch meals after subjects consumed the beverages (no preload = 4323 ± 322 kJ; 300 mL preload = 3175 ± 321 kJ; 600 mL preload 2923 ± 300 kJ ($p < 0.05$).

This too suggests that a preload may affect satiety to the point where individuals reduce their overall energy intake at the subsequent meal. It also suggests that the higher the volume of the food or beverage, the greater the satiating power. These results are difficult to extrapolate to overweight and obese populations, however, so work with these populations is important.

2.2.3. Effects on Binge Eating

There are a number of diagnostic criteria to help define binge eating disorder (BED). According to the American Psychiatric Association, the first component of BED is “eating during a discrete period of time (e.g., within any 2-hour period), an amount of food that is definitely larger than most people would eat during a similar period of time under similar circumstances.” The second diagnostic criterion utilized is “a sense of lack of control over eating during the episode” (e.g., a feeling that one cannot stop eating or control what or how much one is eating).

2.3. Summary

Obesity is an epidemic (Hedley et al., 2004). Although numerous factors can contribute to weight gain, these factors ultimately result in a shift in energy balance. If a person consumes more than they expend, they will gain weight. The traditional behavioral approach to obesity is to reduce energy intake to 1000 to 1500 kcal/day (Jakicic et al., 1999; Wadden et al., 1994; Wing et al., 1996). In addition, individuals are encouraged to increase their energy expenditure through regular physical activity.

Research is now focused on ways to enhance this shift in the energy balance equation; trying to get individuals to take in less energy and expend more. There have been a variety of attempts at various weight loss programs; VLCDs have been shown to be effective in the short term (Wadden et al., 1994), but no better than traditional programs in the long-term.

One correlation researchers have noted is between eating periodicity and body weight (Ma et al., 2003). Several studies have suggested that increased eating periodicity is correlated to a decrease in body weight and BMI (Drummond et al., 1996; Ma et al., 2003; Metzner et al., 1977). However, most of these studies or reviews were conducted in a research facility or metabolic ward, with controlled foods and energy intakes to specifically control for any confounding variables that may affect satiety and other parameters. Often the intervention and control diets were isoenergetic and foods were provided. This of course limits the ability to extrapolate the findings.

Moreover, much of the available literature is on young, healthy, normal weight males. There is no prospective study to date that has considered the eating periodicity of individuals currently engaging in a weight loss program. If it is determined there is a link between eating periodicity and weight loss, interventions may be developed to incorporate this strategy into interventions to improve the prevention and treatment of overweight and obesity.

3. METHODS

3.1. Introduction

There is some evidence that eating periodicity is inversely associated with obesity. However, eating periodicity in obese individuals engaging in weight loss efforts has not been well studied. Therefore, the purpose of this study was to examine the pattern of eating periodicity in obese adults engaging in weight loss efforts, and to examine the relation between eating periodicity and subsequent short-term changes in body weight across a 12-week intervention.

3.2. Subjects

Seventy five sedentary overweight adult women and men were recruited to participate in this study as part of a larger ongoing clinical trial. Individuals were considered eligible if they were 18 to 55 years of age with a body mass index (BMI) of 25.0 to 39.9 kg/m^2. Subjects were recruited using television-, newspaper- and radio-advertisements, and mailings. The subjects for this study were part of a 20-week sub-investigation of an ongoing 18-month clinical weight loss trial. The following criteria were also used to exclude individuals in the main study. The same eligibility criteria were also applied to individuals in the present study.

3.2.1. Exclusionary Criteria Included:

1. Reported weight loss of > 5% in the previous 12 months.
2. Reported participating in a research project involving weight loss or physical activity in the previous 12 months.

3. Reported participating in another research study that may impact the current proposal or the current project of which the potential subject was involved.
4. Reported exercising regularly for $\geq$ 20 minutes per day on $\geq$ 3 days per week over the previous 3 months.
5. Individuals who were pregnant, reported pregnancy during the previous 6 months, or who planned on becoming pregnant in the following 18 months.
6. Being treated for a medical condition that could impact body weight (i.e., diabetes mellitus, cancer, etc.).
7. A history of myocardial infarction or a history of undergoing heart surgery (e.g., bypass, etc).
8. Taking medication that would affect heart rate or blood pressure responses to exercise (e.g., beta blockers).
9. Taking medication that could affect metabolism and/or weight loss (e.g., synthroid).
10. Being treated by a therapist for psychological issues or problems, taking pyschotropic medications, or receiving treatment with psychotropic medications within the previous 6 months.

3.3. Experimental Design

This investigation was a 20-week sub-investigation of an ongoing 18-month weight loss trial conducted through the Physical Activity and Weight Management Research Center at the University of Pittsburgh. The sub-investigation was an observational study where subjects' eating habits were observed for 12-weeks. The larger trial continued for another 15 months after completion of the sub-investigation.

Seventy five subjects were recruited in one cohort and were randomized to one of the following weight loss groups. There were 25 individuals in each group, who were randomized to one of the following intervention conditions:

1. standard behavioral weight loss program (SBWP).
2. weight loss group who received enhanced behavioral strategies for increasing exercise during the initiation phase of the intervention (EX-ADOPT).
3. weight loss group who received enhanced behavioral strategies for increasing exercise at predetermined points throughout the maintenance phase of the intervention (EX-MAINTAIN).

Over the 18-month period there were some variation among the groups; however, each group received the same energy, fat and physical activity recommendations and these differences were subtle during the 20-week sub-investigation. These subtle differences among groups were not expected to affect the outcome of this 20-week sub-investigation. The main differences between groups occurred during the timing of when the groups received various interventions as part of the larger investigation (e.g., phone calls from the staff to promote physical activity, exercising at the Center, or a pedometer campaign to promote physical activity, etc). All subjects received the same menus and it was recommended that they follow the provided menus for the initial 8 to 12 weeks of participation. These menus included suggestions for three well-balanced meals; snacks were recommended if individuals needed to increase their intake to meet their energy and fat recommendations.

The University of Pittsburgh Institutional Review Board approved the ongoing clinical trial and the specific addendums for the sub-investigation. Prior to participation in this investigation, all subjects signed an informed consent. In addition, all subjects provided written medical clearance from their personal physician prior to participating in the study.

Subjects underwent a series of baseline assessments, including: weight and height, completion of a snacking questionnaire, as well as the Gormally Questionnaire (Gormally, Black, Daston, & Rardin, 1982) to measure binge eating. These assessments are described in detail below (see section 3.4). Throughout the 20-week intervention period, subjects were weighed on a weekly basis; however only the baseline and 12 and 20-week data were used in the analyses. The other aforementioned anthropometric data and questionnaires were only collected at baseline and 12-weeks. In addition, subjects were instructed to complete daily food logs that included the frequency of eating episodes (meals and snacks). The data obtained from these diaries was used to assess meal patterns and was used in the analyses to determine the effect of meal periodicity on weight loss.

3.3.1. Intervention Components

Treatment included both a dietary and exercise component, with the specific dietary and exercise goals identical for all groups (see below). The only variation during the 20-week sub-investigation was with one of the three groups, while the other two received identical treatments. The variation among the one group and the other two is that subjects in that group received weekly phone calls from the staff for the 12-week sub-investigation. Because all groups received the same dietary and exercise components of the program, it was not expected that additional phone calls from the staff would impact the results of the sub-investigation.

3.3.2. Standard Intervention Schedule and Delivery of Group Intervention

All subjects, regardless of group assignment, received components of a standard behavioral weight loss program. The behavioral program was delivered in a group format that has demonstrated success in past weight loss programs. During 20-weeks of the sub-investigation, subjects attended weekly group sessions. During that time, the initial 15 minutes were allotted to obtain a weekly weight on participants, collect weekly eating and exercise diaries, return previous eating and exercise diaries, and to distribute participant materials. The remaining 45 minutes were utilized to deliver the behavioral intervention. This consisted of addressing behavioral strategies for modifying eating and exercise behaviors, and structured group interactions led by exercise physiologists and/or registered dietitians.

3.3.3. Standard Dietary Intervention

The dietary component of the proposed intervention targeted reductions in calorie and fat intake, and were based on interventions that have been successfully implemented in prior studies. Subjects were instructed to reduce calorie intake to 1200 or 1500 calories per day, with fat intake reduced to 20% of total caloric intake (26 to 33 grams per day). Subjects ≤ 200 pounds at baseline were instructed to reduce calorie intake to 1200 kcal/d, whereas those >200 pounds at baseline were instructed to reduce caloric intake to 1500 kcal/d. These intake levels allowed for a 1 to 2 pound weight loss per week, which is consistent with recommendations from the American College of Sports Medicine (Jakicic et al., 2001).

The underlying philosophy of the dietary intervention was to facilitate weight loss while also assisting the individual to adopt long lasting healthful eating behaviors. Subjects were provided with meal plans that allowed for a significant amount of choices to accommodate different food preferences. Subjects were provided with three to four complete plans for each meal from which they could choose. They were also provided with snacks to choose from, and both meal plans and snacks allowed for sufficient variety.

Subjects were instructed to self-monitor their food intake on a daily basis. The subjects were provided a diary each week to be used for this purpose, and an example of this diary is provided in Appendix A. Subjects were encouraged to weigh and measure all of their food consumption, and were instructed to use food labels and reported levels of calorie and fat. Subjects were also provided with "The Complete and Up To Date Fat Book" (Bellerson, 2001). Food diaries were returned to the investigators on a weekly basis for review. The investigators provided feedback to patients regarding food choices, meal preparation, and eating behaviors. However, specific feedback related to eating periodicity was not provided. The food diaries were collected for intervention purposes as this has been shown to be an effective behavioral strategy to enhance participation and weight loss. In addition, one component of the diaries was to capture frequency of eating episodes as there are specific questions related to eating periodicity contained within the diaries.

3.3.4. Standard Exercise Intervention

The basic exercise intervention was similar across all treatment conditions. The goal of the exercise intervention was to progressively increase exercise participation to a minimum of 200 minutes per week, and this was based on findings that $\geq$200 minutes of exercise per week is associated with improvements in long-term weight loss. The progression of the exercise is commonly used in behavioral weight loss clinical trials. It was recommended that subjects participate in exercise on 5 days per week, with the exercise progressing from 20 minutes per day at the onset of treatment to 40 minutes per day by the 9th week of treatment. All subjects in the study received the same exercise prescription.

Subjects were instructed to participate in activity that was at least moderate in intensity, with intensity set at a minimum of 11 to 13 on the 15-point RPE scale and/or heart rate prescribed at 60 to 70% of maximal heart rate. Activities that are consistent with this intensity level are activities similar to “brisk walking”.

Subjects recorded their exercise in an exercise log that was part of the diary that was used for dietary intake (see Appendix A). Similar to the dietary records, these exercise records were reviewed by the investigators on a weekly basis, and written feedback was provided to participants.

3.4. Assessments

3.4.1. Weight

Body weight was assessed at 0 and 12-weeks for the sub-investigation. Subjects were clothed in a lightweight hospital gown, with weight measured to the nearest 0.25 lbs between 7:00 AM and 10:00 AM. All subjects were told to fast for at least 12-hours prior to their assessment. Body weight was measured using a calibrated medical balance-beam scale (Health-O-Meter Inc., Bridgeview, IL).

3.4.2. Height

Height was measured using a calibrated, wall mounted stadiometer (Perspective Enterprises, Inc., Kalamazoo, MI). Subjects were instructed to remove their shoes for this measurement. This measurement was only completed at baseline and height was recorded to the nearest 0.1 cm.

3.4.3. Dietary Intake

Dietary intake was assessed using weekly diaries collected from the participants. Food logs were completed daily and submitted on a weekly basis.

3.4.4. Eating Periodicity Questionnaire

A questionnaire developed to monitor participants meal periodicity was used at baseline and at week 12 (Appendix B). This questionnaire was developed at the Physical Activity and Weight Management Research Center. The questionnaire asks specific questions about dietary intake habits, the types of foods typically eaten throughout the day, how frequently participants eat breakfast, and their reasons for increasing their meal periodicity (physiologically hungry, bored, etc).

3.4.5. Binge Eating Behavior

The Gormally Questionnaire (Gormally et al., 1982) was used at baseline to determine if binge eating predicted eating periodicity (e.g., if someone eats more frequently throughout the day, do they binge less often at baseline) at week 12 and week 20.

3.4.6. Statistical Analyses

The statistical analysis was conducted using SPSS statistical software (version 12.0), with statistical significance defined as $p \leq 0.05$. Data was initially analyzed to provide descriptive information on the subject characteristics (age, body weight, BMI, etc.), the pattern of eating periodicity, and energy intake. Analyses were also conducted to determine if the outcome data of this study were normally distributed prior to conducting additional analyses.

Data were analyzed using dependent t-tests to determine changes in the outcome variables from baseline to 12-weeks. The primary and secondary hypotheses were tested using correlation analysis. Data were normally distributed; therefore, Pearson Product Correlation Coefficients were computed to determine the relation between eating periodicity and the outcome variables of interest (body weight, energy intake, binge eating). Correlation coefficients were computed to examine the relationship between variables at baseline, at 12- and 20-weeks, and across the change from baseline to 12- and 20-weeks.

3.4.7. Power Analysis

A power analysis was conducted to determine if the 75 subjects available for this study would provide adequate statistical power to examine the primary outcome of this sub-study. Based on an available sample of 75 subjects, and assuming the possibility of 15 percent attrition, this would allow for 64 subjects to complete this study. This sample size would allow for correlations of 0.40 to be detected with at least 0.95 statistical power. Moreover, this sample size would allow for 0.80 statistical power to detect a correlation of 0.30 in this study.

3.4.8. Retention

In addition to the monetary compensation provided for subjects as part of the 18-month clinical trial, subjects were paid an additional $20.00 each in order to complete the 20-week assessment for this sub-investigation. These funds were obtained from a University of Pittsburgh School of Education Grant.

4. RESULTS

The purpose of this study was to examine the pattern of eating periodicity in obese adults engaging in a weight loss intervention, and to examine the relation between eating periodicity and changes in body weight across a 12-week weight loss intervention. Moreover, this study examined whether eating periodicity within the initial 12-weeks of a weight loss intervention was predictive of weight loss at 20-weeks of the intervention. This was an observational study conducted within the context of a larger randomized clinical trial. The independent variable was eating periodicity. The primary dependent variable was change in percent and absolute body weight, with dietary intake considered as a secondary variable. Moreover, the association between baseline binge eating and eating periodicity was examined.

4.1. Subject Characteristics

Table 1: Baseline Characteristics of Subjects (n=73)

Variable	All Subjects	Male	Female
Age (years)	43.4 ± 7.6	44.1 ± 7.9	43.3 ± 7.6
Height (cm)	165.6 ± 8.3	181.1 ± 7.3	164.0 ± 6.6
Weight (kg)	92.8 ± 11.8	110.8 ± 9.2	90.9 ± 10.3
Body Mass Index (kg/m^2)	33.8 ± 2.9	33.8 ± 2.8	33.8 ± 3.0
% Minority Representation	27% (n= 20)	29% (n=2)	27% (n=18)

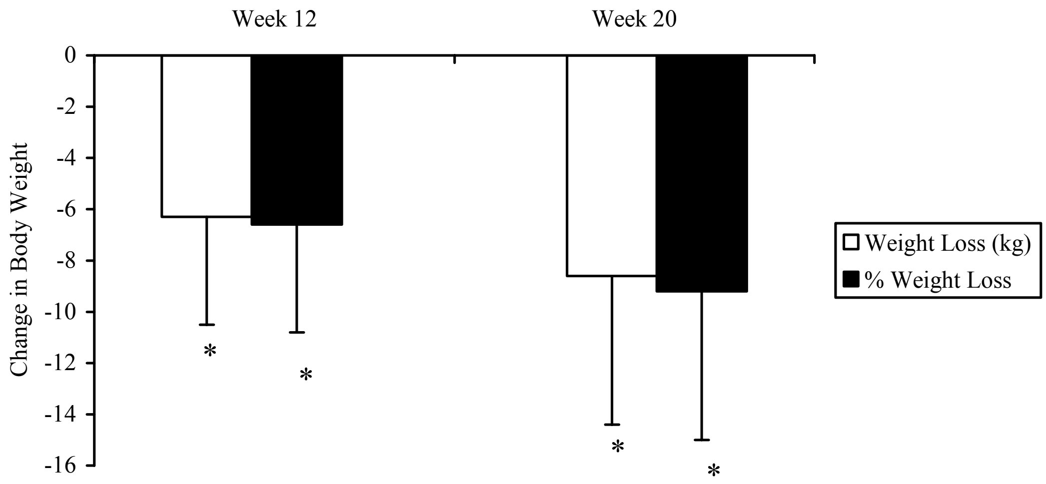
The subjects in this investigation were 73 overweight men and women (66 females and 7 males) participating in a behavioral weight loss intervention at the Physical Activity and Weight Management Research Center at the University of Pittsburgh. Subjects were between 18 and 55 years of age, with a BMI ranging from 25 to 40 kg/m^2. Subject characteristics are shown in

4.2. Subject Retention

Seventy three subjects initiated participation in this study and two individuals were lost to follow-up at 12-weeks. Additional missing or incomplete data included: body weight at week 12 ($n = 8$), body weight at week 20 ($n=16$), self-reported eating behaviors for weeks 1 to 3 ($n=1$), self-reported eating behaviors for weeks 4 to 6 ($n=4$), self-reported eating behaviors for weeks 7 to 9 ($n=5$), and self-reported eating behaviors for weeks 10 to 12 ($n= 8$). Therefore, complete data (body weight and self-reported meals, snacks, calories and fat) from 63 subjects were used for week 12 analyses and data from 55 subjects were used for week 20 analyses in this investigation.

4.3. Change in Body Weight

Repeated measures analysis of variance (ANOVA) revealed a significant weight loss of -6.3 ± 4.3 kg (-6.6 ± 4.2 %) from baseline to week 12 ($n=63$; $p < 0.01$) for change in body weight. Weight loss was significantly reduced by -8.6 ± 5.8 kg (-9.2 ± 5.8 %) from baseline to week 20 ($N = 55$; $p < 0.01$). These results are shown in Figure 1.



* indicates significantly different from Baseline, p< 0.01

Figure 1: Change in Body Weight from Baseline to Week 12 (n=63) and Week 20 (n=55)

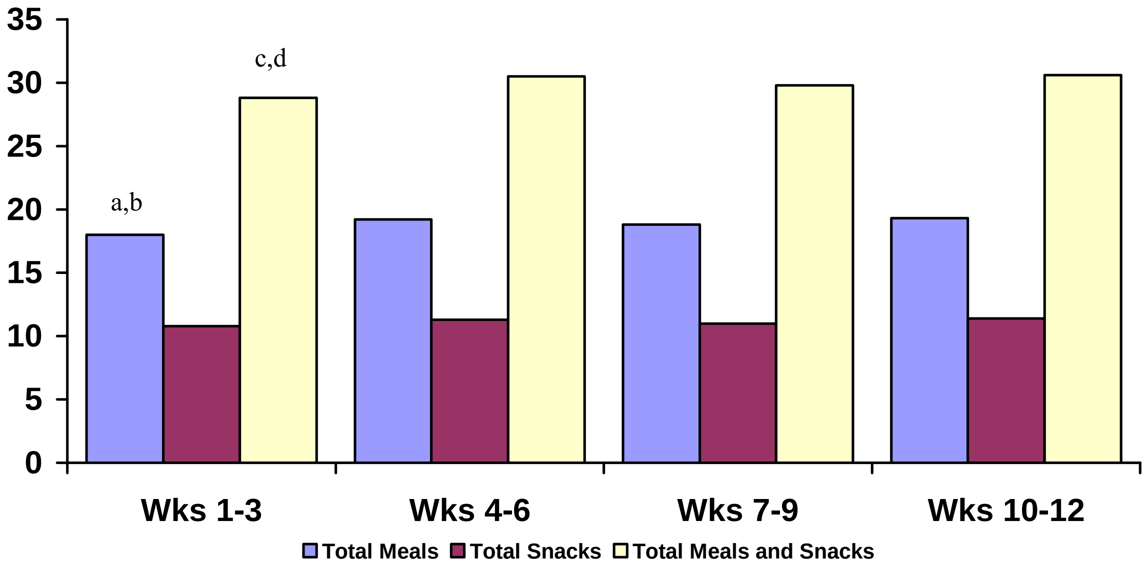
4.4. Change in Eating Periodicity

Eating periodicity during Weeks 1 to 12 is shown in Figure 2. Data were divided into quartiles based on weeks (weeks 1 to 3, 4 to 6, 7 to 9, and 10 to 12) for analyses. A repeated measures analysis of variance (ANOVA) revealed a significant time-effect from baseline to week 12 ($p < 0.01$) for meals, snacks, and meals plus snacks. Subsequent analyses were conducted to determine during which weekly quartiles the meals, snacks, or meals plus snacks there was a change that resulted in these significant time effects. Because of multiple comparisons for each variable (1 to 3 vs. 4 to 6, 1 to 3 vs. 7 to 9, 1 to 3 vs. 10 to 12, 4 to 6 vs. 7 to 9, 4 to 6 vs. 10 to 12, 7 to 9 vs. 10 to 12), the critical p-value was adjusted based on these multiple comparisons (0.05 / 6 comparisons = 0.008).

ANOVA revealed a main effect for time when examining the number of meals per week across the four weekly quartiles ($p<0.05$). Participants reported 18.0 ± 1.9, 19.2 ± 1.9, 18.8 ± 2.2, and 19.3 ± 2.4 meals per week during weeks 1 to 3, 4 to 6, 7 to 9, and 10 to 12, respectively. Subsequent analyses indicated a significant difference for number of meals per week between weeks 1 to 3 (18.0 ± 1.9 meals/week) and weeks 4 to 6 (19.0 ± 2.2 meals/week) ($p < 0.008$). There were also significant differences between weeks 1 to 3 (18.0 ± 1.9 meals/week) and weeks 10 to 12 (19.3 ± 2.4 meals/week) ($p < 0.008$). There were no other significant differences between any of the other weekly quartiles for total number of meals per week (see Figure 2).

ANOVA did not reveal a main effect for time when examining the number of snacks per day across the four weekly quartiles ($p < 0.05$). Participants reported 10.8 ± 3.4, 11.3 ± 3.8, 11.0 ± 4.0, and 11.4 ± 4.0 snacks per week during weeks 1 to 3, 4 to 6, 7 to 9, and 10 to 12, respectively. The types of snacks individuals reported eating at baseline and week 12 are listed in Appendix C.

When total meals and snacks were added together (meals plus snacks), ANOVA revealed a significant time effect across the four weekly quartiles ($p < 0.05$). Participants reported 28.8 ± 4.4, 30.5 ± 4.7, 29.8 ± 5.0, and 30.6 ± 5.3 meals per week during weeks 1 to 3, 4 to 6, 7 to 9, and 10 to 12, respectively. Subsequent analyses indicated a significant difference for number of meals plus snacks per day between weeks 1 to 3 (28.7 ± 4.6 meals plus snacks per week) and weeks 4 to 6 (30.0 ± 5.2 meals plus snacks per week) ($p < 0.008$). There was also a significant difference between weeks 1 to 3 (28.8 ± 4.5 meals plus snacks per day) and weeks 10 to 12 (30.7 ± 5.2 meals plus snacks per day) ($p < 0.0008$). There were no other significant differences between any of the other weekly quartiles for total number of meals per day (see Figure 2).



a indicates eating periodicity for total meals is significantly different from Weeks 4-6, within the same variable, p<0.008
b indicates eating periodicity for total meals and snacks is significantly different from Weeks 10-12 within the same variable, p< 0.008
c indicates eating periodicity for total meals and snacks is significantly different from Week 4-6, within the same variable, p < 0.008
d indicates eating periodicity for total meals and snacks is significantly different from Week 10-12, within the same variable, p < 0.008

4.5. Absolute Weight Change (kg)

Pearson Product Moment Correlation Coefficients were calculated to determine the relationship between change in body weight and percent weight change with dietary intake over the 12-week period. Correlations are presented in Table 2. Weight change from baseline to week 12 was significantly correlated with average fat intake/day for weeks 1 to 3 and weeks 7 to 9 ($r=0.27$, and 0.31, respectively, $p < 0.05$) and weeks 4 to 6, $r=0.34$, $p<0.01$). There was no significant correlation between weight change at week 12 and fat intake/day during weeks 10 to 12 or from weeks 1 to 12. In addition, no other variables were correlated with 12-week weight change. Mean calories per day at any time point between weeks 1 to 12 were not significantly correlated with week 20 weight change. Mean fat intake from weeks 7 to 9 was significantly inversely associated with body weight change at week 20 ($r = -0.36$, $p < 0.05$). There was no association between total meals and snacks at any time period and change in body weight at week 12 or week 20 ($p < 0.05$).

4.6. Percent Weight Change

Percent weight change from baseline to week 12 was significantly correlated with average fat intake/day for weeks 1 to 3 ($r=0.31$, $p<0.05$), 4 to 6, and 7 to 9 ($r=0.39$ and 0.35, respectively, $p<0.01$). There was no significant correlation between weight change at week 12 and fat intake/day during weeks 10 to 12 or from weeks 1 to 12. No other variables were significantly correlated to percent weight loss at week 12. During weeks 1 to 3 and 10 to 12, average fat/day was significantly correlated to percent weight loss at week 20 ($r=0.27$ and 0.30, $p<0.05$). It was also significant from weeks 7 to 9 ($r=0.42$, $p<0.01$). At weeks 1 to 3, 4 to 6 and from weeks 1 to 12, average kcals/day were negatively associated with percent weight loss; however, these values were not significant. Similarly, there were negative correlations between total meals and snacks and percent weight loss at weeks 4 to 6, 7 to 9, and 1 to 12; these were also not significant, however.

Table 2: Correlations between Change in Body Weight and Eating Periodicity

	Body Weight Change at Week 12	Body Weight Change at Week 20

	(n=63)		(n=55)	
Weeks 1 to 3	Weight Loss (kg)	Weight Loss (%)	Weight Loss (kg)	Weight Loss (%)
Average Kcals/d	-0.05	-0.01	-0.12	-0.09
Average Fat/d	0.27*	0.31*	0.24	0.27*
Average Meals/week	0.13	0.13	0.11	0.10
Average Snacks/week	0.17	0.11	0.12	0.05
Total Meals and Snacks/quarter	0.18	0.14	0.14	0.08
Weeks 4 to 6				
Average Kcals/d	-0.14	-0.09	-015	-0.10
Average Fat/d	0.34**	0.39**	0.38	0.44
Average Meals/week	-0.20	-0.25*	-0.20	-0.25
Average Snacks/week	0.17	0.11	0.10	0.03
Total Meals and Snacks/quarter	0.06	-0.01	0.00	-0.07
Weeks 7 to 9				
Average Kcals/d	-0.14	-0.08	-0.12	-0.05
Average Fat/d	0.31*	0.35**	0.36*	0.42**
Average Meals/week	0.41	-0.02	0.04	-0.02
Average Snacks/week	0.03	-0.02	-0.01	-0.06
Total Meals and Snacks/quarter	0.04	-0.02	0.01	-0.05
Weeks 10 to 12				
Average Kcals/d	-0.10	-0.03	-0.03	0.06
Average Fat/d	0.18	0.22	0.25	0.30*
Average Meals/week	-0.06	-0.06	-0.01	-0.02
Average Snacks/week	0.05	0.02	0.04	0.01
Total Meals and Snacks/quarter	0.01	-0.01	0.02	-0.01
Weeks 1 to 12				
Average Kcals/12 weeks	-0.13	-0.07	-0.09	-0.03
Average Fat/12 weeks	-0.03	0.09	-0.08	0.03
Average Meals/week	-0.04	-0.07	-0.01	-0.10
Average Snacks/week	0.15	-0.05	0.10	0.03
Total Meals and Snacks	-0.04	-0.09	0.03	-0.06

Note: bodyweight calculated pre - post
*indicates significance at $p < 0.05$
**indicates significance at $p < 0.01$

4.7. Relationships between Absolute Body Weight and Eating Periodicity

4.7.1. Week 12 Body Weight

Correlations between body weight assessed at Week 12 and eating periodicity (average and total meals and snacks) are presented in Table 3. A significant correlation between average fat intake and body weight ($r=0.35$, $p<0.01$) and a significant negative correlation between total meals and snacks and body weight ($r = -0.39$, $p<0.05$) was observed from weeks 1 to 12. During weeks 4 to 6, significant negative correlations were observed between body weight and average meals per week ($r=-0.31$, $p<0.05$) and average snacks per week ($r=-0.29$, $p < 0.05$). There were also significant negative correlations between total meals and snacks per quarter and body weight at weeks 4 to 6 ($r=-0.36$, $p< 0.01$) and at weeks 7 to 9 ($r=-0.25$, $p < 0.05$).

4.7.2. Week 20 Body Weight

Body weight assessed at week 20 was significantly inversely correlated with average meals per week during weeks 1 to 3 ($r=-0.51$, $p < 0.05$). Average fat intake during the remaining three quarters (weeks 4 to 6, weeks 7 to 9, and weeks 10 to 12) were all significantly associated with change in body weight at week 20 ($r=0.41$, $p<0.01$, $r=0.31$, $p<0.05$, and $r=0.31$, $p<0.05$, respectively). There were non-significant negative associations between average meals and average snacks at both weeks 7 to 9 and weeks 10 to 12. When meals and snacks were totaled, however, there were significant negative correlations at weeks 4 to 6 ($r=-0.42$, $p<0.01$), weeks 7 to 9 ($r=-0.30$, $p<0.05$), and from weeks 1 to 12 ($r=-0.40$, $p <0.05$).

Table 3: Correlations between Absolute Body Weight and Eating Periodicity

	Body Weight at Week 12 (n=63)	**Body Weight at Week 20 (n=55)**
Weeks 1 to 3	Weight Loss (kg)	Weight Loss (kg)
Average Kcals/d	0.17	0.07
Average Fat/d	0.13	0.20
Average Meals/week	-0.04	-0.51
Average Snacks/week	-0.22	-0.28*
Total Meals and Snacks/quarter	-0.18	-0.23
Weeks 4 to 6		
Average Kcals/d	0.18	0.11
Average Fat/d	0.30	0.41**
Average Meals/week	-0.31*	-0.34
Average Snacks/week	-0.29*	-0.35**
Total Meals and Snacks/quarter	-0.36**	-0.42**
Weeks 7 to 9		
Average Kcals/d	0.18	0.19
Average Fat/d	0.17	0.31*
Average Meals/week	-022	-0.26
Average Snacks/week	-0.20	-0.25
Total Meals and Snacks/quarter	-0.25*	-0.30*
Weeks 10 to 12		
Average Kcals/d	0.24	0.25
Average Fat/d	0.18	0.31*
Average Meals/week	-0.04	-0.04
Average Snacks/week	-0.21	-0.19
Total Meals and Snacks/quarter	-0.17	-0.16
Weeks 1 to 12		
Average Kcals/12 weeks	0.19	0.17
Average Fat/12 weeks	0.35**	0.32*
Average Meals/week	-0.21	-0.21
Average Snacks/week	-0.31*	-0.33*
Total Meals and Snacks	-0.39*	-0.40*

Note: bodyweight calculated pre - post
*indicates significance at $p < 0.05$
**indicates significance at $p < 0.01$

4.7.3. Binge Eating

The correlation among binge eating, eating periodicity, and the ability to predict weight change is shown in Table 4. There was a significant inverse correlation between binge eating score and absolute weight at week 20 ($r = -0.27$, $p<0.05$) and average calories/day across week 1 to week 12. There were significant positive correlations between binge eating score and average snacks per week ($r = 0.29$, $p < 0.05$) and average meals per week across weeks 1 to 12 ($r = 0.29$, $p < 0.05$).

Table 4: Correlation between Binge Eating, Body Weight, and Eating Periodicity

	Binge Eating Score at Baseline
Absolute Weight at Week 12	-0.23
Absolute Weight at Week 20	-0.27*
Change in Body Weight at Week 12	-0.15
Change in Body Weight at Week 20	-0.24
Average Kcals/Day, Week 1-12	-0.28*
Average Fat/Day, Weeks 1-12	0.19
Average Meals/Week across Weeks 1-12	0.19
Average Snacks/Week across Weeks 1-12	0.29*
Average Meals & Snacks/Week across Weeks 1-12	0.29*

*indicates significance at $p < 0.05$

5. DISCUSSION

5.1. Introduction

There is evidence to support an inverse relationship between increased eating periodicity, which includes frequency of meals and snacks, and decreased risk of overweight and obesity (Braun et al., 1967; Fabry et al., 1964; Ma et al., 2003). Data from the Ma et al (2003) study showed that subjects who reported four or more eating episodes per day versus three or fewer eating episodes per day had a significant 45% lower risk of being obese. Similarly, Speechly et al (1999) examined the effects of meal periodicity on appetite reduction in obese men (37.4 ±18.5 years of age; BMI = 40.02 ± 10.93 kg/m). Researchers provided subjects isoenergetic diets, divided into either one large meal or five smaller meals over a five hour period in a controlled environment. The men in the five-meal group consumed 27% less in a subsequent ad libitum meal than those in the single meal group. This provides evidence that obese individuals may also control their energy intake when energy is more evenly distributed on a daily basis.

Despite this relationship, there are limitations to these previous studies which may impact the application of these findings to clinical settings. These limitations include examination of this relationship in animal models rather than humans, a restricted range of body mass index (BMI) in human studies, the cross-sectional design of these investigations, and that they were conducted in a controlled laboratory setting versus in free-living humans (Campfield & Smith, 1986, 1990; Gibney & Wolever, 1997; Johnstone et al., 2000; Louis-Sylvestre & Le Magnen, 1980; Ma et al., 2003). Because of these limitations, it is difficult to determine if frequency in eating periodicity affects changes in body weight.

Factors such as stress, boredom, and social activities may also cause individuals to eat (Chiva, 1997; de Castro, 1997). Moreover, animal studies have demonstrated that declines in blood glucose concentrations may precede an eating episode (Campfield & Smith, 1986, 1990;

hLouis-Sylvestre & Le Magnen, 1980). Similar feeding pattern responses have been replicated in humans as well (Bernstein et al., 1981) and studies have also demonstrated that macronutrient intake and volume might effect subsequent food choices (Rolls et al., 1994; Rolls et al., 2004).

Therefore, future research should consider expanding the length of the observation period, as this may provide valuable insight into the pattern of eating periodicity in overweight adults and the potential long-term impact of this eating pattern on weight control. The current study was designed to primarily examine the effect of eating periodicity on changes in body weight at 12 and 20 weeks of a behavioral weight loss intervention in overweight adults. To our knowledge, the present investigation is the first to examine the relationship between eating periodicity and weight change in overweight or obese humans actively engaging in weight loss efforts.

5.2. Conclusions

Results of this study demonstrated a weight loss of 6.3 $\pm$ 4.3 kg (6.6 $\pm$ 4.2 %) at 12-weeks and 8.6 $\pm$ 5.8 kg (9.2 $\pm$ 5.8%) at 20-weeks of the behavioral intervention that was implemented (see Figure 1). These weight losses are similar to the weight loss typically achieved in behavioral interventions of this length (Wing, 2002). In addition, participants in this study reported consuming 18.8 $\pm$ 1.6 meals/week, 13.1 $\pm$ 2.8 snacks/week, and 32.0 $\pm$ 3.9 meals + snacks/week across the intervention period (see Figure 2). These data were used to examine the primary aim of this study.

It is important to note that the addition of even one meal per day over the course of a year could add to up to a significant amount of weight. It is estimated that one pound of body fat represents 3500 calories. Researchers suggest the efficiency of energy storage is approximately 50% (Hill, Wyatt, Reed, & Peters, 2003), meaning for every 100 calories consumed, approximately 50 calories are stored as energy. Hill et al. suggest that as little as 100 calories per day could contribute to weight gain (Hill et al., 2003), meaning that if each meal was 100 calories over metabolic needs, this could translate to several pounds over a year's time. Since meals are not typically less than 100 calories, a seemingly small increase in food consumption each day could translate into a large weight gain overtime.

The primary aim of this study was to examine the relationship between eating periodicity and weight loss in overweight and obese adults following a short-term behavioral weight loss intervention. Results of this study revealed no significant relationship between eating periodicity and weight loss (see Table 2) resulting in the rejection of the primary hypothesis for this study. This appears to be the first investigation to track frequency of eating periodicity across a weight loss intervention, which may indicate the need for these results to be replicated in additional clinical interventions. However, the lack of a relationship between eating periodicity and weight loss may be a result of numerous factors.

It is difficult to determine or predict the specific physiological mechanism as to why the cross-sectional research conducted has demonstrated an inverse correlation between eating periodicity and decreases in body weight, though, because humans do not eat solely to sustain energy needs. There are a number of psychosocial factors (e.g., stress, depressive symptoms, etc.) which may influence eating behavior (Chiva, 1997; de Castro, 1997; Williamson, Martin, & Stewart, 2004). These factors were not examined in this study, and therefore conclusions related to these speculative influences on the results are premature, which may indicate the need to examine these factors in future studies of eating periodicity and weight loss.

Previous research in the area of eating periodicity has shown a significant inverse correlation between eating periodicity and body weight. Results from the current study demonstrated a significant inverse correlation between eating periodicity and absolute body weight at 12 and 20 weeks (see Table 3), and these results are consistent with previous research in this area (Ma et al., 2003; Speechly et al., 1999).

Thus, while eating periodicity was not correlated with weight loss, eating periodicity was correlated with absolute body weight. This may have implications for prevention of weight gain or weight regain, with results from this study demonstrating the ability to maintain a lower body weight with greater eating periodicity. Unfortunately this current study was not designed to examine the impact of eating periodicity on long-term maintenance of body weight.

A secondary aim of this study was to examine the relationship between eating periodicity and energy intake during the intervention period. Results of this study indicated that the association between eating periodicity and energy intake were not statistically significant. These results may partially explain the lack of an association between eating periodicity and weight loss in this study. Considering that weight loss appears to be influenced by the magnitude of the energy deficit (Hill et al., 1989; Jeffery, Hellerstedt, French, & Baxter, 1995; Ross, Freeman, & Janssen, 2000) it would be important to demonstrate that eating periodicity results in a lower energy intake, which was not demonstrated in this study. It should be noted that this lack of a relationship may be impacted by error in the measurement of either eating periodicity or energy intake in this study. For example, it has been well-documented that overweight adults significantly under-report their energy intake (Heymsfield et al., 1995; Lara et al., 2004; Ortega et al., 1996) and this may also influence measures of eating periodicity due to under-reporting of meals or snacking episodes. Therefore, future studies should refine the measurement of both eating periodicity and energy intake when examining the potential influence of eating periodicity on body weight outcomes. Similarly, the findings in this study with regards to correlating eating periodicity, change in body weight, and BMI may have differed from others because this was conducted with free-living adults currently engaged in a weight loss study. The studies that showed a correlation among the above factors are limited in application because they were conducted in a laboratory setting or with animals and not with free-living humans (Ma et al., 2003; Speechly et al., 1999).

A third aim of the study was examine the relationship between eating periodicity and binge eating in free-living overweight and obese adults prior to and during weight loss. Binge eating scores at baseline were not correlated with eating periodicity. However, there were no scores taken at week 12 or week 20 to determine if there was a change in score with weight change. These data indicate that binge eating scores are not predictive of eating periodicity or 12 and 20-week weight change in this study. The findings that binge eating score were inversely correlated to caloric intake is surprising; however, suggests that those who had higher binge eating scores may not have reported their calories accurately. This is unfortunately an inherent error with using self-report, suggesting other intake measures may have better predicting a true outcome. Future studies should examine the potential correlation among these factors because binge eating has previously been demonstrated to affect weight loss (Spitzer et al., 1993).

5.3. Application of Findings

The major finding of this investigation was that the individuals who consumed more meals and snacks were those who had a greater absolute weight loss. This finding supports the primary hypothesis of the study that eating periodicity is inversely correlated to weight loss. Although there were no significant correlations between change in body weight and meal periodicity (see Table 2), it was shown that individuals of lower body weight had greater levels of eating periodicity (see Table 3), and this is consistent with previous research in this area

(Drummond et al., 1998; Ma et al., 2003). These findings may be important because they suggest that maintenance of a lower body weight may be influenced by greater levels of eating periodicity. While this study was not designed to specifically examine this aspect of eating periodicity, future research should consider research designs which provide a greater understanding of how eating behaviors may be modified to have the greatest influence on prevention of weight loss and maximizing long-term weight loss success.

5.4. Limitations and Recommendations for Future Research

This study is not without limitations and these may minimize the application of these findings. Future studies should address these factors to improve the generalizability and impact of these findings.

1. This study used a prospective, observational design and this limits the ability to fully examine the impact of eating periodicity and weight change during periods of weight loss. Therefore, future studies should used a randomized clinical study design to determine the impact of increased eating periods on weight change in overweight adults during periods of weight loss.
2. This was a short-term study examining eating periods and weight change during the initial 20-weeks of a behavioral weight loss intervention. Future studies should examine the long-term relationship between change in body weight and eating periodicity.
3. The present investigation used self-report as the only measure of energy intake. Self-report is valuable, but limited in that it is known that individuals and particularly overweight and obese individuals underreport their dietary intake (Heymsfield et al., 1995; Lara et al., 2004; Ortega et al., 1996). This underreporting could not only affect the total energy and fat grams consumed, but could also affect the frequency of meal and

snack intake. Each of these values was obtained from self-report in this study thereby potentially impacting the results by misrepresenting the total energy, fat, and either over or underestimating meal and snack frequency. Thus, future studies should include other validated measures of energy intake or potentially an objective measure such as doubly labeled water to more accurately describe the changes in energy intake during periods of weight loss.

4. This study examined the impact of eating periodicity on body weight and weight loss during a short-term behavioral weight loss intervention. However, it is likely that increased eating periodicity may have a favorable impact on other physiological variables such as the diet induced thermogenesis (DIT), blood glucose, insulin, body composition, etc. For example, it is understood that DIT represents approximately 10% of total daily energy expenditure (Halberg et al., 2005; Jeukendrup & Gleeson, 2004). The magnitude of DIT depends on several factors, including the energy content, size, and composition of the meal. If one were to spread meals out throughout the day versus eating larger, less frequent meals, the body would have to increase digestion and metabolism to utilize the additional energy. Therefore, this could translate to reduced body weight overtime. Likewise, insulin is released during digestion to increase the uptake of blood glucose from the blood by the tissues. This necessary process also inhibits lipolysis (Halberg et al., 2005). Digestion of food causes an increase in blood glucose concentrations, which subsequently causes a release of insulin. The larger the volume of food, the greater the release of glucose and insulin. Since this entire process inhibits lipolysis, it theoretically may be detrimental to weight control. Thus, future investigations should consider examining the impact of eating periodicity on a variety of physiological factors that may

improve health outcomes in normal and overweight adults versus only body weight losses.

5. The results of the present investigation indicated that greater eating periodicity was associated with a lower short-term body weight in overweight individuals during periods of weight loss. It is unclear if this same relationship would be found in individuals at risk for overweight and whether increased eating periodicity could be used as a strategy to prevent weight gain in individuals at risk for overweight and obesity or weight regain in individuals who previously lost weight and are attempting to maintain their weight loss maintenance.

5.5. Summary

The important findings of this study are those demonstrating a significant, inverse correlation between meal periodicity and absolute body weight. These findings may be important because they may suggest eating periodicity can influence body weight by allowing for the maintenance of a lower body weight, which appears to be consistent with previous research in this area (Ma et al., 2003; Speechly & Buffenstein, 1999). However, this study did not support the hypothesis that eating periodicity would result in greater weight loss (see Table 2). Moreover, because this study was not designed to specifically examine eating periodicity and weight loss maintenance, conclusions related to this aspect of weight control are reliant on additional studies that will be designed to examine this important research question. It should be noted that the lack of a significant association between eating periodicity and weight change in this study may be a result of limitations in the measurement of eating behavior in free-living adults. Thus, future studies in this area should attempt to overcome this limitation. While there are limited studies related to eating periodicity and body weight, one strength of this current study is that it appears to be one of the first to examine eating periodicity during weight loss in free-living adults. Therefore, the results of this study need to be replicated in additional studies designed to examine the impact of eating periodicity on weight loss and weight loss maintenance in free-living overweight and obese adults.

APPENDIX A

Meal Periodicity Questionnaire

1. On average, how many days/week did you eat breakfast over the past month? (circle number of days)

1	2	3	4	5	6	7

2. If you snack, what types of foods do you typically snack on? Check the box that best describes your behavior during the last one month.

	Never or hardly ever	Some of the time	About half of the time	Much of the time	Always or almost always
Fruit	1	2	3	4	5
Granola Bars	1	2	3	4	5
Candy (e.g., Kit Kat, Snickers, etc)	1	2	3	4	5
Chips (e.g., Doritos, Potato Chips, Cheese Doodles)	1	2	3	4	5
Yogurt	1	2	3	4	5
Ice Cream/Frozen Yogurt	1	2	3	4	5
Vegetables	1	2	3	4	5
Cereal	1	2	3	4	5
Energy or Sports Bars (e.g., Luna, Slim Fast, Balance, Atkins, etc)	1	2	3	4	5
Cookies	1	2	3	4	5
Crackers, pretzels or popcorn	1	2	3	4	5
Cheese (e.g., string cheese)	1	2	3	4	5
Ready-to-Drink Shakes (Slim Fast, Boost, Ensure, etc)	1	2	3	4	5
Juice (e.g., orange juice, apple juice)	1	2	3	4	5
Soup	1	2	3	4	5
Other (please list)	1	2	3	4	5

3. On average, what times of the day did you typically eat snacks over the past month? Check the box that best describes your behavior during the last one month.

	Never or hardly ever	Some of the time	About half of the time	Much of the time	Always or almost always
Before breakfast	1	2	3	4	5
Between breakfast and lunch (mid-morning)	1	2	3	4	5
Between lunch and dinner (mid-afternoon)	1	2	3	4	5
After dinner	1	2	3	4	5
In the middle of the night	1	2	3	4	5

4. On average, during the times of the day you do snack, what is your major reason for snacking? Check the box that best describes your behavior during the last one month.

	Never or hardly ever	Some of the time	About half of the time	Much of the time	Always or almost always
Before Breakfast					
Physiological hunger	1	2	3	4	5
"Hunger" from boredom	1	2	3	4	5
Others are eating, so I do too	1	2	3	4	5
Stress at work and/or home	1	2	3	4	5
Curb your appetite	1	2	3	4	5
Other (please explain)	1	2	3	4	5
Between breakfast and lunch (mid-morning)					
Physiological hunger	1	2	3	4	5
"Hunger" from boredom	1	2	3	4	5
Others are eating, so I do too	1	2	3	4	5
Stress at work and/or home	1	2	3	4	5
Curb your appetite	1	2	3	4	5
Other (please explain)	1	2	3	4	5
Between lunch and dinner (mid-afternoon)					
Physiological hunger	1	2	3	4	5
"Hunger" from boredom	1	2	3	4	5
Others are eating, so I do too	1	2	3	4	5
Stress at work and/or home	1	2	3	4	5
Curb your appetite	1	2	3	4	5
Other (please explain)	1	2	3	4	5
After dinner					
Physiological hunger	1	2	3	4	5
"Hunger" from boredom	1	2	3	4	5
Others are eating so, I do too	1	2	3	4	5
Stress at work and/or home	1	2	3	4	5
Curb your appetite	1	2	3	4	5
Other (please explain)	1	2	3	4	5
In the middle of the night					
Physiological hunger	1	2	3	4	5
Cannot otherwise sleep	1	2	3	4	5
Others are eating, so I do too	1	2	3	4	5
Other (please explain)	1	2	3	4	5

5. On average, during the times of day you do snack, do you perceive your snacking as healthy or unhealthy over the last one month?

	Healthful	Unhealthful	Do not snack at this time
Before breakfast	1	2	3
Between breakfast and lunch (mid-morning)	1	2	3
Between lunch and dinner (mid-afternoon)	1	2	3
After dinner	1	2	3
In the middle of the night	1	2	3

APPENDIX B

Frequency (%) of Common Snack Foods at Baseline (n=63) and Week 12 (n=63)

	Never or Hardly Ever	Some of the Time	About Half of the Time	Much of the Time	Always or Almost Always	Missing
Fruit	19.0	42.9	19.0	11.1	4.8	3.2
Fruit	---	30.2	14.3	28.6	15.9	11.1
Granola Bars	66.7	19.0	9.5	1.6	---	3.2
Granola Bars	42.9	27.0	6.3	4.8	4.8	14.3
Candy	22.2	52.4	7.9	9.5	4.8	3.2
Candy	69.8	17.5	1.6	---	---	11.1
Chips	23.8	46.0	12.7	7.9	4.8	4.8
Chips	55.6	23.8	7.9	---	---	12.7
Yogurt	41.3	36.5	14.3	4.8	1.6	1.6
Yogurt	17.5	27.0	12.7	23.8	4.8	14.3
IceCream/ Frozen Yogurt	30.2	55.6	6.3	4.8	1.6	1.6
Ice Cream/ Frozen Yogurt	33.3	34.9	4.8	12.7	1.6	12.7
Cereal	42.9	27.0	11.1	4.8	6.3	7.9
Cereal	34.9	20.6	12.7	9.5	7.9	14.3
Vegetables	41.3	25.4	19.0	4.8	4.8	4.8
Vegetables	19.0	36.5	7.9	14.3	11.1	11.1
Energy or Sports Bars	79.4	11.1	1.6	3.2	---	4.8
Energy or Sports Bars	74.6	9.5	1.6	1.6	1.6	11.1
Cookies	14.3	44.4	15.9	20.6	1.6	3.2
Cookies	55.6	25.4	6.3	1.6	---	11.1
Crackers, pretzels, popcorn	9.5	38.1	27.	11.1	9.5	4.8
Crackers, pretzels, popcorn	14.3	39.7	15.9	6.3	9.5	14.3
Cheese	31.7	44.4	9.5	6.3	3.2	4.8
Cheese	58.7	22.2	1.6	4.8	---	12.7
Ready-to-Drink Shakes	85.7	4.8	3.2	1.6	---	4.8
Ready-to-Drink Shakes	84.1	3.2	---	---	---	12.7
Juice	54.0	23.8	9.5	7.9	1.6	3.2
Juice	52.4	22.2	7.9	3.2	---	11.1
Soup	50.8	23.8	12.7	---	---	12.7
Soup	50.8	23.8	12.7	---	---	12.7

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