APPROVAL SHEET

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE **2003**	2. REPORT TYPE	3. DATES COVERED **-**
4. TITLE AND SUBTITLE **Understanding the Regulation of Body Weight: A Focus on Eating Patterns, Energy Intake, and Metabolic Rate**		5a. CONTRACT NUMBER 5b. GRANT NUMBER 5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)		5d. PROJECT NUMBER 5e. TASK NUMBER 5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Uniformed Servicces universsity of the Health Sciences,F. Edward Herbert School of Medicine,4301 Jones Bridge Road,Bethesda,MD,20814-4799**		8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)		10. SPONSOR/MONITOR'S ACRONYM(S) 11. SPONSOR/MONITOR'S REPORT NUMBER(S)
12. DISTRIBUTION/AVAILABILITY STATEMENT **Approved for public release; distribution unlimited**		
13. SUPPLEMENTARY NOTES		
14. ABSTRACT **see report**		
15. SUBJECT TERMS		

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**		**243**	

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std Z39-18

ABSTRACT

Title of Thesis: "Understanding the Regulation of Body Weight: A Focus on Eating Patterns, Energy Intake, and Metabolic Rate"

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The clinically observed eating pattern of gorging (eating fewer, larger meals later in the day) is ill defined in the literature and inconsistently linked to metabolic rate suppression and body composition. The purpose of this study was to further understand the relationship between gorging, metabolic rate, and body composition with a consideration of daily physical activity and purposeful exercise. Gorging was defined as two or fewer meals per day with at least seven hours between waking and the first meal for at least three days per week. It was hypothesized that gorgers would have 1) lower metabolic rates, 2) more body fat, 3) lower energy and higher fat intakes, and 4) more pathological eating attitudes than non-gorgers. Participants were 12 obese gorging (OG), 11 obese non-gorging (ON), 14 normal weight gorging (NG), and 14 normal weight non-gorging (NN; age-matched), non-smoking, otherwise healthy women. Metabolic testing included assessment of resting metabolic rate (RMR), active metabolic rate (AMR) while riding a stationary bicycle at a rate of 50 rpm and workload of 1kg, and dietary induced thermogenesis (DIT) where postprandial metabolic rate was assessed. Results were partially supported. Contrary to the first hypothesis, the eating pattern groups did not differ by RMR [$F(1,47) = 3.96$, $p = 0.05$], AMR [$F(1, 47) = 2.03$, $p = 0.16$], or DIT [F(1,

47) = 0.40, p = 0.53] after covarying lean body mass. Lean body mass was the best predictor of metabolic rate accounting for 72% of the variance. These findings are limited by the small effect sizes for these analyses. Future investigations should increase statistical power and consider increasing the both the exercise and meal challenges so they may have a greater affect on metabolic rate. The eating pattern groups did not differ by body composition [$F(1,47) = 1.02$, $p = 0.32$], contrary to the second hypothesis. However, the gorging group reported less energy intake than the non-gorging group [$F(1,47) = 14.50$, $p = 0.001$] supporting the third hypothesis. Estimated energy intake for the participants was calculated using measured RMR multiplied by an activity factor of 1.3. Based on these results the gorgers underreported food intake to a greater degree than the non-gorgers. There was an interaction effect for fat consumption. The ON consumed the greatest amount of fat followed by the obese and normal weight gorgers, and then the NN group. Contrary to the fourth hypothesis, there were no significant differences between the eating pattern groups' eating pathology. This was one of the first studies to thoroughly operationalize gorging and examine existing eating patterns. While several of the major hypotheses were not supported, the results of this study do support the importance of the relationship between weight regulating behaviors, body composition, and metabolic rate. The findings are clearly worth further study and it is clear that a biopsychosocial framework is needed when examining the interrelationship of eating patterns and metabolism.

UNDERSTANDING THE REGULATION OF BODY WEIGHT:

A FOCUS ON EATNG PATTERNS, ENERGY INTAKE, AND METABOLIC RATE

BY

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Dissertation submitted to the Faculty of the Department of Medical and Clinical Psychology of the Uniformed Services University of the Health Sciences in partial fulfillment of the requirements for the degree of

Doctor of Philosophy 2003

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Background and Significance

The Burden of Obesity

More Americans are now overweight and obese than ever before. The National Heart Lung and Blood Institute (NHLBI) currently defines overweight as a body mass index of 25 kg/m^2 to 30 kg/m^2 and obesity as body mass index greater than 30 kg/m^2. Using these definitions, from 1960 to 1976 the obese population grew from 48.5% of Americans to 50.6% (Pi-Sunyer, 1996). By 2000, nearly 64.9% of Americans were obese (Flegal, Carroll, Ogden, & Johnson, 2002). This documented trend is of great concern given the strong link between excess weight and chronic, often debilitating, and sometimes fatal diseases (Allison et al., 1999; Blair & Brodney, 1999; Colditz, 1999; Flegall, 1998; Must et al., 1999; WHO, 1997). Obesity has been demonstrated to directly cause Type 2 Diabetes Mellitus, coronary heart disease, and stroke (WHO, 1997). It also increases the risk of several types of cancer, gallbladder disease, and respiratory problems (including sleep apnea and some types of asthma; WHO, 1997).

Interestingly, overweight[1] increased disproportionately from 1988 to 2000 among certain populations (Flegal, Carroll, Ogden, & Johnson, 2002; Mokdad et al., 1999). Compared to their demographic counterparts, greater increases were seen in the number of overweight women, African American women, older adults aged 60-69 years (Flegal, Carroll, Ogden, & Johnson, 2002), individuals with some college education, and those living in the South Atlantic states (Mokdad et al., 1999). Hypertension and Type 2

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[1] Throughout this paper, the term overweight will be used to refer to both overweight and obesity inclusively, unless otherwise stated.

Diabetes Mellitus are the most common obesity-related diseases and are higher in some ethnic minority populations (Mokdad et al., 1999; WHO, 1997).

In many individuals, hypertension and Type 2 Diabetes Mellitus can be controlled with weight loss and exercise (FDA, 2002; Taubes, 1998). Unfortunately, getting individuals (regardless of weight status) to change their eating and exercise habits is not easily accomplished (e.g., Colditz, 1999; Taubes, 1998). In fact, decreased exercise may be one of the most important contributors to the global rise in overweight and obesity (Jebb & Moore, 1999) despite publicized evidence linking exercise to improved health (Colditz, 1999). These health improvements include a reduction in the risks of osteoporosis, heart disease, colon and breast cancer, and other types of cancer (Colditz, 1999).

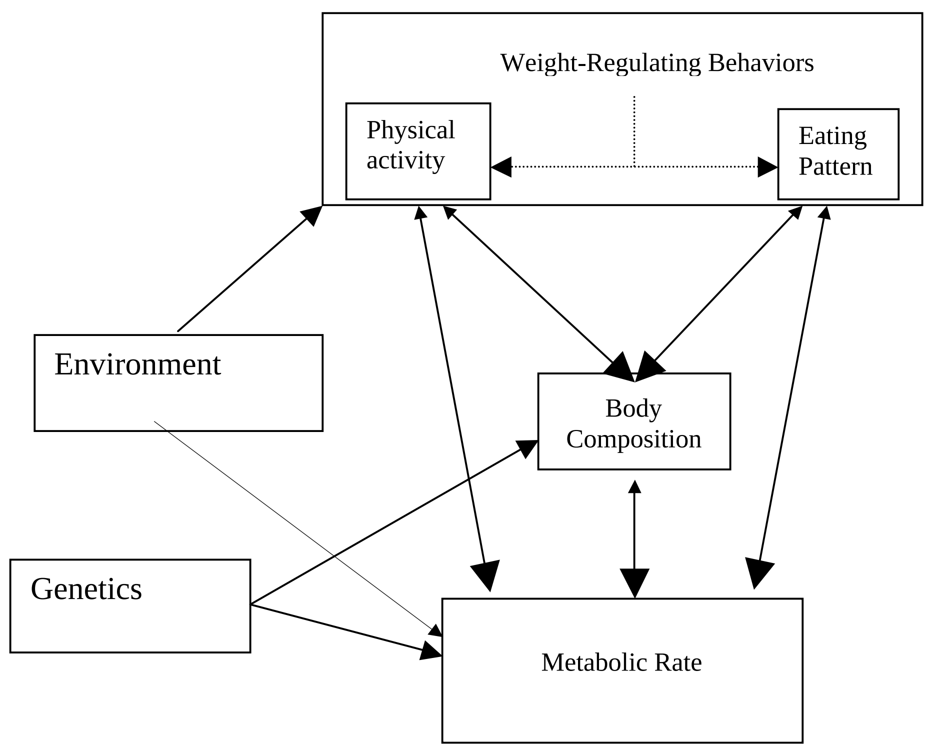
As a result of the difference in getting individuals to change eating and exercise behaviors, the medical and scientific communities have turned to treatment alternatives, primarily pharmacotherapy (Colditz, 1999). In addition to improving exercise and eating habits, many obesity-related diseases can now be medically treated or managed, but at significant costs (Colditz, 1999). The current cost estimates for treating obesity are near those of cigarette smoking related diseases (Colditz, 1999). Since 1996, $70 billion has been spent annually on direct health care costs for diseases related to excess weight (Allison et al., 1999; Colditz, 1999). This amounts to approximately 7% of the total health care costs in the U.S. and is up from 5.7% in 1995 (Wolf & Colditz, 1998). For diseases related to inactivity alone, with or without the presence of overweight, approximately $24.3 billion per year is spent on direct health care delivery costs (Colditz, 1999).

The indirect costs attributable to overweight are also substantial. Approximately, 10% of sick leave and disability pensions in women may be attributable to weight related conditions (Colditz, 1999). In 1998 alone, this amounted to 39.2 million days of lost work per year with incalculable monetary costs (Wolf & Colditz, 1998). Furthermore, the indirect health care delivery for weight-related conditions, such as coronary heart disease, stroke, and some types of cancer, cost approximately $200 billion each year in medical expenses and lost productivity (FDA, 2002). The costs of overweight to society are not solely financial; approximately 280,000 annual deaths can be attributed (directly and indirectly) to excess weight (Allison et al., 1999). More than 80% of these were among those with body mass indices (BMI) greater than 30 kg/m^2 (Allison et al., 1999). Furthermore, overweight individuals may suffer ridicule, self-contempt, and dissatisfaction with their bodies as a consequence of being overweight (Ciliska, 1990). Overweight individuals are, unfortunately, often viewed as "lazy, stupid, ugly, and cheaters" (Ciliska, 1990, pp. 16). Given the substantial cost to Americans, it is not surprising that in the last 50 years, scientists have increasingly focused on the etiology of and effective treatments for overweight with the ultimate goal of preventing this major health problem.

Overweight as a Multifaceted Disorder

Overweight is a multifaceted disorder that cannot be fully understood by either biological or environmental explanations exclusively. Examining overweight from only one of these perspectives may negate the important contributions of the other. For the proposed study, a framework that encompasses interactions between the biological and environmental processes involved in the etiology, prevention, and treatment of weight gain will be used. The conceptual framework depicted in Figure 1 shows interactions among environmental, behavioral, genetic, and physiological factors important in weight regulation. The environment directly influences weight-regulating behaviors, and therefore indirectly influences body composition and physiological processes (such as metabolic rate). Eating and exercise behaviors impact body composition and physiological processes. Genetic factors also impact physiological processes of weight and body composition. Each of these relationships will be discussed further in the following sections.

Figure 1. A Biopsychosocial Conceptual Framework of Weight Regulation



Relationship between Genetics and Weight-Regulating Behaviors

Throught this framework, we can better understand the increasing prevalence of overweight within societies. The physiological regulators of overweight involve the control of weight and eating behaviors by a finely tuned orchestration of hormonal pathways, neurological pathways, and energy stores with a genetic predisposition toward energy conservation (e.g., Campfield, 1997; Campfield, Smith, & Burn, 1998; Gura, 1998; Le Magnen, 1999). Genetic variants in any of these eating and weight control pathways can lead to overweight or obesity given the right circumstances such as an environment that provides an excess of food and/or a sedentary lifestyle (Campfield, 1997; Campfield, Smith, & Burn, 1998; Gura, 1998; Le Magnen, 1999).

Genetically determined variations in the physiological processes of weight regulation are key factors in understanding why overweight and obesity affect only about half (rather than all) of the population given that individuals are subject to the same, or similar, environmental and societal influences. For some individuals, overweight is a phenotypic expression of genes that over-stimulate lipogenesis (e.g., Jequier, 1992; Raben et al., 1994). For others it may be a slowed metabolic rate (Ravussin & Bogardus, 1989; Treuth, Butte, & Wong, 2000; Seagle, Bessesen, & Hill, 1998). Surprisingly, however, a slowed metabolic rate may be the cause of excess weight for only about 21% of obese Americans (Allison & Faith, 1998). For the remaining 79% of the population, heritability may account for 40% to 70% of the variation in body mass index (BMI), fat-free mass, and body fat percentage (Comuzzie & Allison, 1998; Hill & Melanson, 1999). The remaining 30% to 60% of the variance in BMI, fat-free mass, and body fat can be explained by eating patterns and physical activity (Comuzzie & Allison, 1998; Hill & Melanson, 1999).

In order for overweight to increase at a rapid rate within a society, given minimal environmental changes, a rapid genetic transition must occur (Allison & Faith, 1998). A genetic transition is a phenomenon in which a great proportion of the members of a population all experience the same genetic mutation and pass it on to their offspring (Allison & Faith, 1998). Similar to the turning of an aircraft carrier at sea, genetic transitions within a population are slow and delayed processes that demonstrate phenotypic differences only after more than a few generations.

The rate at which the prevalence of overweight is increasing in the United States is far too rapid to be explained purely by genetic transition (Hill & Melanson, 1999). For these same reasons, the worldwide rise in overweight is also not reasonably explained by genetic transition. These phenomena provide further support for a model incorporating the interaction of genetically determined biological processes in a rapidly changing worldwide environment (Allison & Faith, 1998; Hill & Melanson, 1999). The relationships between environment, weight-regulating behaviors, and physiological processes will be discussed further in the following sections.

Relationship between the Environment and Weight-Regulating Behaviors

The environment impacts both physical activity and eating behaviors used to regulate weight. In the last century, societal shifts (e.g., technological advances) in the United States have significantly changed the average lifestyle of most Americans (Poston & Foreyt, 1999). Modern technology has reduced much of the need for physical exertion in the workplace for most jobs and has made food more available, more accessible, and more fattening (Stern, 1983).

Sedentary Lifestyles Affect Energy Expenditure

Modern American society is dominated by a lifestyle with increased energy savings in many daily activities, such that Americans are more productive at lower energy expenditures (Poston & Foreyt, 1999; Simopoulos, 1992). For example, Simopoulos (1992) found that at the turn of the 20th century, 30% of energy used in farm and factory work came from muscle power. One hundred years later, muscle power accounted for a mere 1% of the energy used in these occupations. Labor-saving technology, such as automobiles, elevators, computers, televisions, remote controls, the internet, and e-commerce pervade the lives of most Americans allowing them to accomplish more with less energy (Poston & Foreyt, 1999).

Unfortunately, most Americans have not compensated for the decreased daily energy expenditure by adding intentional physical activity, such as scheduled exercise or leisure-time sports, or by decreasing energy intake (Colditz, 1999; Poston & Foreyt, 1999). Only about 30% of adults participate in moderate, scheduled exercise on a regular basis (60 minutes at least three days per week; Healthy People 2010, 2000) and approximately 44.6% of the adult population in the United States reports no leisure-time physical activity (Colditz, 1999; Healthy People 2010, 2000). Among minority populations in the U.S., greater than 50% report little or no leisure time physical activity as part of their lifestyles (Poston & Foreyt, 1999). The lack of physical activity is high, despite evidence of the health benefits of regular exercise for those in all weight categories (Blair & Brodney, 1999). The risks of cardiovascular disease, hypertension, and Type 2 Diabetes Mellitus are significantly reduced with regular exercise (Blair & Brodney, 1999).

The Availability of Food Affects Energy Intake

Although the sedentary lifestyle of Americans significantly contributes to the increase in the prevalence in overweight, it is not a sufficient explanation (Harnack, Jeffery, & Boutelle, 2000; Poston & Foreyt, 1999). Changes in the quality and quantity of available foods have also played an important role in the rise of overweight (Harnack, Jeffery, and Boutelle, 2000; Poston & Foreyt, 1999). The increased efficiency of food production has increased the quantity and decreased the cost of food available to most Americans (Hill & Peters, 1998). In contrast to developed countries such as America, food availability in underdeveloped countries is usually inconsistent (Hill & Peters, 1998; Woods et al., 1998). Consequently, for most individuals living in the United States (U.S.), food consumption patterns are based on physiological or psychological demand rather than on food availability (Hill & Peters, 1998; Woods et al., 1998). In the last 20 to 30 years, available food in the U.S. has increased by about 15% (Harnack, Jeffrey, & Boutelle, 2000; Hill & Peters, 1998).

Furthermore, the quantity of food eaten in one meal has increased by about 12% while the quality (determined by nutritional value per gram) of food has decreased (i.e., increased fat content; Harnack, Jeffrey, & Boutelle, 2000; Hill & Peters, 1998). The decrease in quality of available foods can be attributed, in part, to the rise in processed foods and fast foods, which usually contain more fat and fewer valuable nutrients (Harnack, Jeffrey, & Boutelle, 2000; Hill & Peters, 1998). Although Americans are eating more lean meats, the use of all fats and oils, primarily in fast food and other restaurants, increased 21.8% from 1970 to 1995 (Harnack, Jeffrey, & Boutelle, 2000). Possibly under the misconception that they are making a wiser choice, Americans have likely switched from eating red meats to eating white meats cooked in oil and fat. Nearly 40% of the total money spent on food is now accounted for by food purchased outside of the home (restaurants and fast food outlets), which, in addition to being higher in fat, also requires little or no energy expenditure in its preparation or acquisition (FDA, 2002; Harnack, Jeffrey, & Boutelle, 2000; Poston & Foreyt, 1999). The use of pre-cooked or frozen meals, which usually contain more fat and sodium has also helped to reduce the amount of time Americans have been spending in the kitchen (Harnack, Jeffrey, & Boutelle, 2000). Currently, approximately two-thirds of all meals are not prepared from primary (or basic) ingredients, compared to nearly one-half two decades ago (Harnack, Jeffrey, & Boutelle, 2000).

Weight Regulation Through Dieting.

In response to an environment with excess food and energy-saving devices that encourage weight gain, many Americans have attempted to regulate their weight through dieting (Hill & Melanson, 1999; Thomas, 1995). The cultural drive for thinness also contributes to the high prevalence of dieting behaviors (Ciliska, 1990). Each year, an estimated 58.6% of Americans who consider themselves overweight—77% women and 42% men (Mifflin et al., 1990)—try to lose weight (ADA, 1997; Thomas, 1995). It has been speculated that women are more likely to diet than men because of the potential influences of extremely thin models that represent the cultural ideal of female attractiveness (Ciliska, 1990).

Americans spend about 40 billion dollars each year on weight loss treatment programs that typically consist of very-low-calorie meal plans, specific types of foods, powders, pills, shakes, or other interventions (ADA, 1997; Wickelgren, 1998). Dieting usually involves a relatively short period of energy restriction (several weeks to months) and/or adherence to strict meal plans to induce weight loss. Energy restriction is then followed by a resumption of previous energy intake (Mifflin et al., 1990). This period of energy restriction can and often does lead to what has been termed "the dieting mentality" (Sbrocco, Nedegaard, Stone, & Lewis, 1999). The dieting mentality refers to cognitive biases about food and exercise. Frequently, dieters buy into an "eat less, move more" dictum, which can lead to extreme behaviors, such as meal skipping or avoiding certain foods altogether. Hunger sensations are associated with success and believed to lead to weight loss (Foreyt & Goodrick, 1994; Mead, 2001; Schlundt et al., 1992; Wing, 1992). Consequently, behaviors like meal skipping and avoiding certain foods are thought to be signs of self-control (Foreyt & Goodrick, 1994; Mead, 2001; Schlundt et al., 1992; Wing, 1992). A pattern of skipping meals early in the day (breakfast and lunch) has been linked to periods of excessive energy intake and/or loss of control while eating later in the day (Foreyt & Goodrick, 1994). This pattern of "late-day" eating is relatively common (as high as 24%) among women, dieting or not (Schlundt et al., 1992).

Relationship between Weight-Regulating Behaviors and Body Composition

Physical activity and eating patterns, both independently and in combination, work to regulate weight by changing body composition. When weight is lost, it is composed of interstitial water, fat mass, and fat-free mass (any body tissue other than fat; Votruba, Horvitz, & Schoeller, 2000). Caloric restriction that leads to weight loss will result in the reduction of both fat and fat-free mass (Votruba, Horvitz, & Schoeller, 2000). Increasing physical activity, alone or in combination with caloric restriction, will arguably result in a preservation of muscle mass while still resulting in reduced fat mass (Votruba, Horvitz, & Schoeller, 2000). The preservation of fat-free mass in combination with a reduction of fat mass will help to regulate weight by positively influencing metabolic rate.

Physical Activity Affects Body Composition

Physical exertion, whether in the form of daily physical activity or scheduled exercise, affects both body weight and body composition (Wing, 1999). "Physical activity is any voluntary bodily movement produced by the contraction of skeletal muscle that elicits an increase in energy expenditure. Exercise is planned, structured, repetitive bodily movement that is performed for the purpose of maintaining or improving some component(s) of physical fitness such as muscular strength and aerobic capacity" (Winett & Carpinelli, 2000, pp. 237).

Exercise can increase weight loss by up to three times the amount expected with dietary restriction alone (Votruba, Horvitz, & Schoeller, 2000). When dieters lose weight, fat-free mass may be preserved, or even increased, if exercise is combined with caloric restriction (Stern, 1983). The amount of fat loss with physical exertion is related to the type, quantity, and intensity of the exercise (Broeder et al., 1992b; Stern, 1983). Endurance exercise, such as running, results in a loss of both fat mass and fat-free mass (Broeder et al., 1992b; Dolezal & Potteiger, 1998). Whereas resistance exercise alone, such as lifting weights, or in combination with endurance exercise may actually increase fat-free mass and decrease fat mass (Broeder et al., 1992b; Dolezal & Potteiger, 1998;

Geissler, Miller, & Shah, 1987). Consequently, weight loss may possibly appear to slow when physical activity is combined with decreased energy intake because of the greater weight of fat-free mass (Stunkard, 1987; Wing, 1999).

Exercise can also impact energy intake such that food intake commonly remains unchanged after moderate exercise. In other words, physical activity does not automatically generate an increase in the drive to eat to compensate for energy expenditure (as might be expected if a weight set point exists; Blundell & King, 1999). Exercise may also help to maintain a normal weight and body composition by limiting individuals' capabilities to gain weight while exercising on a regular basis (i.e., inducing a higher level of energy expenditure; Blundell & King, 1999).

At a certain higher level of energy expenditure (e.g., regular, purposeful exercise), individuals may have difficulty eating sufficient calories to create a positive energy balance (Blundell & King, 1999). Vigorous or intense exercise (such as high altitude climbing expeditions) can temporarily suppress hunger through an activation of the sympathetic nervous system (McArdle, Katch, & Katch, 2000). During exercise, the sympathetic nervous system is activated and the parasympathetic system is inhibited causing a shunting of blood flow to organs required for the activity (i.e., skeletal and heart muscles) and away from organ systems less essential to exercise (e.g., the gastrointestinal tract, skin, etc.; McArdle, Katch, & Katch, 2000). The decreased flow to the gastrointestinal may serve to suppress hunger during exercise (McArdle, Katch, & Katch, 2000). Over time, decreased hunger associated with exercise may be the result of a compensatory response to weight loss such that the metabolic rate decreases (Blundell & King, 1999).

Kilocaloric Restriction Affects Body Composition

Just as exercise and physical activity influence body composition, so does eating behavior. In conditions of excess energy intake, about two-thirds of the energy may be stored as fat (Tremblay et al., 1992). Whereas energy excess can lead to increased body weight and fat, energy restriction (such as in dieting) can also have the opposite affect on body weight and composition.

The unfortunate consequence of dieting is that many adopt the "dieting mentality" that defines hunger, low energy intake, and intense exercise as requisites for weight loss—which may only promote future weight gain (Apfelbaum, Fricker, & Igoin-Apfelbaum, 1987; Sbrocco, Nedegaard, Stone, & Lewis, 1999). From an evolutionary perspective, humans have evolved very efficient physiological mechanisms for slowing weight loss in conditions of extreme energy deficits (Hill & Peters, 1998; Woods et al., 1998). Weight loss is slowed by the stimulation of lipogenesis (the conversion of consumed energy to body fat) when food is irregularly available (Hill & Peters, 1998; Woods et al., 1998). Lipogenesis is increased during the "feasting" periods in response to the "fasting" periods (Hill & Peters, 1998; Woods et al., 1998). The increased energy storage in the form of fat helps to ensure that the body will have the necessary energy when food intake declines (Hill & Peters, 1998; Woods et al., 1998).

At the termination of dieting, the increased proportion of body fat in combination with previous eating behaviors is likely to lead to a weight rebound (Leermakers, Perri, Shigaki, & Fuller, 1999; Sbrocco, Nedegaard, Stone, & Lewis, 1999; Woods et al., 1998). Although the physiological response to food deprivation increases the probability of survival in environments of food irregularity and low total energy intake, it may contribute to overweight in America, where food is more abundant and regularly available (Hill & Peters, 1998). For this reason, dieting programs are clearly successful at inducing weight loss, but not weight maintenance (Foreyt & Goodrick, 1994; Hill & Wyatt, 1999; Sbrocco, Nedegaard, Stone, & Lewis, 1999). Unsuccessful weight maintenance can lead to frustration, reduced self-esteem, and reduced self-efficacy (Foreyt & Goodrick, 1994).

Assessment of Body Composition

Since body composition is one of the critical outcomes of interest in the proposed biopsychosocial conceptual framework, the potential methods for measurement will be considered. Body composition can be assessed in a number of ways, including hydrostatic weighing, dual-energy x-ray absorptiometry (DEXA), skinfold thickness and body circumference measures, and bioelectric impedance (BEI). Hydrostatic weighing involves weighing a fully water-submerged individual and determines body fat percentage using Archimedes' principle (Evans, Arngrimsson, & Cureton, 2001). DEXA measures bone mineral content, fat tissue mass, and lean tissue mass and can measure regional fat distribution through a whole-body scan (Bolanowski & Nilsson, 2001; Evans, Arngrimsson, & Cureton, 2001).

Hydrostatic weighing and DEXA are the gold standards for measuring body composition, but they are both expensive, require a great deal of space for the equipment, require technical training for administrators, and may be psychologically aversive to some participants (Bolanowski & Nilsson, 2001; Cable et al., 2001; Evans, Arngrimsson, & Cureton, 2001; Kyle et al., 2000). For these reasons, DEXA and hydrostatic weighing are used less frequently in research (Bolanowski & Nilsson, 2001).

Indirect measures of body fat, such as measuring skinfold thickness and body circumference, are frequently used because of the low cost and ease of use (Bolanowski & Nilsson, 2001). However, these measures have limited validity and reliability because they are subject to mechanical limitations, human error, and low inter-rater reliability (Kyle et al., 2000; Tucker & Greenwell, 2001). In obese populations, the calipers used to measure skinfold thickness may not be adequately adjustable. When using body circumference measures, it may be difficult to accurately define the points of measurement (e.g., defining an obese woman's waist; Kyle et al., 2000; Tucker & Greenwell, 2001). Finally, the regression equations used in conjunction with both of these measures have not necessarily been validated for use with the target populations (Kyle et al., 2000; Tucker & Greenwell, 2001).

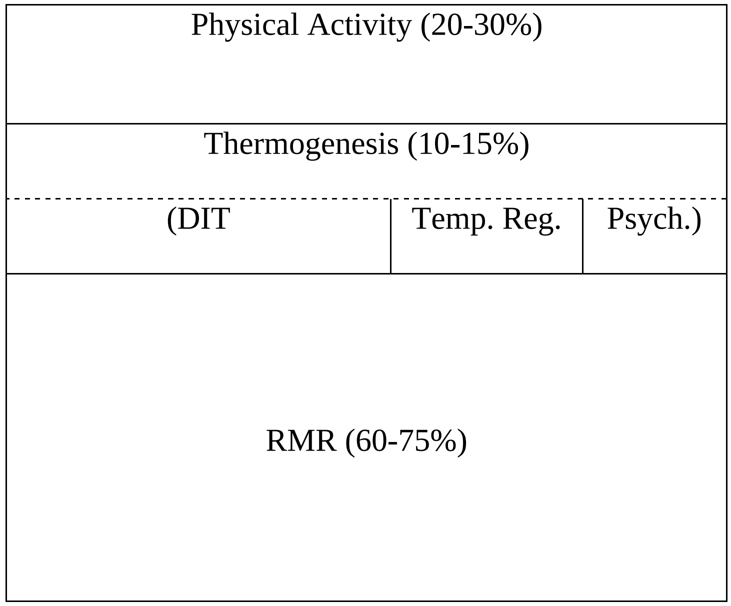
BEI has proven more useful for overweight populations and has been validated using both normal weight and overweight populations (Cable et al., 2001). The actual measurement involves placing electrodes at specified locations on the body (the hand and foot), which may be much less anxiety provoking than the submersion required for hydrostatic weighing (Foster & Lukaski, 1996). The reactance and resistance of the alternating electrical current are measured and a regression equation is used to calculate body fat percentage, lean mass percentage, and total body water (Foster & Lukaski, 1996). BEI is considered to be a reliable and valid measure of body composition and significantly correlates with DEXA (r = 0.97 in normal weight men, 0.96 in normal weight women, 0.95 in overweight men, and 0.82 in overweight women; Kyle et al., 2001). Furthermore, the use of bioelectric impedance requires the purchase of relatively inexpensive equipment that is portable and easy to use (Cable et al., 2001; Evans, Arngrimsson, & Cureton, 2001). BEI has been validated on a variety of populations, is non-aversive, portable, and has been frequently used in research and epidemiological studies (Oldham, 1996; Roubenoff, 1996).

Metabolic Rate

Eating behavior and weight are controlled by a complex interaction of physiological processes, including neurological and hormonal pathways. Despite the importance of all of the physiological regulators, the proposed research places a particular focus on metabolic rate. Metabolic rate is of particular interest because of its role in weight regulation and the relationship between metabolic rate and weight-regulating behaviors. Determining if and how much exercise and eating behaviors impact metabolic rate could play an important role in current weight management and overweight prevention programs.

Total, or daily, metabolic rate is accounted for by the summation of resting metabolic rate (RMR), thermogenesis, and the energy expended in physical activity (PA; Astrup et al., 1996; Mifflin et al., 1990; Schutz, 1995). Figure 2 depicts the breakdown of the influences of each of these factors (adapted from Danforth & Landsberg, 1992). RMR is the rate at which the body utilizes ingested energy in the form of food and drink to sustain basic bodily functions (Astrup et al., 1996; Jequier, 1990; Tai, Castillo, & Pi-Sunyer, 1991). RMR accounts for 60-75% of total daily energy expenditure (Danforth & Landsberg, 1992; Mifflin et al., 1990).

Figure 2. Composition of Total Metabolic Rate.



Note. Adapted from Danforth & Landsberg, 1992. DIT = dietary induced thermogenesis; Temp. Reg. = temperature regulation; Psych. = psychogenic responses.

Thermogenesis is defined as the energy expenditure above RMR caused by food intake, cold exposure, thermogenic agents and/or psychological influences (Jequier, 1990; Kunz et al., 2000; Weinsier et al., 1998). As shown in Figure 2, one important determinant of thermogenesis for humans is the Dietary Induced Thermogenesis (DIT). DIT is defined as the increase in energy expenditure due to the ingestion of food (Jequier, 1990; Jequier, 1992; Kunz et al., 2000; Weinsier et al., 1998). DIT accounts for 10-15% of daily energy expenditure (Danforth & Landsberg, 1992; Kunz et al., 2000; Mifflin et al., 1990; Weinsier et al., 1998).

The relationship between energy expenditure in response to food and the amount of time after the ingestion of food is a curvilinear relationship with a peak between 30 minutes and 1 hour after the start of the meal (Reed & Hill, 1996). The size of the meal and the individual's amount of fat-free mass are positively correlated with the magnitude of the peak thermic response to food ingestion (Reed & Hill, 1996). The relative proportions of ingested fat and body fat are negatively correlated with the peak (i.e., magnitude of rise) thermic response to food ingestion such that as ingested fat and body fat increase, the peak thermic response decreases (Reed & Hill, 1996). The time to peak response was found to be positively correlated with meal size and percent fat in the meal. Area under the curve is positively correlated with fat-free mass and meal size. Other ingested substances, such as caffeine and nicotine are also positively correlated with and may significantly contribute to thermogenesis (Jequier, 1992).

Maintenance of body temperature, primarily in cold environments, also serves an important role in thermogenesis. Temperature homeostasis is positively correlated with metabolic rate such that as environmental temperature drops, metabolic rate increases to maintain core body temperature because the body must work harder to prevent hypothermia (Jequier, 1992). However, body temperature regulation in cold environments accounts for a very small percentage of total thermogenesis because humans avoid cold temperatures by wearing clothing and staying indoors (Danforth & Landsberg, 1992; Jequier, 1992).

The final contributor to thermogenesis is the psychogenic response (Danforth & Landsberg, 1992). Psychogenic responses to stimuli may only minimally impact thermogenesis and, therefore, total metabolic rate (Danforth & Landsberg, 1992; Jequier, 1990; Jequier, 1992). However, frequent psychogenic responses that raise metabolic rate, such as anxiety, or lower metabolic rate, such as depressed mood, may have a greater influence on thermogenesis for some individuals (Danforth & Landsberg, 1992; Jequier, 1992). Finally, the remaining 20-30% of the variability in daily metabolic rate is influenced by physical activity (Danforth & Landsberg, 1992; Mifflin et al., 1990). Physical activity is also positively correlated with metabolic rate. The impact of physical activity will be further discussed in subsequent sections.

Measurements of Metabolic Rate.

Metabolic rate can be assessed using a number of methods including predictive equations, indirect calorimetry, and direct calorimetry (Mifflin et al., 1990). Approximately 80 years ago, Harris and Benedict developed the first and, currently the most widely used, regression equations for predicting RMR. Men (n = 136) and women (n = 103; Schofield, Schofield, & James, 1985) were studied and regression equations based on age, gender, weight, height, and activity level (which is assigned a factor of 1.6 for women and 1.7 for men) were developed from the results. However, the subjects were mostly normal weight Caucasians and therefore the equations have limited generalizability to overweight and minority populations (Hayter & Henry, 1994; Heshka et al., 1993; Piers & Shetty, 1993).

To account for these limitations, researchers in this field have developed several other equations by studying underrepresented populations (Hayter & Henry, 1994; Heshka et al., 1993; Piers & Shetty, 1993). Heshka and colleagues (1993) tested the convergent reliability of 12 prediction equations, including the Harris-Benedict equations, in relation to measured metabolic rates in normal weight and overweight participants. Most of the 12 equations overestimated RMR by as much as 10 to 15% in obese individuals (Cunningham, 1991; Mifflin et al., 1990). The equations were also limited by the use of a weighting factor for physical activity (Heshka et al., 1993). By categorizing physical activity based on recall of general activity, physical activity may be grossly over- or underestimated (Heshka et al., 1993).

Consequently, RMR regression equations in their original form are likely not applicable to overweight populations and they may, at best, only account for 56-63% of the variance in measured RMR. Therefore, the actual differences in RMR may not be detected when regression equations are used to compare overweight and normal weight populations (Cunningham, 1991; Heshka et al., 1993). Despite the limitations of the developed regression equations, they may be useful in epidemiological studies in which the interest lies in trends rather than exact measurements.

Indirect calorimetry and direct calorimetry are often used when a more accurate measure of RMR is needed (Hayter & Henry, 1994; Mifflin et al., 1993). Indirect calorimetry measures oxygen (O_2)-carbon dioxide (CO_2) gas exchange using a canopy hood, facemask, or enclosed room while resting (usually in the supine position) to estimate RMR (Lichtman et al., 1992; Weststrate, 1993). The amount of oxygen consumed in relation to carbon dioxide produced while resting is used to calculate RMR (Hayter & Henry, 1994; Mifflin et al., 1993). Composite air samples (O_2 consumption and CO_2 production volumes) are continuously (for short monitoring periods) or periodically (for longer monitoring periods) collected and analyzed (de Boer, van Es, van Raajj, & Hautvast, 1987; Henson, Poole, Donahoe, & Heber, 1987). The energy expenditure (in kJ/min or kcal/day) is calculated based on these measures (de Boer, van Es, van Raajj, & Hautvast, 1987; Henson, Poole, Donahoe, & Heber, 1987).

Although indirect calorimetry through a ventilated hood system may be more accurate than the use of predictive equations, it has several limitations (Hayter & Henry, 1994; Mifflin et al., 1990). First, the metabolic cart can be costly. Second, the equipment requires trained personnel to operate. Third, indirect calorimetry measured by a ventilated hood or mask can overestimate metabolic rate in some individuals due to anxiety or distress from breathing through a mask and the wear of a mouthpiece/nose plug (Hayter & Henry, 1994). Allowing the participants time to adjust to the hood, mask, or mouthpiece/nose plug may help to reduce any associated anxiety (Hayter & Henry, 1994). Fourth, the procedure can take up to an hour to assess RMR, which may reduce the number of participants willing to participate. Finally, RMR is most accurately assessed immediately upon waking before any physical activity occurs. Since the equipment is not easily transported, this is usually not feasible (Hayter & Henry, 1994).

The use of whole-room calorimetry has made assessing RMR upon waking possible (Hayter & Henry, 1994). Although whole-room calorimetry can also directly measure energy expenditure by measuring body heat, it is more expensive and time-consuming than the metabolic cart (Hayter & Henry, 1994). Consequently, RMR is only infrequently measured upon waking, which requires participants to spend the night in the lab. More often, the participants are asked to arrive at the lab early in the morning and RMR is measured only after a period of rest (e.g., 30 minutes; Hayter & Henry, 1994).

An alternate method to indirect calorimetry measures is the use of doubly labeled water (DLW; Warwick & Baines, 1996). This method requires that participants drink a specified amount (based on body weight) of the isotopes $^{2}H_2O$ and $H_2{}^{18}O$ (Warwick & Baines, 1996). When these isotopes are ingested, they follow the same metabolic path as unlabeled H_2O, which is both a fundamental component and a by-product of metabolism (Warwick & Baines, 1996). The use of isotopes allows the time from ingestion to excretion of water to be measured and metabolic rate to be calculated. The urinary quantity of the isotopes can be measured for up to approximately 14 days (Warwick & Baines, 1996). Although this method more accurately measures daily metabolic rate, it is very costly and time consuming for both the researchers and the participants, who are asked to return to the lab frequently for urine sample collections (Warwick & Baines, 1996). Participants may also be hesitant to ingest the isotopes (Warwick & Baines, 1996).

In summary, the limitations of all of these methods must be thoroughly considered when choosing the most appropriate measure for metabolic rate. When general trends in metabolic rate are of interest, RMR regression may be the most appropriate outcome measure given the low cost, ease of use, and minimal participant burden (Heshka et al., 1993). However, when a more accurate assessment of RMR is desired, deciding between the metabolic cart, the whole-room calorimetry, and doubly labeled water may be a matter of assessing and utilizing currently available resources including staff training and equipment (Hayter & Henry, 1994).

The Role of Inheritance on Metabolic Rate

Although metabolic rate is undoubtedly influenced by eating patterns and physical activity, research suggests that as much as 50% of the variance in individuals' metabolic rates can be accounted for by inheritance (Amatruda, Statt, & Welle, 1993; Bouchard et al., 1989). This is based on genetic and twin studies; Certain genotypes have been linked to lower RMR's and children with two obese parents tend to have lower RMR's (Treuth, Butte, & Wong, 2000). Furthermore, African American girls, who are known to be at greater risk for overweight, have been shown to have significantly lower RMR's than their Caucasian counterparts, after controlling for fat-free mass (Jakicic & Wing, 1998; Treuth, Butte, & Wong, 2000). Finally, individuals with the lowest RMR's generally have the highest incidences of weight regain (Jequier, 1992). However, not all obese individuals and not all of those individuals at greater risk for overweight have lower metabolic rates (Astrup et al., 1996; James, Davies, Bailes, & Dauncey, 1978; James, Lean, & McNeill, 1987; Leibel & Hirsch, 1984; Treuth, Butte, & Wong, 2000). Consequently, the evidence of a direct genetic link between defective or lower metabolic rates and overweight is not conclusive (e.g., Astrup et al., 1996; James, Davies, Bailes, & Dauncey, 1978; James, Lean, & McNeill, 1987; Leibel & Hirsch, 1984; Treuth, Butte, & Wong, 2000).

Postprandial fat oxidation is the process of metabolizing consumed fat (i.e., the resynthesis of adenosine triphosphate, the body's source of energy for biologic work; Jequier, 1992; McArdle, Katch, & Katch, 2000). This process has been examined as a potential genetic link to overweight. A suppressed postprandial fat oxidation would increase the amount of consumed fat that is stored in adipose tissue (Jequier, 1992; McArdle, Katch, & Katch, 2000). Raben et al. (1994) studied the effect of high-fat meals in 12 post-obese women (obese women reduced to normal weight) compared to 12 closely matched never-obese women. They found that normal weight control individuals oxidized 2.5 times more fat than post-obese individuals. Although this finding might lead one to conclude a genetic sensitivity to fat storage exists, eating and exercising behaviors were not controlled or addressed in this study. If the post-obese were skipping meals or severely limiting caloric intake to regulate weight, this might stimulate lipogenesis and inhibit fat oxidation. Furthermore, differences in physical activity levels between the groups might also have influenced fat oxidation. Since intra- and extra-cellular fat supplies the energy for physical activity those individuals who exercised more often and/or more intensely may have become more efficient metabolizers of fat (Hill & Wyatt, 1999; McArdle, Katch, & Katch, 2000).

Astrup et al. (1996) found that a group of post-obese participants with a family history of overweight expended 540 kilojoules (128.6 kilocalories; as measured by indirect calorimetry) less per day than the closely matched never-obese control group. After one year of equal energy intake, the post-obese would be expected to weigh 13 pounds more than the normal weight control participants (based on the assumption that an excess of 3,500 kilocalories leads to one pound of weight gain). Although this could reasonably lead one to conclude that genetically reduced energy expenditure is significantly contributes to overweight, Astrup and colleagues (1996) failed to control for differences in daily physical activity, which is a significant contributor to energy expenditure.

A similar neglect of eating and exercise patterns, which are known to significantly impact both weight and RMR (Hill & Wyatt, 1999), is also seen in Astrup and colleagues' (1999) meta-analysis of 12 studies on resting metabolic rate in the post-obese. They found that the post-obese had 3-5% lower RMR's than the control participants after adjusting for fat-free mass and fat mass (Astrup et al., 1999). However, the dietary and physical activity practices of the post-obese were overlooked in nearly all of the studies examined and were not addressed in the meta-analysis (Astrup et al., 1999).

Neglecting the significance of physical activity and eating patterns limits the generalizability of these findings and limits the support for a genetic model. To fully examine the impact of genetics on metabolic rate, weight-regulating behaviors and body composition need to be controlled. This points to the need to conceptualize and conduct this type of research in a biopsychosocial context.

The Role of Age and Gender in Metabolic Rate

Age, and its associated decreases in physical activity and fat-free mass, has been significantly correlated with decreases in resting metabolic rate (Poehlman, Toth, & Gardner, 1995). In response to decreased physical activity and muscle mass common with aging, metabolic rate slows (Armellini et al., 2000; Ravussin & Bogardus, 1989). Many people report less leisure time physical activity later in life (Healthy People 2010, 2000). In the U.S., approximately 51% of the elderly, between the ages 65-74, report no physical activity, compared to 31% of young adults between the ages of 18 and 24 (Healthy People 2010, 2000). Interestingly, however, metabolic rate can slow, although to a lesser degree, in response to a loss of muscle mass even if physical activity does not decrease (Heymsfield et al., 1994). Muscle mass can be lost in the absence of physical activity, in response to hormonal changes, some health conditions, and dramatic decreases in food intake (Heymsfield et al., 1994).

Women tend to experience greater metabolic reductions with age because of the additional impact of hormonal changes during menopause (Heymsfield et al., 1994). Menopause is defined as the cessation of menses, although a number of other symptoms are also experienced during this natural process (e.g., hot flushes and brittle nails; Beckmann et al., 1998). Most women in the United States experience menopause between the ages of 50 and 52 with 95% experiencing menopause between the ages of 44 and 55 (Beckmann et al., 1998). The process of menopause can accelerate the rate of weight gain, losses of fat-free mass, and increased adiposity because of the dramatic drop in estrogen and progesterone (Heymsfield et al., 1994; Poehlman, Toth, & Gardner, 1995). Such changes in body composition result in lowered resting and exertion metabolic rate (Heymsfield et al., 1994; Poehlman, Toth, & Gardner, 1995). In a longitudinal study of women ages 44 to 48 (at the beginning of the study), Poehlman, Toth, and Gardner (1995) found that women who experienced menopause in the six years of the study lost more fat-free mass and gained more body fat, had greater decreases in metabolic rate, and exercised less than pre-menopausal women. In summary, genetically determined factors (i.e., gender) and the natural aging process are likely to have a profound affect on metabolic rate.

Relationship between Weight-Regulating Behaviors and Metabolic Rate

Despite evidence of genetic influences on metabolic rate, some research indicates that body composition (which is greatly determined by physical activity and eating patterns) may have a greater impact on weight than does heritability (e.g., Amatruda, Statt, and Welle 1993; Hill & Melanson, 1999; Hill & Peters, 1998). Fat-free mass accounts for approximately 85% of the individual variance in RMR (Cunningham, 1991). When weight is lost, typically 75% is fat mass and 25% is fat-free mass (Jequier, 1992). The metabolic rate of a fat mass (which is not metabolically active) is determined by the organ it surrounds (Apfelbaum, Fricker, & Igoin-Apfelbaum, 1987; Broeder, Burrhus, Svanevik, & Wilmore, 1992b; Ravussin & Bogardus, 1989); whereas fat-free mass is itself metabolically active tissue (Broeder, Burrhus, Svanevik, & Wilmore, 1992a;

Cunningham, 1991; Foreyt & Goodrick, 1994; Nelson, Weinsier, Long, & Schutz, 1992). Not surprisingly, then, losses in fat mass account for very little of the changes seen in RMR (Nelson, Weinsier, Long, & Schutz, 1992). Rather, it is the loss of fat-free mass that primarily accounts for reductions in RMR (Nelson, Weinsier, Long, & Schutz, 1992).

For example, Amatruda, Statt, and Welle (1993) assessed the metabolic rates of obese women, post-obese women, and never-obese normal weight women while controlling physical activity and energy intake. Physical activity was not controlled. Participants were instructed “to maintain a level of activity equal to that of the first energy expenditure studies” (Amatruda, Statt, and Welle, 1993, p. 1236). The obese participants were put on a very low calorie diet (about 420-800 kcal/day) until ideal body weight was achieved. RMR was measured before weight loss (obese) and after weight loss (post-obese). The obese, post-obese, and never-obese normal weight women all had similar metabolic rates after adjusting for fat-free mass. The hypothesis that the post-obese and obese would have lower metabolic rates, which contributed to their ease of weight gain, was not supported. These data provide further support for the influence of physical activity and energy intake on body composition and, consequently, on metabolic rate (Amatruda, Statt, & Welle, 1993).

This study, however, did not examine the impact of weight-reducing behaviors commonly used by obese individuals. When the slimming process involves severe energy restriction, in the absence of increased physical activity, diet-induced thermogenesis decreases (Apfelbaum, Fricker, & Igoin-Apfelbaum, 1987; Ravussin, Burnand, Schutz, & Jequier, 1985; Frey-Hewitt, Vranizan, Dreon, & Wood, 1990;

Weigle et al., 1988). In both normal weight and obese individuals, acute, short-term reductions in RMR caused by restrictive energy intake do not seem to be permanent and will likely normalize upon a resumption of energy-balanced energy intake (Weinsier, Nagy et al., 2000; Welle, Amatruda, Forbes, & Lockwood, 1984). The longer term reductions in RMR caused by energy restriction and weight loss can best be accounted for by losses of lean body mass (Frey-Hewitt et al., 1990; James et al., 1978; James, Lean, & McNeill, 1987). With the loss of lean body mass, the energy cost of movement also decreases, which additionally reduces total metabolic rate (Apfelbaum, Fricker, & Igoin-Apfelbaum, 1987; Ravussin, Burnand, Schutz, & Jequier, 1985; Frey-Hewitt, Vranizan, Dreon, & Wood, 1990; Weigle et al., 1988).

The proportionately large loss of lean body mass may explain why a significant number of dieters report frequent weight rebounds (Broeder et al., 1992a; Broeder et al., 1992b). Essentially, weight loss, in the absence of exercise, results in greater loss of fat-free mass than weight loss with exercise (Broeder et al., 1992b; Frey-Hewitt et al., 1990; Henson et al., 1987; Schlundt, Hill, Sbrocco, Pop-Cordle, & Sharp, 1992; Votruba, Horvitz, & Schoeller, 2000). Since RMR is, to a degree, contingent on fat-free mass as well as body mass, after energy restriction ceases, the resumed caloric intake, in combination with the lowered metabolic rate, can lead to weight regain exceeding the pre-diet body weight.

The Relationship between Physical Activity and Metabolic Rate

Physical activity is positively correlated with resting metabolic rate (Broeder et al., 1992a). Increased physical activity can increase metabolic rate by building muscle tissue in both men and women (Broeder et al., 1992a; Weinsier et al., 1998). Increasing muscle tissue is of potential importance to the slimming process. For example, Frey-Hewitt and colleagues (1990) found that loss of fat mass was approximately equal for those participants who increased physical activity through running without changing caloric intake to those participants who decreased caloric intake without increasing physical activity. However, the participants who followed the exercise regimen did not experience decreases in RMR with weight loss, while those who followed the calorie restriction regimen did (Frey-Hewitt et al., 1990). Although exercise may appear to slow weight loss, this is explained by changes in body composition. And, the loss of fat mass is the same while the loss of fat-free mass or muscle is reduced (Stunkard, 1987; Wing, 1999). This suggests that RMR was preserved with the addition of exercise to the slimming process (Wing, 1999).

The type of physical activity in which individuals participate may also be important in determining the increase or preservation of lean body mass (Broeder et al., 1992b). Resistance exercise has been shown to increase RMR (Broeder et al., 1992b). This finding is accounted for by the increases in fat-free mass (Broeder et al., 1992b). Broeder and colleagues (1992b) placed 47 normal weight men, 18 to 35 years of age into one of three 12-week exercise programs: endurance only; endurance/resistance (combined); and resistance only. All three groups lost approximately the same amount of body fat. The combined and resistance groups gained approximately the same amount of lean body mass. Only the endurance group’s metabolic rate decreased, which was expected because of the losses in both fat mass and fat-free mass. The endurance/resistance and the resistance groups, however, showed increases in their metabolic rate, despite weight losses. This was explained by the resultant increase in fat-free mass that accompanies resistance exercises and is supported by other research findings (e.g., Geissler, Miller, & Shah, 1987).

Dolezal and Potteiger (1998) found similar support for the benefits of combined endurance and resistance training in a study of thirty healthy, normal weight adult males. They more clearly defined the differences in the specific changes in body composition in relation to RMR. Those in the resistance only training group showed increases in muscle mass, muscle strength, and RMR (Dolezal & Potteiger, 1998). The participants in the endurance only training groups had decreases RMR, decrease in fat mass and improved cardiovascular functioning (Dolezal & Potteiger, 1998). Finally, those in the combined resistance and endurance training group, experienced both increases in muscle mass and RMR and decreases in fat mass (Dolezal & Potteiger, 1998). These studies provide strong evidence for the impact of physical activity on metabolic rate through changes in body composition.

Assessing Daily Energy Expenditure.

The most common method of measuring daily physical activity is self-report. Recall methods and daily activity diaries are simple and inexpensive (Westerterp, 1999). However, they are subject to recall errors and biased reporting (Ainsworth et al., 2000; Westerterp, 1999) and may not be a good indication of intensity of physical activity when compared to accelerometers (Ainsworth et al., 2000).

Another method incorporated into research is heart monitoring, which requires participants to wear an apparatus that continuously measures changes in their heartbeats per minute (Ekblom, 1992). The premise of this method is the positive correlation between heart rate and oxygen uptake (Ekblom, 1992). Since heart rate is significantly impacted by a number of factors not related to physical fitness (e.g., age, medications, or stress), this method is not specific enough to accurately measure physical activity unless monitored individually and used in conjunction with an activity diary (Ekblom, 1992; Westerterp, 1999). Consequently, heart monitoring is less frequently used to measure in vivo physical activity (Westerterp, 1999). It is however, frequently used during treadmill maximal and cycle ergometry submaximal load tests (Moseley & Jeukendrup, 2001). For load tests, physical fitness is determined by the changes in heart rate when the load is increased. This method is a valid and reliable measure of physical fitness in most populations (Ekblom, 1992; Moseley & Jeukendrup, 2001).

A far more accurate method for assessing physical activity is doubly labeled water (Westerterp, 1999). As described previously, this is a valid and reliable measure of energy expenditure (Westerterp, 1999). Physical activity can be calculated by dividing the RMR into the total daily energy expenditure (Westerterp, 1999). Despite the benefits of this method, as described ealier, it is expensive and frequently difficult to attain O^{18}, which is used in this process (Westerterp, 1999).

Other widely used for measuring in vivo physical activity include accelerometers and pedometers. Accelerometers are a reliable measure of physical activity ($r = 0.94$) that monitor physical movement in three planes detecting quality or intensity of movement (Ainsworth et al., 2000; Freedson & Miller, 2000; Hendelman et al., 2000). They are now available to researchers at a reasonable cost ($50 - $500 per unit). Accelerometers, or actometers, are designed to be worn on the hip, wrist, or ankle providing more accurate and detailed information on total body movement (Meijer et al., 1991). When compared to the now commercially available pedometer, the actometer is expensive, cumbersome, and less user friendly (Freedson & Miller, 2000; Meijer et al., 1991). However, it does assess other types of activity, such as upper body movements, that may be missed through a pedometer.

The pedometer measures daily physical activity through a horizontal, spring-suspended lever arm that moves up and down in response to the movement associated with walking (Bassett et al., 2000). The pedometer has demonstrated usefulness as a valid (within 1% of actual values; Welk et al., 2000), reliable (r-values between 0.76- 0.92 when compared to VO_2 measures; Hendelman et al., 2000; Welk et al., 2000), and inexpensive (average cost of $25 per unit) measure of physical activity in a wide variety of populations (Hendelman et al., 2000). The newer models more reliably record movement at a variety of speeds (i.e., jogging and walking) sometimes overestimating energy expenditure (Bassett, Cureton, & Ainsworth, 2000). However, they are limited in their ability to detect upper body movement and movement in the vertical plane, which may actually lead to underestimating total energy expenditure (Saris & Binkhorst, 1977; Bassett et al., 2000).

Yamax, a commercially available, inexpensive brand, has been used in a number of studies and has been shown to be moderately correlated with energy expenditure (r = 0.47-0.88; Bassett, 1996; Bassett, Cureton, & Ainsworth, 2000; Gretebeck & Montaye, 1992; Mizuno, Yoshida, & Udo, 1990; Welk et al., 2000). A period of at least five to six days of monitoring has been shown to be a sufficient amount of time to assess individuals' daily activity and minimize intra-individual variance (Greteback & Montoye, 1992). Therefore, a monitoring period of at least 5 days should be sufficient to gain an accurate picture of an individual's typical daily physical activity.

The Relationship between Eating Patterns and Metabolic Rate

While daily physical activity and exercise have a significant impact on body composition and consequently metabolic rate, eating patterns also play an important role in metabolism. The ingestion of food causes an increase in energy expenditure over RMR because of the physiological processes required for digestion, energy storage, and energy use (e.g., Jequier, 1990; Jequier, 1992). Eating patterns, primarily macronutrient composition and the time-distribution of meals, are also hypothesized to have specific impacts on metabolism (Fabry, Fodor, Hejl, Braun, & Zvolankvoa, 1964; Fabry, Hejda, Cerny, Osancova, & Pechar, 1966; George et al., 1989; Huenemann, Hampton, Shapiro, & Behnke, 1966). Currently, the findings on the relationship of meal frequency to body weight, body fat, and metabolism are inconsistent (Fabry, Fodor, Hejl, Braun, & Zvolankvoa, 1964). The inconsistency may be partially due to the limitation of the methods for assessing dietary intake, which is the primary outcome measure of studies on meal pattern. The inconsistency may also be due to differences in methodology across studies, particularly differences in the definition of types of meal patterns.

Assessment of Daily Energy Intake.

The current methods for assessing food intake have been extensively studied and evaluated (Thompson & Byers, 1994). In vivo dietary assessment methods include food recall, food frequency questionnaires, and dietary records (Thompson & Byers, 1994). One source of error common to all three methods of assessment is the participant's ability to estimate portion sizes (Smith, Jobe, & Mingay, 1991). Participants are typically very poor estimators of portion size, frequently leading to underestimates of their actual food intake (Smith, Jobe, & Mingay, 1991). Another source of inaccuracy is the tendency for participants to record in a socially desirable manner (Korotitsch & Nelson-Gray, 1999). Researchers may also inadvertently bias the foods reported by participants, especially if the dietary assessment is in conjunction with nutrition or weight interventions (Kristal et al., 1998).

Food recall measures typically ask participants to report on their food intake for the previous 24-hours. These methods are used to assess general eating patterns and can be beneficial to researchers with limited time (Thompson & Byers, 1994). 24-hour recall methods may not be appropriate when detail of food intake is desired because participants must rely on their memories of eating and their estimations of portion sizes (Thompson & Byers, 1994).

Food frequency questionnaires are an alternate method to 24-hour recall measures because they enable researchers to assess dietary intake with potentially less time spent with participants (Thompson & Byers, 1994). This approach asks participants to report their usual food intake by selecting foods from provided checklists (Thompson & Byers, 1994). This method is very useful to epidemiologists and researchers interested in assessing food intake trends of groups (Friedenreich, 1994; Thompson & Byers, 1994). However, it is limited in that it relies on participants' interpretations of and ability to recall their serving sizes (Friedenreich, 1994; Smith, 1993). Furthermore, it is limited by the ability to assess detailed information about food intake (Friedenreich, 1994).

Compared to food recall and food checklists, dietary records, or food diaries, enable researchers to more accurately assess individuals' eating patterns and food intake (Thompson & Byers, 1994). This method is not typically useful when group trends are of interest because of the time required for coding and recording (Thompson & Byers, 1994). For this reason, they are more applicable in clinical settings and smaller research studies (Thompson & Byers, 1994). This method is also less susceptible to recall errors, if participants record their foods as they eat them (Thompson & Byers, 1994). However, participant fatigue and underreporting frequently occur (Schoeller, 1990). Participant fatigue becomes an issue when the task of recording foods is cumbersome (such as carrying around notebooks) or the diet logs are kept for an extended period of time (Thompson & Byers, 1994).

Some studies suggest that dietary records may not be accurate because of underreporting, especially in the overweight population (Fricker et al., 1992; Klesges, Eck, & Ray, 1995; Lichtman et al., 1992; Livingstone et al., 1990; Myers et al., 1988; Schoeller, 1990). However, when dietary records are the most appropriate assessment method for the given hypothesis and methodology, several means of improving the accuracy and reliability of the recorded data are available (Thompson & Byers, 1994). First, participants should be asked to record their food intake as they are eating (rather than trying to recall what they ate). This limits recall error and bias. Secondly, they should also weigh their foods to reduce errors in estimating serving sizes. Third, participants should be provided specific recording forms or be given handheld computers to improve compliance. Fourth, participants should record their foods for a minimum of 5 to 6 days and no more than 7 days (Thompson & Byers, 1994). Having participants record dietary intake for 7 days increases the likelihood of capturing a “day of the week effect” in which participants ingest significantly different amounts and types of foods on different days of the week (Thompson & Byers, 1994). Finally, when participants think their entries can be verified by the researchers, they are more likely to report their food intake accurately (Muhlheim, Allison, Heshka, & Heymsfield, 1998). In summary, there are limitations in the assessment of both food intake and metabolic rate. These limitations add to the debate on the impact of eating frequency on weight and metabolic rate and require that findings are carefully examined in the context of methodologic limitations.

Macronutrient Dietary Composition and the Dietary Induced Thermogenesis.

Dietary composition and the Dietary Induced Thermogenesis (DIT) are important components of meal patterns. In response to eating, the physiological processes involved in digestion (such as intestinal absorption, transport, processing, and storage of food) raise metabolic rate (Jequier, 1990). The ingestion of food causes a similar increase in RMR in both obese and normal weight populations (Felig et al., 1983). This increase is known as postprandial thermogenesis.

The specific properties of macronutrients may also impact metabolic rate (Agus et al., 2000; Poppitt & Prentice, 1996; Raben et al., 1994). The thermic effect of carbohydrates (i.e., the rise in energy expenditure after the consumption of carbohydrates) is arguably twice that of the thermic effect of fat, although this may depend on several factors including body fat percentage, total caloric intake, gender, age, genetics, and physical activity levels (Jequier, 1990). When carbohydrates, fats, and/or proteins are consumed, any excess beyond what is metabolized (i.e., used in ATP resynthesis) is stored as adipose tissue (McArdle, Katch, & Katch, 2000; Poppitt & Prentice, 1996). Additionally, fat is more energy dense than carbohydrates and is metabolized at a slower rate (McArdle, Katch, & Katch, 2000), which may help to explain why a meal with a high carbohydrate to fat ratio induces a higher thermogenic response than a meal with a low ratio (Jequier, 1990; Jequier, 1992; Reed & Hill, 1996). Weststrate and Hautvaust (1990) found that carbohydrate overfeeding increased metabolic rate above RMR by 39% in normal weight healthy adults.

A similar increase in thermogenesis is *not* seen when an individual ingests excessive amounts of fat (Poppitt & Prentice, 1996). Over-consumption of fat may lead to a preferential storage of fat (Poppitt & Prentice, 1996) because dietary fat is more easily stored as body fat (McArdle, Katch, & Katch, 2000). Findings that diets higher in fat have been correlated with both higher BMI and higher body fat percentage provide support for this theory (Poppitt & Prentice, 1996). Dietary fat is dense in energy (9 kilocalories per gram) containing more than twice the amount of energy per gram than either carbohydrates or protein (both 4 kilocalories per gram). Consequently, a small amount of a high fat food may have the same energy content as a larger amount of a high carbohydrate food, which may also be bulkier (Poppitt & Prentice, 1996).

In a study by Raben and colleagues (1994) of 12 post-obese women (weight stable for at least 3 months) and 12 never-obese normal weight matched controls, the differential influence of macronutrient composition on thermogenesis were further supported. Participants were given a dietary regimen consisting of 58% carbohydrates, 29% fat, and 13% protein. They were to follow this diet for two days preceding the test day in order to reduce the likelihood of any macronutrient deprivation effects. On the test day, participants consumed a meal composed of 50% fat, 34.4% carbohydrates, and 15.4% protein. Overall, there were no significant differences found between the groups' postprandial thermogenesis peaks, time to peak onset, or area under the curve. However, when postprandial fat oxidation was specifically examined, the post-obese women converted 2.5 times more food into metabolically inert body fat than the never-obese matched control group.

Larson, Ferraro, Robertson, and Ravussin (1995) also found a suppression of postprandial fat oxidation in 11 dieting overweight women when compared to 110 non-dieting normal weight men and women. Given the imbalance of group size, which can increase Type I error, the findings of this study should be accepted with caution. Although DIT is partially determined by macronutrient meal composition, total kilocaloric content and body composition also play important roles (Reed & Hill, 1996). Total kilocaloric content of the meal and the peak postprandial thermogenesis are likely to be positively related, such that as meal size increases, peak postprandial thermogenesis increases, regardless of body weight or body fat percentage (Reed & Hill, 1996). On the contrary, as body fat percentage increases (regardless of meal size), peak postprandial thermogenesis may be reduced and delayed, but the total DIT is not reduced in these individuals (Reed & Hill, 1996). Taken in combination, an overweight individual's (with a higher body fat percentage) peak postprandial thermogenic response to a high-kilocalorie meal is likely to be lower and delayed when compared to a normal weight individual's peak postprandial response. The effect of meal size and body composition in relation to peak postprandial response may be important in understanding the potential effect of meal frequency.

Time-Distribution of Meals.

The effect of meal frequency (i.e., the inter-meal interval) in combination with meal size may be an important determinant of body composition. The terms nibbling and gorging, have been used to describe distinctive categories of eating styles, rather than a continuum of meal frequency. Nibbling is typically defined as an eating pattern in which total daily energy intake is distributed into frequent small meals. Gorging, on the other hand, is typically defined as an eating pattern in which total daily energy intake is consumed in one or two large meals. Gorging eating patterns are hypothesized to increase body fat percentage and lower metabolic rate (e.g., Fabry et al., 1964, Metzner et al., 1977). However, more recent studies have not consistently supported this hypothesis (e.g., Taylor & Garrow, 2001). To understand the inconsistency of the findings, it is important to follow the progression of both the methods and the operational definitions of eating patterns used in this line of research.

Studies on the relationship between time-distribution of meals (i.e., inter-meal interval) and body composition in humans first began to appear in the early 1960's (e.g., Fabry et al., 1964, Fabry et al., 1966). This research continued until the late 1970s, but then seemed to fade away until the early 1990's. The terms nibbling and gorging were not used until this resurgence (e.g., Kinabo & Durnin, 1990; Metzner et al., 1977). With the reappearance of research on the impact of meal frequency on body composition came improved technological advances in assessing metabolic rate. Advanced technology has made it possible to closely examine the physiological effects of the time-distribution of meals.

Key studies in the history of time distribution of meals are summarized in Appendix A. Each study is described in terms of its methodology, including the design, the participants, and the operational definitions used for meal patterns. A key methodologic issue includes distinguishing between those studies in which the participants were recruited based on self-reported meal patterns versus studies where the meal pattern was manipulated. Additionally, weight status, gender, and age are addressed. Finally, the operational definitions of meal patterns used in these studies are carefully described.

In 1964, Fabry, Fodor, Hejl, Braun, and Zvolankvoa hypothesized that a relationship observed between meal frequency and body composition found in animals also existed in humans. They found that rats fed larger amounts of food at longer intervals between eating episodes experienced physiological adaptations, including increased blood glucose, increased fat absorption, increased rates of lipogenesis, and increased blood-lipid levels (Fabry et al., 1964). They then examined 440 normal weight and overweight men divided into five groups based on their reported typical frequency of meals: 3 or fewer; 3-4; 3-4 with between meal snacks; 3-4 with a snack at bedtime; and 5 or more. They found that despite having lower caloric intake, participants with the lowest meal frequency (3 or fewer) had the highest rates of overweight (determined by body fat percentage), hypercholesterolemia, and diminished glucose-tolerance (Fabry et al., 1964).

Although the results of this research (Fabry et al., 1964) support the hypothesis of a negative relationship between meal frequency and body fat percentage, they are somewhat limited. Technologic advances in assessment enable a more thorough examination of the relationship between meal pattern and metabolism and body composition possible. Specific limitations of this study include the accuracy of self-report, lack of assessment for physical activity, and crude measure of body composition. Since the accuracy of the participants' reported meal patterns was not verified, underreporting, which has been found to occur more frequently among overweight participants (e.g., Klesges, Eck, & Ray, 1995; Lichtman et al., 1992; Lowe, Kopyt, & Buchwald, 1996; Myers et al., 1988), may have biased the results. The researchers also did not assess physical activity, which is known to affect energy intake and body composition (e.g., Blundell & King, 1999). Furthermore, the measures of body composition (skinfold measurements) and overall health (hypercholesterolemia and glucose-tolerance) used in this study were reflective of the available technology, but may not have fully addressed the proposed hypothesis. Finally, the results of this study may have limited generalizability because the participant population was limited to adult men.

Fabry and colleagues' work in 1966 partially addressed the issues of accuracy and generalizability in their previous findings. They again tested the hypothesis of a negative relationship between meal frequency and body fat, but did not rely on self-report to assess meal frequencies. Instead, they designed a study in which meals were manipulated. In each of three boarding schools for 226 overweight and normal weight children and adolescents (both male and female), cafeteria schedules were arranged to serve three, five, or seven meals per day for one school year. At the beginning of the school year, there were no significant differences in the body weights or body fat percentages between the schools. By the end of the school year, however, the students who had the greatest time-distribution of meals (three meals per day) also had the highest amounts of body fat (Fabry et al., 1966).

By manipulating the time-distribution of meals, the hypothesis of an order effect was supported such that meal pattern preceded and potentially influenced weight and fat gain. However, Fabry and colleagues' findings were still somewhat limited because they did not assess daily physical activity, their inability to measure metabolic rate (due to the absence of the technology at that time), and their food intake assessment methods. Although they were able to manipulate the frequency of food availability, they did not actually monitor or assess how frequently the participants ate. In other words, just because a meal was served does not mean that the child or adolescent ate it. Despite these methodological limitations and the limited generalizability to adult women, their findings were now generalizable to a population (male and female children and adolescents) distinctly different from the first study (adult males).

In 1972, Huenemann employed the use of dietary records in a study of the eating habits of 122 male and female, normal weight and overweight high school students. The students were trained to keep food diaries for four separate one-week periods during the school year. The students' heights, weights, and body fat percentages (based on skinfold thickness) were assessed. The obese students (not including overweight participants) recorded the lowest energy intake and meal frequency. Although Huenemann's (1972) findings potentially further support the hypothesis that meal frequency and body fat percentage are negatively correlated, the data are subject to reporting bias and have limited generalizability. The likelihood of response bias is greater with the use of dietary records than when food intake frequency is manipulated (e.g., Klesges, Eck, & Ray, 1995; Lichtman et al., 1992; Lowe, Kopyt, & Buchwald, 1996; Myers et al., 1988). The focus on adolescents in this study limits the generalizability of the findings to adult populations.

The meal patterns of overweight and normal weight adults in relation to body composition were assessed as part of the Tecumseh Community Health Study (Metzner et al., 1977). Nine hundred forty-eight men and 108 women were interviewed and asked to recall their food intake for the previous 24 hours. Each participant's height, weight, and body fat were measured (Metzner et al., 1977). The data from this study again support the hypothesis that as the number of meals increases (from two to six), body fat percentage decreases (Metzner et al., 1977). Although these data support a relationship between meal patterns (based on total energy intake) and body composition, physical activity was not controlled or co-varied. Furthermore, 24-hour recall measures may be less reliable than food diaries given serving size and recall bias (e.g., Klesges, Eck, & Ray, 1995; Lichtman et al., 1992; Lowe, Kopyt, & Buchwald, 1996; Myers et al., 1988).

The works of Fabry et al. (1964; 1966), Huenemann et al. (1972), and Metzner et al. (1977) were revolutionary because the findings contradicted previously believed notions about the causes of overweight and obesity. The findings seemed to suggest that those who ate more frequently and had greater total energy intakes also weighed less and had lower body fat percentages. Despite the potential importance of these findings in the prevention and treatment of overweight, further research on this topic became scarce until the early 1990's. At this point, the focus shifted from the effects of meal patterns on body composition to the effects of meal patterns on metabolic rate. This conceptual shift is important because demonstrating a relationship between metabolic rate and meal pattern composition may be the key to understanding the relationship between eating patterns and body composition.

Kinabo and Durnin (1990) attempted to demonstrate the relationship between metabolic rate and meal frequency using 18 normal weight women. Participants ate one of two types of meals on two separate occasions after an overnight fast (Kinabo & Durnin, 1990). The meals were either high in fat (26% carbohydrates, 65% fat, and 11%

protein) or high in carbohydrates (70% carbohydrates, 19% fat, and 11% protein). On one occasion the meal was ingested as one large serving (5040 kJ or 1200 kcal) and on the other occasion the other meal was ingested in two smaller servings (2520 kJ or 600 kcal each). Dietary Induced Thermogenesis (DIT) was measured continuously through indirect calorimetry for 400 minutes beginning at the end of the first meal. There were no differences in postprandial thermogenesis between the two meal patterns. However, although they controlled for the potential bias of self-report by manipulating meal frequency, the differences between the two meal patterns may not have been sufficient to detect any metabolic responses. Fabry et al. (1964; 1966) and Huenemann (1972) found that significant difference in body composition between different eating patterns when comparing those who ate three or fewer meals to those who ate five or more meals. Consequently, comparing meal frequencies of only one and two meals may not be sufficient to induce a metabolic response. A better test might be one meal per day versus six, for example. Furthermore, the manipulation of meal pattern occurred on two separate occasions and not for a duration greater than one day. In Fabry et al. (1966), the meal patterns were manipulated for nearly one year. Therefore, a single day of gorging may not have been sufficient to induce a change in metabolic response. Such patterns may need to be examined over a longer period of time.

Verboeket-van de Venne and Westerterp (1991) are particularly important to this line of research because they are one of the first to operationally defining the eating patterns of interest and to use the terms gorging and nibbling. They defined gorging as eating two meals per day with the first meal after 12:00 p.m. Nibbling was defined as eating seven small meals per day with the first meal at 7:00 a.m. and the last meal at 8:30

p.m. They asked 13 normal weight male and female participants to follow either a gorging or nibbling meal pattern for two days and then assessed energy expenditure using indirect calorimetry, carbohydrate oxidation, and fat oxidation. The gorging meal pattern was associated with an increase in carbohydrate oxidation between the first and second meals and induced diurnal lipogenesis (Verboeket-van de Venne & Westerterp, 1991). In other words, carbohydrate oxidation increased after the first meal, but fat storage increased after both meals. The nibbling meal pattern induced no physiological changes in macronutrient oxidation or body fat storage rates (Verboeket-van de Venne & Westerterp, 1991). Despite not finding significant differences between the participants' RMR's, which may have been a result of limited power given the small sample, the effect of meal pattern on other physiological processes of weight regulation was demonstrated in a relatively short period of time.

Similar to Kinabo and Durnin (1990), the short duration of the meal pattern manipulation in Verboeket-van de Venne & Westerterp (1991) may not have been sufficient to induce a measurable change in metabolic rate. Furthermore, the daily physical activity patterns of the participants were not assessed, which could again significantly impact the outcome. For example, while following the gorging meal pattern, the participants may have felt fatigued and reactively decreased their physical activity at certain times of the day, leading to a decrease in total energy expenditure.

In summary, Fabry et al. (1964), Fabry et al. (1966), Huenemann (1972), and Metzner et al. (1977) found support for the theory of a negative relationship between meal frequency and body fat percentage. While revolutionary, research by Kinabo and Durnin (1990) and Verboeket-van de Venne & Westerterp (1991) did not support these findings. There are several key methodological differences between these groups of studies that may have had a significant impact on their findings. The studies with supportive results used observational methods of meal pattern (in Fabry et al., 1966 meal patterns were only minimally manipulated) and used body weight and body fat percentage as outcomes. The studies with non-supportive results manipulated meal pattern for a short period of time and measured metabolic rate. The length of practicing a specific meal pattern could potentially impact the degree of metabolic response (and consequent physiological responses). Furthermore, in all of these studies, physical activity, a key component in energy expenditure, was not measured, manipulated, or controlled. Again, by neglecting this variable, the true nature of the relationship between eating pattern and metabolism may not be fully tested.

Although these studies conflicted in results, they do provide important information and clues to stimulate future research. First of all, it is not likely that short-term manipulations in meal pattern affect metabolic rate. Second, the connection between metabolic rate and body composition may not be clear-cut. For example, if energy intake remains at a level to maintain weight regardless of frequency, then metabolic rate may not be affected. These studies provided the stimulus for investigating the hypothesis of a relationship between energy restriction and metabolic rate.

Time-Distribution of Eating during Kilocaloric Restriction.

Tai, Castillo, and Pi-Sunyer (1991) hypothesized that eating frequency and metabolic rate may be negatively related in the presence of energy restriction. They administered 750 kilocalories per day in either six small doses or one large dose to 7 healthy normal weight women on two separate occasions. As expected, the ingestion of six small meals resulted in a lower peak postprandial thermogenesis, but there were no significant differences in RMR between the two manipulations (Tai, Castillo, & Pi-Sunyer, 1991). However, due to the small sample size, power may not have been sufficient to detect actual differences between the two groups (Tai, Castillo, & Pi-Sunyer, 1991). The total caloric intake of 750 kilocalories may have been such a dramatic energy deficit, far below that of basal metabolic requirements for most adults, that the physiological energy conservation response was induced during both manipulations. The strengths of this study's methodology include the assessment of RMR and the manipulation of meal frequency. However, the limitations are similar to those previously discussed in that the meal pattern manipulations were only induced for a very short period of time (two nonconsecutive days) and the daily physical activity of the participants was not assessed.

Schlundt and colleagues (1992) were also interested in the effect of meal patterns on dieting individuals who did or did not eat breakfast. Although they did not find differences in RMR between the breakfast-skipping and non-breakfast-skipping groups, they did find differences in the impact of skipping breakfast on weight loss. Fifty-two self-reported breakfast-skipping and non-breakfast-skipping obese (BMI > 30kg/m2) women were stratified, based on whether they ate breakfast or not, to one of two 12-week 1200 kcal weight loss programs; breakfast treatment or no-breakfast treatment. The baseline breakfast-skipping individuals in both treatment groups lost less weight during the 12 weeks than the individuals who did not initially skip breakfast and vice versa (Schlundt et al., 1992). Furthermore, regardless of baseline eating behavior, eating breakfast reduced impulsive snacking and fat intake (Schlundt et al., 1992).

A study conducted by Verboeket-van de Venne, Westerterp, and Kester (1993) induced caloric restriction (1000 kcal/day) through either gorging (2 meals per day) or nibbling (7 meals per day) meal patterns for four weeks in 14 moderately obese women. They found no significant differences in weight loss, loss of fat mass or fat-free mass, metabolic rate, or dietary induced thermogenesis. Similar to Tai, Castillo, and Pi-Sunyer (1991), the strength of this study is the manipulation of meal frequency and the weaknesses include the severe level of energy restriction, lack of assessment of daily physical activity, and the limited power due to a small sample size. The restricted energy intake in moderately obese women may have been low enough to induce a physiological reduction in metabolic rate that would occur regardless of the time distribution of the meals.

Keim and colleagues (1997) examined the impact of mild energy restriction [106 kJ/(kg*d) or 25.24 kcal/(kg*d)] and food intake patterns on weight loss in 10 overweight women with body fat percentage greater than 30%. Participants were divided into two groups that consumed food differently based on time per day (AM pattern; PM pattern). After a 3-week weight stabilization period for both groups, they engaged in a 6-week weight loss treatments. The AM meal pattern group consumed food as follows: 35% of kcal intake at breakfast, 35% at lunch, 15% at dinner, and 15% at evening snack. The PM meal pattern group followed a reversed different pattern: 15% of kcal intake at breakfast, 15% at lunch, 35% at dinner, and 35% at an evening snack. The AM meal pattern resulted in slightly greater weight loss, greater fat loss, and greater fat-free mass loss (Keim et al., 1997). Although the PM meal pattern resulted in less weight loss and fat loss, the PM meal pattern lead to a preservation of fat-free mass (Keim et al., 1997).

Given these results, the typical dieting behavior of meal-skipping earlier in the day (primarily breakfast) might actually result in reduced weight loss.

Summary of Eating Pattern Research.

In summary, the results of earlier studies on eating pattern consistently found results of that gorgers (i.e., those who eat fewer than 3 meals per day) were at greater risk for overweight, hyperlipidemia, heart disease, and diabetes (e.g., Fabry et al., 1964; Fabry, et al., 1966; Huenemann, 1972; Huenemann, Hampton, Shapiro, & Behnke, 1966; Metzner et al., 1977; Schlundt et al., 1992). More recent research has not consistently supported these conclusions (e.g., Kinabo & Durnin, 1990; Verboeket-van de Venne & Westerterp, 1991). However, it is important to note that there have been several methodological differences between the earlier and later studies. Importantly, there have been inconsistencies in the definitions of meal patterns in both the earlier and later studies. Fabry et al.'s (1964) research and others like it examined time distribution of eating from the perspective that the effects of changes in meal patterning on weight related factors (body fat and overweight) would be seen after an extended period of time. However, studies from three to four decades ago were limited by the absence of the more sophisticated physiological measurements. Newer studies have incorporated modernized measures of metabolic rate, but often have not induced meal pattern changes for extended periods of time or have severely limited caloric intake.

This leaves an opening for future studies to incorporate modern measures of metabolic rate in a study on different meal patterns. In addition, meal patterns need to be examined in the absence of moderate to severe energy restriction as this, in and of itself, can reduce metabolic rate and is a separate issue. Finally, operational definitions of gorging and nibbling should be agreed upon and consistently used in future research. The literature currently provides no consistent definitions of gorging and non-gorging eating patterns.

Current Investigation

The current study was designed to examine the impact of a gorging meal pattern on metabolic rate. Several methodological considerations were addressed to control for some of the previously described limitations of meal pattern studies. First, given the potential for daily physical activity to affect metabolic rate, this variable was measured and participant activity was controlled immediately prior to testing. Second, dietary records and food scales were used to improve the accuracy and reliability of the recorded data by reducing recall error and bias, increasing the likelihood of capturing a "day of the week effect," and reducing errors in estimating serving sizes (Thompson & Byers, 1994). Third, meal patterns were not manipulated; rather participants were recruited based on their meal pattern, controlling for weight status. In addition, weight-stable individual (versus those engaged in caloric restriction) were sought.

Opting to recruit participants meeting specific criteria rather than manipulating these criteria addresses several key issues. Optimally, the measurement of metabolic rate on the test day would be a good representation of the participant's actual metabolic rate. In situations where a participant's body weight has fluctuated significantly and/or her food intake varies a great deal on a daily basis, a discreet measurement of metabolic rate may be less accurate. Variability in energy consumption affects body weight and may influence metabolic rate, measurement of metabolic rate at a discreet point may be less accurate for these individuals. “Stable” was defined as consistency in weight and eating pattern for at least the previous four weeks. Additionally, differences in metabolic rate due to factors other than lean body mass are likely to be subtle. Therefore, selecting participants in specific weight categories may help to maximize the differences in weight-related factors between the obese and normal weight groups and increase the probability of finding more subtle differences.

Finally, specific definitions of eating patterns were created combining historical research, clinically observed patterns, and pilot study data. The definitions of gorging and non-gorging incorporated the time of day of the first eating episode, the frequency of eating episode, and the proportion of total energy eaten throughout the day. The process of defining gorging and non-gorging for this study is further described in the next section.

Defining Non-gorging and Gorging Eating Patterns

Across research conducted during the past four decades, a variety of meal patterns have been examined and labeled as “gorging.” Consequently, comparing the findings of metabolic rate/eating pattern research is difficult at times and impossible at others due to variability in the operational definitions. Some inconsistencies in the definitions used among different studies include the number of meals eaten per day, the proportion of total daily food intake eaten during “gorging” meals, references to time of day during which “gorging” meals were eaten, and inter-meal interval.

For example, gorging has been defined as both eating two meals per day (Iwao et al., 1996; Schlundt et al., 1992; Taylor & Garrow, 2001; Verboeket-van de Venne, Westerterp, & Kester, 1993) and eating one meal per day (Tai, Castillo, & Pi-Sunyer, 1991). Further complicating the comparison of studies of eating pattern/metabolic rate is that gorging was compared to "nibbling" in some studies and the USDA recommendations for meal pattern in other studies (three meals and two snacks per day; USDA, 2000). Additionally, nibbling has also been defined in a variety of ways, including seven meals per day (Verboeket-van de Venne, Westerterp, & Kester, 1993), six meals per day (Iwao et al., 1996; Tai, Castillo, & Pi-Sunyer, 1991), five meals per day (Verboeket-van de Venne & Westerterp, 1992), and two meals per day (Kinabo & Durnin, 1990).

The difference between eating one meal and two meals per day may be more or less important when taking into consideration the other variables of concern, such as the proportion of total food intake eaten in the "gorging" meal or the time of day the meals were eaten. Whether a participant consumes nearly all of his/her daily energy consumption in one meal or consumes a relatively large meal at some point in the day may be an important differential when examining the metabolic responses to meal pattern (e.g., Schlundt et al., 1992; Tai, Castillo, & Pi-Sunyer, 1991).

Additionally, the previous factors may play a greater or lesser role in the relationship between meal pattern and metabolic rate after considering inter-meal interval. For example, consuming 750 kilocalories in one meal or across 6 meals (as in Kinabo & Durnin, 1990) may not have a measurable impact on metabolic rate. An energy intake of 750 kilocalories in one day is likely to be insufficient for weight maintenance for most adults regardless of meal interval.

Given the importance of clearly and consistently defining the eating patterns of interest, the operational definitions of gorging and non-gorging eating patterns used in this study were designed to capture the key components of the definitions presented in previous research and to maximize the differences between the groups. Although other meal patterns (such as regularly skipping breakfast) may exist and may be potentially important for future investigation, the focus of this study was to examine eating patterns found among dieters compared to the USDA recommended eating pattern guidelines (USDA, 2000).

The definitions of gorging and non-gorging created for the current study include the phrase "eating episode." An eating episode is considered a period of food consumption of more than 100 kilocalories without consideration of time for consumption. It is used in the following definitions of meal pattern to reduce confusion regarding reporting of "meal" patterns. For example, a cup of coffee with a moderate amount of cream and sugar consumed in place of a breakfast meal likely contains less than 100 kilocalories, but was not considered to be a meal in this study. Participants were asked to report the consumption of this food item, but it was not labeled as a meal for data analysis.

The definitions of gorging and non-gorging did not include energy intake restrictions because total energy intake was of interest and was, therefore, a dependent variable in the data analysis. The following operational definitions of gorging and non-gorging were used in the current study:

1. **Non-gorging.** The term non-gorging was used in place of nibbling to purposely increase the pool of potential participants by including volunteers with eating patterns consistent with the USDA recommendation (three meals and two snacks; USDA, 2000). This definition may have incidentally captured those individuals who could be described as "nibblers" (i.e., those

who eat more than 5 times per day). Non-gorging eating patterns met the following criteria:

   a. Number of eating episodes: An average of three or more eating episodes per day (including labeling three of these episodes as breakfast, lunch, and dinner).

   b. Proportion of total food intake eaten per eating episode: No less than 100 kilocalories per eating episode. One hundred percent of daily energy intake consumed at regular intervals throughout the day.

   c. Time of day: Less than three hours between waking and the first eating episode.

   d. Inter-meal interval: Meal skipping occurred less than three out of seven days for the past month and breakfast and lunch were not skipped in the same day in the four weeks prior to the assessment day (Fabry et al., 1964, Fabry et al., 1966; Schlundt et al, 1992).

2. **Gorgers.** Gorging eating patterns met the following criteria:

   a. Number of eating episodes: An average of one or two eating episodes per day.

   b. Proportion of total food intake eaten per eating episode: No more than 100 kilocalories eaten from waking to first eating episode. Nearly 100% of daily energy intake consumed in one or two eating episodes. No constraints were placed on the proportion of kilocalories of the two eating episodes if the participant reported two.

c. Time of day: Seven or more hours between waking and the first eating episode.

d. Inter-meal interval: Breakfast and lunch were skipped three days out of every seven-day-period over the past four weeks (Fabry et al., 1964, Fabry et al., 1966; Iwao et al., 1996; Schlundt et al, 1992). No time constraints were placed on the inter-meal interval if the participant ate two meals so long as the first of these eating episodes occurred greater than seven hours after waking.

The a priori definition of gorging was a meal pattern that met the following criteria: 1) breakfast was not eaten, 2) the first meal was eaten at least 9 hours after waking, and 3) no more than 100 kilocalories were eaten during this 9 hour period. The requirement for 9 hours between waking and eating the first meal was modified (decreased to 7 hours) to increase the number of eligible volunteers. During the phone screen it was noted that many volunteers reported waiting closer to seven hours than nine hours before eating. Changing the criteria to seven hours increased the number of eligible volunteers in the gorging group. The energy facets of the definition remained the same.

Specific Aims and Hypotheses

The overall goal of this study was to investigate the relationship of two eating patterns, gorging and non-gorging, to metabolic rate and body composition in normal weight and obese individuals. Four specific aims will be addressed in the following sections.

Aim One: The relationship of eating pattern and energy expenditure. The first aim of this study is to explore the relationship between eating patterns (gorging and non-gorging) and total daily energy expenditure (TDEE) while controlling for lean body mass. Individuals engaging in a gorging eating pattern may do so in an effort to reduce overall energy intake and control weight. Although gorging behaviors are often associated with weight loss efforts, they may actually be counterproductive to weight loss. Long periods between eating episodes may be associated with an energy conservation response and a decrease in TDEE.

A pattern of gorging is expected to be associated with lower TDEE when compared to a distributed intake pattern (non-gorging). Gorging and the hypothesized reduction in TDEE are expected to occur among both the normal weight and the obese groups. Additionally, TDEE is composed of resting metabolic rate (RMR), active metabolic rate (AMR), and Dietary Induced Thermogenesis (DIT) and a reduction in energy expenditure is expected to occur for each of these components. Since lean body mass (LBM) is the best predictor of RMR and largely accounts for the age differences in TDEE (McArdle, Katch, & Katch, 2000), LBM was co-varied when comparing gorgers' and non-gorgers' total daily energy expenditure.

1a. **Resting Metabolic Rate.** RMR is defined as the rate at which the body utilizes ingested energy to sustain basic bodily functions in a resting state. RMR comprises approximately 60-75% of total daily energy expenditure (McArdle, Katch, & Katch, 2000). Because irregular eating patterns among gorgers may result in energy conservation, the gorgers' RMR was expected to be lower than that of the non-gorgers' (Hill & Mellanson, 1999; Trembaly et al., 1992). Additionally, because lean body mass (LBM) directly influences RMR and obese individuals are expected to have more LBM, the obese group is expected to have higher RMR's than the normal weight group prior to covarying LBM (McArdle, Katch, & Katch, 2000). We therefore postulate the following hypotheses:

Hypothesis 1.a.1. The RMR of the gorgers is significantly lower than that of the non-gorgers.

Hypothesis 1.a.2. The differences between the gorging and non-gorging groups are expected to remain significant after adjusting for LBM such that the gorging group would have lower RMR's.

Hypothesis 1.a.3. The RMR's of the obese group are significantly higher than that of the normal weight individuals.

Hypothesis 1.a.4. The differences between the obese and normal weight groups are not expected to remain significant after adjusting for LBM.

No a priori hypotheses about interaction effects are made. In the case of a significant interaction effects, post hoc analyses on the change terms were conducted.

1b. **Active Metabolic Rate.** The active metabolic rate (AMR) was defined as the rise in energy expenditure above RMR induced by physical exertion. In this study, AMR was induced through minimal physical exertion. Participants rode a stationary bicycle at a workload of 50 watts for 10 minutes to induce AMR.

Because active metabolic rate comprises approximately 15-30% of total daily energy expenditure, it is expected that the hypothesized reduction in TDEE due to gorging meal pattern would be observed at the level of AMR as a part of TDEE (e.g., Felig et al., 1983). Additionally, because lean body mass (LBM) directly influences TDEE and obese individuals are expected to have more LBM, the obese group is expected to have higher AMR's than the normal weight group prior to covarying LBM (McArdle, Katch, & Katch, 2000). We therefore postulate the following hypotheses:

Hypothesis 1.b.1. The AMR's of the gorgers are significantly lower than that of the non-gorgers.

Hypothesis 1.b.2. The differences between the gorging and non-gorging groups are expected to remain significant after adjusting for LBM such that the gorging group would have lower AMR's.

Hypothesis 1.b.3. The AMR's of the obese group are significantly higher than that of the normal weight individuals.

Hypothesis 1.b.4. The differences between the obese and normal weight groups are not expected to remain significant after adjusting for LBM.

No a priori hypotheses about interaction effects are made. In the case of a significant interaction effects, post hoc analyses on the change terms were conducted.

1c. **Dietary Induced Thermogenesis.** The Dietary Induced Thermogenesis (DIT) is defined as the postprandial increase in energy expenditure above RMR required to digest, absorb, and assimilate nutrients (McArdle, Katch, & Katch, 2000). DIT comprises approximately 10% of total daily energy expenditure. In this study, DIT was measured after the participants consumed a 300 kilocalorie liquid meal. The hypothesized reduction in TDEE due to gorging eating pattern is expected to be observed in DIT such that the gorgers would have lower DIT's than the non-gorgers (Hill & Mellanson, 1999; Trembaly et al., 1992). Additionally, because lean body mass (LBM) directly influences TDEE and obese individuals are expected to have more LBM, the obese group is expected to have higher DIT's than the normal weight group prior to covarying LBM (McArdle, Katch, & Katch, 2000). We therefore postulate the following hypotheses:

<u>Hypothesis 1.c.1.</u> The DIT of the gorgers is significantly lower than that of the non-gorgers.

<u>Hypothesis 1.c.2.</u> The differences between the gorging and non-gorging groups are expected to remain significant after adjusting for LBM such that the gorging group would have lower AMR's.

<u>Hypothesis 1.c.3.</u> The DIT of the obese group is significantly higher than that of the normal weight individuals.

<u>Hypothesis 1.c.4.</u> The differences between the obese and normal weight groups are not expected to remain significant after adjusting for LBM.

No a priori hypotheses about interaction effects are made. In the case of a significant interaction effects, post hoc analyses on the change terms were conducted.

Aim Two: The relationship between eating pattern and body composition. The second aim of this study is to examine the relationship between eating pattern and body composition after controlling for daily physical activity. Daily physical activity was controlled by having the participants restrict activity for 12 hours prior to the metabolic testing and having them rest quietly for 30 minutes prior to the actual testing. The efficiency of the human body to conserve energy when food is inconsistently available is hypothesized to account for a measurable increase in body fat percentage. We postulate the following:

Hypothesis 2.a. The gorgers have higher body fat percentages than the non-gorgers.

Hypothesis 2.b. The obese group has higher body fat percentages than the normal weight group.

Aim Three: The relationship of eating pattern and energy intake. The third aim of the study is to examine the relationship of eating pattern to total energy intake and fat intake. There is evidence to suggest that a pattern of over-consumption at one or two meals late in the day is associated with lower energy intake and greater fat intake (Harnack, Jeffrey, & Boutelle, 2000; Hill & Peters, 1998; Poston & Foreyt, 1999). The gorgers are expected to report lower energy intake because a slower metabolic rate requires less energy intake for maintenance. It may also be more difficult to consume a day's worth of energy in a short period of time later in the day. The gorgers are expected to have a greater fat consumption because they might be more likely to make poorer food choices (Schlundt et al., 1992). Therefore, we postulate the following:

Hypothesis 3.a. The energy intakes of the gorgers are significantly lower than that of the non-gorgers. No effects of obese versus normal weight on self-reported energy intake are expected as a consequence of reporting biases (e.g., Fricker, Baelde, Igoin-Apfelbaum, Huet, & Apfelbaum, 1992; Goris, Westerterp-Plantenga, & Westerterp, 2000; Lichtman et al., Lowe, Kopyt, & Buchwald, 1996; 1992; Mead, 2001).

Hypothesis 3.b. The gorgers consume significantly more fat than the non-gorgers.

Aim Four: The Association of Eating Attitudes and Meal Pattern. The fourth, and final, aim of this study is to examine the relationship between eating pattern group and eating/body image attitudes as assessed by self-report measures. The evidence linking dieting history and gorging eating patterns suggests the presence of dieting schema or pathological eating attitudes (Schlundt et al., 1992; le Grange, Stone, & Brownell, 1998). Pathological eating/body image attitudes were operationalized using the eating pathology subscales on the EDI-2 (Garner, 1991; which include drive for thinness, bulimia, body dissatisfaction) and the subscales of the EI (Stunkard & Messick, 1985; dietary restraint, disinhibition, and cues for hunger). We postulate the following:

Hypothesis 4.a. The gorging group has greater pathology in eating/body image attitudes than the non-gorgers.

Hypothesis 4.b. The obese group has greater pathology in eating/body image attitudes than the normal weight group.

Research Design and Methods

The primary purpose of this study was to compare gorgers and nongorgers metabolic responding to exercise and meal challenges. In addition, the relationships between eating pattern, eating pathology, body composition and metabolic rate (resting metabolic rate, active metabolic rate, and Dietary Induced Thermogenesis) were carefully considered and examined.

Participants

Recruitment

Fifty-six pre-menopausal, non-smoking, otherwise healthy women (28 normal weight, 28 obese) between the ages of 21 and 51 [mean (SD): 32.71 (8.25)] were recruited to participate in a study on metabolism. Ads were posted in both newspaper advertisements in the Washington D.C. metropolitan area and flyers at the University in which the study was conducted. A copy of the advertisement can be found in Appendix B.

Participants were categorized as normal weight or obese according to the National Heart Lung and Blood Institutes guidelines (NHLBI, 1998). Those with a body mass index (BMI) between 18.5 kg/m^2 and 24.9 kg/m^2 were in the normal weight group and those with a BMI greater than 30.00 kg/m^2 were in the obese group.

Informed Consent

Participants meeting the initial requirements for participation were consented at two points; they signed both the Screening Informed Consent Form and the Participation

Informed Consent Form, which can be found in Appendix C. Participants were first consented over the phone and mailed the Screening Informed Consent Form. The second point of consent occurred during orientation where the Participation Informed Consent Form was reviewed. Both consent forms contained information about the complete study and the risks/benefits to the participants.

Screening

In addition to the Screening Consent, the screening packet mailed to participants included the Eating Disorders Examination-Self-Report Questionnaire Version (EDE-Q; Fairburn & Beglin, 1994), the BDI-II (Beck, Steer, Ball, & Ranieri, 1996**)**, and the Medical Information Form. Participants mailed the completed packet back to the primary investigator. Please see the measures section (page 71) for a complete description of these procedures.

The purpose of the screening packet was to screen out those volunteers who may have had a medical or psychological condition known to interfere with eating habits and/or metabolism (such as thyroid problems or depression). The BDI, EDE-Q, and the Medical Information Form were reviewed to ensure the participants did not endorse items consistent with clinical levels of depression (i.e., scores above 16 or endorsing suicidal intent), any eating disorders (excluding binge eating disorder), or any medical conditions that may influence metabolism (e.g., thyroid conditions or Type 2 Diabetes Mellitus). Three volunteers were excluded from participation due to BDI-II scores above 16. No volunteers endorsed any eating disorders or medical conditions on the EDE-Q and Medical Information Form, respectively, that would exclude them from participation.

Categorizing Participants

The participants were classified into one of two eating pattern groups (gorging, non-gorging) based on the phone screen, the initial assessment from the EDE-Q (Fairburn & Beglin, 1994), and the food diaries. The flowcharts in Figures A, B, and C can be used to follow the decision process in classifying the volunteers into gorging and non-gorging groups. These flow charts can be found in Appendix D. Please refer to Figure A in Appendix D for clarification of the first step in categorizing the volunteers. This step occurred during the phone screen. One hundred eleven subjects were assigned subject numbers during the phone screen (i.e., they met demographics criteria). Eight participants were excluded during the phone screen process. Therefore, 103 participants were mailed screening packets.

The volunteers were asked if they had a condition or took any medications that dictated how often or what they should eat. Those who answered in the affirmative were not included in the study. Those who answered in the negative were asked, “In the last month, how many meals did you eat per day?” Regardless of their response, they were asked if they eat breakfast regularly (defined as at least 3 days per week for the past 4 weeks). Lunch was not examined for regularity since some participants could potentially report eating lunch seven or more hours after waking; although this could not be determined until after the participant turned in the food diary.

To preliminarily categorize gorgers, those who endorsed eating two or fewer meals per day and ate breakfast regularly were excluded from participation. Those who endorsed eating two or fewer meals per day and did not eat breakfast were asked the length of time between waking and their first eating episode[2]. Volunteers who reported less than 7 hours between waking and their first eating episode were excluded from participation; whereas, volunteers who reported 7 hours or more between waking and their first eating episode were given a preliminary categorization of gorger when being screened through step 2 (EDE-Q).

To preliminarily categorize non-gorgers, the volunteers who endorsed eating three or more meals per day (at the second decision point) were asked if they ate breakfast regularly. A negative answer resulted in exclusion from participation. Those who answered in the positive (meaning they ate three meals per day and ate breakfast) were asked the length of time between waking and their first eating episode. Volunteers who reported more than 3 hours between waking and their first eating episode were excluded from participation; whereas, volunteers who reported 3 hours or less between waking and their first eating episode were given a preliminary categorization of non-gorger when being screened through step 2 (EDE-Q). The limitation of this method is that it may be influenced by responder bias such that volunteers may have answered in a manner they believed might increase the likelihood of being included in the study.

The use of the EDE-Q helps to reduce some responder bias by making the specific criteria desired by the investigator less obvious. Please reference Figure B in Appendix D to follow the procedures used for the second step in screening volunteers. Those who were preliminarily classified as either gorgers or non-gorgers based on the phone screen were mailed the screening packet, which contained the EDE-Q. The first question of the

[2] This question was not originally on the phone screen form, but was added after screening the first preliminarily categorized gorger to improve the screening process.

EDE-Q (Fairburn & Beglin, 1994) was used as the second step to more fully assess the reported eating patterns and to reduce volunteer reporting bias. The question assesses how many times each meal (breakfast, morning snack, lunch, afternoon snack, dinner, and nocturnal snack) was eaten in the last 28 days. Using these data, the decision point in solidifying category assignments was whether or not the volunteer reported skipping breakfast on 12 of the past 28 days. The data from those in the preliminary category of gorger who reported eating breakfast 12 of the last 28 days were excluded from participation. Twenty-eight of the 103 participants mailed screening packets did not return their packets. Therefore, 75 participants were evaluated in step 2. Six participants were excluded during the step 2 process. Sixty-nine participants were scheduled for lab visits and evaluated in Step 3.

The data for those preliminarily classified as non-gorgers was examined to determine if the volunteers reported skipping meals. Those reporting no meal skipping (excluding snacks) were classified as non-gorgers for step 3. The data from those that reported meal skipping were further examined to determine if they met the meal skipping criteria for gorging (skipping breakfast 12 of the last 28 days). Those that met criteria for gorging were reclassified as gorgers. Those that reported skipping meals more than 5 days of the last 28, but did not meet criteria for gorging were excluded. Although this step helped to more objectively categorize volunteers, it may have been subject to recall error. No participants were reclassified at step 2, which may be an indication that this step is unnecessary or would server better as part of step 1 (i.e., during the phone screen).

The use of the food diaries in the categorization process was incorporated to help reduce responder bias and recall error by eliminating the need to rely on participant memory and not requesting the frequency of meals (which might reveal the investigator's specific meal pattern criteria). Please reference Figure C in Appendix D to follow the final step in classifying participants. This step utilized the prospective one-week eating diaries kept by the participants.

Of the 69 participants beginning step 3, four participants were excluded during step 3, eleven participants did not show for their scheduled lab appointments or were excluded during step 3 (4 non-gorgers), and 3 participants were excluded after completing all of the steps (for BDI scores, described in the procedures section, page 85).

Matching the Groups

The eating pattern groups (gorgers, non-gorgers) were matched on age and BMI. Volunteers meeting criteria for the non-gorging eating pattern group were matched with volunteers meeting criteria for the non-gorging eating pattern group for age ($\pm$ 4 years) and BMI ($\pm$ 3 kg/m^2). Participants were first matched on age, then BMI. The eating pattern groups (gorging, non-gorging) did not significantly differ from each other in mean BMI or age (see results section for data).

Inclusion/Exclusion Criteria

Gender.

Participation in the study was limited only to **women** because this study focuses on disordered eating patterns, which disproportionately affect women and may arise from dieting behaviors (NIH, 2001). Women are 10 times more likely to develop eating disorders than men (NIH, 2001). Women are also more likely to diet, accounting for 77% of dieters in America (Mifflin et al., 1990; Thomas, 1995). Some eating disorders and dieting behaviors have been identified as precipitants to weight gain and decreased metabolic rate (e.g., Chamberlin, 2000; Fabry et al., 1966). The "dieting mentality" (please see page 8 for a more detailed discussion on the dieting mentality) contributes to several disordered eating patterns common to both eating disorders (e.g., binge eating disorder and bulimia) and dieting (Sbrocco, Nedegaard, Stone, & Lewis, 1999). These disordered eating patterns include dietary restriction, meal skipping, and postponing eating until the later hours of the day (e.g., Chamberlin, 2000; Fabry et al., 1966).

Weight Category.

Normal weight (BMI between 18.5 kg/m^2 and 24.9 kg/m^2) and obese (BMI's between above 30.0 kg/m^2) women were recruited and classified according to the NHLBI weight categories. It was hypothesized that weight status was a key independent variable related to eating patterns. To increase the chances of finding differences between weight groups necessitated having a clear differentiation in weight status. As such, overweight women (BMI's between 24.9 kg/m^2 and 30.0 kg/m^2) were excluded from participation. Women in this weight category may have energy intake and daily physical activity patterns similar to either the normal weight or obese categories. In addition, BMI is a good indicator of being overfat for population studies, but is less reliable for individuals who may be overweight, but are not overfat (Koop et al., 2002). For example, individuals who participate in physical conditioning that increases muscle mass (e.g., power lifting) and consequently total body mass, may fall into the overweight category, but may have lower body fat percentages and healthier diets than individuals in the same weight category who do not practice regular physical conditioning. It is unlikely (except in rare cases such as Olympic athletes) that individuals with a BMI greater than 30.00 kg/m^2 would have a body fat percentage in the normal range (NHLBI, 1998).

During the phone screen process, approximately 8 individuals with BMI's in the NHLBI overweight category were excluded from participation. Three participants recruited as normal weight (2 non-gorging and 1 gorging category) actually had BMI's ranging from 25.00 kg/m^2 to 25.39 kg/m^2. Unfortunately, the discrepancy was not caught at the weigh-in and these participants completed the remainder of the study. Following completion of data collection, a decision was made to include these participants in the data analysis for several reasons. First, the participants were needed to keep the sample sizes sufficiently high. Second, their BMI's were close to the cut-off of 24.99 kg/m^2 (25.00 kg/m^2, 25.30 kg/m^2, and 25.39 kg/m^2). Finally, a 5 kg/m^2 difference between the normal weight and obese groups still exists when including these participants in the normal weight group, which was the intention of purposely recruiting normal weight and obese participants.

Menopause.

Peri-menopausal and post-menopausal women were not included in this study. Effects of the menopause-related hormone fluctuations on metabolic rate, such as accelerated weight gain and body composition changes, have been demonstrated (e.g., increased body fat; Heymsfield et al., 1994; Poehlman, Toth, & Gardner, 1995). Natural menopause has been associated with decreases in RMR and TEE due to greater than expected losses of fat-free mass and increased central adiposity (Poehlman, Toth, & Gardner, 1995). Menopause is defined as the cessation of menses, although a number of other symptoms are also experienced during this natural process (e.g., hot flushes;

Beckmann et al., 1998). Participants were asked about their menstrual cycles during the phone screen and were excluded from participation if they reported fewer than 12 menstrual cycles per calendar year, regardless of having a diagnosis from a physician. Approximately 20-25 individuals were excluded from participation for this reason. The large number of post-menopausal women interested in this study may have resulted from the placement of one ad in the Washington Post, which was unintentionally run during a special edition for the elderly.

Eating Disorders and Depressive Symptoms.

Participants who met criteria for any eating disorder (e.g., Anorexia Nervosa, Bulimia Nervosa, etc.) other than Binge Eating Disorder or who scored in the clinical depression range on the BDI-II (greater than 16; Beck, Steer, Ball, & Ranieri, 1996**)** were excluded from participation and offered referrals to a local community mental health center or mental health professional. Depression has been shown to significantly affect eating pattern in dieting and non-dieting overweight and normal weight women (Baucom & Aiken, 1981). Women may also be more likely to eat in response to negative mood without having clinical levels of depression (Forster & Jeffrey, 1986). Both normal weight and overweight women may be at greater risk for disruptions in eating pattern in response to a negative event—dieting women are more likely to eat more while non-dieting women are more likely to eat less than usual (Baucom & Aiken, 1981). Consequently, the presence of depressive symptomatology could significantly impact a volunteer's eating pattern. Four individuals were excluded from participation during the phone screen for previously diagnosed eating disorders (1) or depression (3). All four declined referrals and were under a physician's care.

Measures

Demographic Information. Each participant completed the Demographics Form requiring age, date of birth, ethnicity/race, education, weight, height, marital status, education information, annual household income, and employment information. Please see Appendix E for a copy of the Demographics Form.

Medical Information. Eligible participants were mailed the Medical Information Form as part of the screening packet. Each participant completed a Medical Information Form, requiring basic medical information and confirmation of being under regular physician's care. Please see Appendix F for a copy of the Medical Information Form. The medical information form includes questions on major medical illnesses that might impact weight status and eating behaviors (such as Diabetes and pregnancy).

During the phone screen and on the Medical Information Form the volunteers were asked to report the start date of their most recent menstrual cycle and to report whether or not they have a tendency to have irregular periods. Post-menopausal women were declined participation since significant changes in body composition and metabolic rate due to menopause have been demonstrated (see Inclusion/Exclusion Criteria section; Heymsfield et al., 1994; Poehlman, Toth, & Gardner, 1995; Schofield, Schofield, & James, 1985). Participants who reported irregular menstrual cycles and were not peri-menopausal were not excluded from participation if their reported variance in days between cycles was approximately 2-5 days difference (i.e., their cycles varied between being 26 to 33 days long, but they had 12 menstrual cycles in a calendar year). Regular menstrual cycles were defined as 28-day cycles.

Participants with irregular menstrual cycles were instructed to call on the first day of their next period and the metabolic testing was scheduled 5 to 9 days after the first day. Of the 10 participants reporting irregular periods (defined as one period per month, but not always 28 days between periods), 8 called in on the first day of their period and were included in the study, 1 could not be reached, and 1 declined further participation when she was contacted.

Body Weight. Body weight was measured with a calibrated balance beam metric scale. Weight was measured at the initial visit. Height was measured to the nearest _ inch or 1 centimeter at either the orientation or the lab visit. Body Mass Index (BMI) in kg/m^2 was calculated from the weight and height measurements.

Body Composition. Body fat percentage and fat-free mass percentage were measured by bioelectric impedance (BEI) using the portable RJL body composition analyzer (MI, 1992). Bioelectric impedance calculates body composition by measuring tissue conductivity (Heymsfield et al., 1996). Resistance and Reactance are entered into accompanying software that calculates body fat percentage. Assessing body composition using bioelectric impedance equipment is safe, noninvasive, portable, easy, and accessible (Foster & Lukaski, 1996; Houtkooper, Lohman, Going, & Howell, 1996). Studies on the measurement properties of this device indicate that if proper procedures are followed, BEI is both reliable and valid (r^2 between 0.85 and 0.98 and errors between 1% and 20%) when compared to doubly labeled water and hydrostatic weighing (Evans, Arngrimsson, & Cureton, 2001; Heymsfield et al., 1996; Houtkooper, Lohman, Going, & Howell, 1996; Oldham, 1996). In order to increase the reliability of BEI, the participants must report to the laboratory after at least 4 hours of restricted physical activity (in this study the time was to 12 hours), in a fasted state, well-hydrated and, having removed all items containing metal (such as jewelry and underwire bras) (Houtkooper, Lohman, Going, & Howell, 1996). Since the participants had to meet these criteria for the metabolic measurement, the compliance questions were only asked one time at the beginning of the assessment. In the cases where participants could not remove all of their jewelry or the BEI output indicated that they were dehydrated, body fat was also measured by skinfold measurement.

Dietary Intake. The participants used the Palm Pilot m100 (Palm, Inc., Santa Clara, CA, 2000) palmtop computers to record their daily food intake. They were asked to weigh all of their foods with a portable scale and record foods eaten in ounces or grams (rather than serving sizes). The Palm Pilot m100 (Palm, Inc., Santa Clara, CA, 2000) contains a 2 megabytes internal disk and dietary intake was recorded using DietLog v1.83 (HealtheTech, Golden, CO, 2001) nutrition assessment program. The program contains an expandable database of 1,500 of everyday foods and their nutritional contents (HealtheTech, Golden, CO, 2001). Foods that are not already contained in the database can be easily entered into the program memory. The program prompts the user for nutritional information contained on the Nutrition Facts panel found on packaged foods. Nutrient composition analysis can be done for a single food, a meal, a day, or a week. This allowed the eating diaries to be used to index eating patterns.

Diaries requiring participants to weigh all foods consumed are currently considered the "standard" for self-assessment measures of caloric intake (Little et al., 1999), while doubly-labeled water is currently considered the "gold standard" for measuring caloric intake (Lichtman et al., 1992). Dietary assessment has proven to be a reliable and valid measure of dietary intake, accounting for between 60% and 80% (Block & Hartman, 1989) of actual dietary intake when compared with doubly labeled water (Lichtman et al., 1992; Wolper, Heshka, & Heymsfield, 1995). Dietary records of at least 3-5 days have demonstrated to be valid representations of "long-term usual intake of an individual" (Block & Hartman, 1989, p. 1136).

Estimated required daily energy intake for weight maintenance was calculated using the calculated resting metabolic rate (using the Weir method) and an estimate of physical activity intensity (1.3 METs; McArdle, Katch, & Katch, 2000). A light level of physical activity (1.3 METs) was chosen based on classifications of physical activity presented in McArdle, Katch, and Katch (2000, p. 164).

$$\text{Predicted daily energy expenditure (kcal/day)} = [(1.1 * RQ) + 3.9) * VO_2 \text{ in L/day}] * 1.3 \text{ METs}$$

Daily Physical Activity. To record daily physical activity levels, participants wore the Robic Electronic Pedometer M-387 (Oxford, CT, 2001) during waking, non-purposeful exercise hours of the day. This pedometer has demonstrated to be a valid and reliable measure of daily steps taken on a variety of surfaces (Hughes, 2002). To test the reliability and validity of the Robic (Oxford, CT, 2001), ten normal weight and overweight adult male and female participants walked 100 steps multiple times on a variety of surfaces (including indoor carpet, outdoor streets, and indoor and outdoor stairs) while wearing the Robic pedometer (Oxford, CT, 2001) on one hip and the Yamax Digiwalker (Toyko, Japan, 1999) on the other (Hughes, 2002). When compared to actual number of steps taken (assessed by counting), the Robic pedometer (Oxford, CT, 2001) measured 99.3% of the steps taken, demonstrating its validity over other commercially available brands (Hughes, 2002). When the Robic (Oxford, CT, 2001) was measured against the Yamax Digiwalker (Tokyo, Japan, 1999), which has been validated in several studies (e.g., Bassett, Cureton, & Ainsworth, 2000), the two were strongly correlated (Hughes, 2002). The Robic (Oxford, CT, 2001) was chosen over the Yamax Digiwalker (Tokyo, Japan, 1999) because of the cost difference.

The participants recorded their activity using the measured number of steps and the distance in miles on the pedometer (see Appendix G). Participants were asked to remove and/or stop the pedometer during scheduled or purposeful exercise (which was recorded using the Palm Pilot m100). The pedometer was calibrated during the first visit by having the participants walk ten steps and measuring the distance from "toe-to-toe" in inches. The recorded distance was divided by ten to calculate stride length. The stride length was then entered into the pedometer. (See Appendix G for activity monitoring form).

Since the energy cost of walking a given distance is independent of speed when the range is between 50-100 m/min, a walking speed of 75 m/min was chosen to estimate energy expenditure per day (Bassett, Cureton, & Ainsworth, 2000). This is because as walking speed increases, the increased rate of energy expenditure is offset by the decreased time it takes to walk the distance. The energy expenditure in $Met*min*day^{-1}$ (referred to as energy for the remainder of the paper) and kilocalories per day was calculated from the distance recorded on the pedometer. The calculations were derived from equations in Bassett, Cureton, & Ainsworth (2000).

$$\text{Energy } (MET*min*day^{-1}) = \text{pedometer distance (km/day)} * (43\ MET*min*km^{-1})$$

$$\text{kcal/day} = ((MET*min*day^{-1}) * 3.5\text{ ml/kg/min per MET} * (\text{BW in kg} * 5\text{kcal}/LO_2))/1000$$

Scheduled or Purposeful Exercise. The Participants used the Palm Pilot m100 (Palm, Inc., Santa Clara, CA, 2000) palmtop computers to record scheduled or purposeful exercise (such as jogging or swimming). The Palm Pilot m100 (Palm, Inc., Santa Clara, CA, 2000) contains a 2 megabyte internal disk and dietary intake was recorded using ExerLog v1.83 (HealtheTech, Golden, CO, 2001) exercise assessment program. The program contains an expandable database of 250 of typical exercise routines (including aerobic dance, karate, and yoga; HealtheTech, Golden, CO, 2001). The ExerLog program (HealtheTech, Golden, CO, 2001) allows the user to enter the duration of the exercise and provides the amount of energy expended during that exercise (estimated based on personal data entered into the program, including age, height, weight, and gender).

Resting Metabolic Rate. The SensorMedics Deltatrac Metabolic Measurement Cart (Yorba Linda, CA, 1992) was used to assess metabolic rate using indirect calorimetry. RMR is calculated using air samples [carbon dioxide (CO_2) and oxygen (O_2)] continuously collected by a canopy hood while the participant is resting in the supine position (Lichtman et al., 1992; Weststrate, 1993). Indirect calorimetry is a valid and reliable measure of metabolic rate (Ravussin, Harper, Rising, & Bogardus, 1991; Seale, Rumpler, Conway, & Miles, 1990; Webb, 1991). When the method of doubly labeled water (an alternate form of indirect calorimetry; Webb, 1991) and metabolic cart are compared, the energy expenditures are nearly equivalent (mean difference 0.63 kJ/min +/- 0.44 kJ/min; Seale, Rumpler, Conway, & Miles, 1990).

Since metabolic rate can be impacted by monthly menstrual cycles, all participants were scheduled for the assessment during the mid-follicular phase of their menstrual cycle (Armellini, 2000). Mid-follicular phase is estimated as the seventh day after the start of menstruation with an error of plus or minus two days (Armellini, 2000). Therefore, the participants were tested between the fifth and ninth days following the first day of menstruation.

Improving the accuracy of RMR measurement requires a minimum of 4 hours of sedentary activity, fasting, and the absence of stimulatory substances prior to assessment (Sensormedics, Yorba Linda, CA 1992). In this study, participants were asked to refrain from exercising, eating, or drinking caffeine for 12 hours prior to testing (SensorMedics, Yorba Linda, CA, 1992). To ensure compliance with these requirements, all participants were asked to affirm the questions on the Metabolic Assessment Compliance Form in Appendix H upon arrival.

Participants arrived at the lab no later than 7:00 a.m. and were asked to void upon arrival. To help induce a relaxed state, they then filled out paperwork for approximately 20 minutes while sitting and began the RMR assessment no later than 8:00 a.m. The assessment began with the participants lying as still as possible on a medical exam table (similar in strength and structure to a massage therapy table). They were instructed to lie still with no voluntary movements and, to not sleep or participate in any activities, such as reading, for the duration of the RMR assessment. The hood canopy was placed over their heads—resting on the table at the back end and on their chests at the front end. The plastic sheet attached to the canopy was patted down to create a seal by eliminating large gaps. Participants were instructed to signal the investigator to stop the assessment at any time should they become nervous or anxious as a result of the canopy. None of the participants reported anxiety as a result of the canopy or requested the assessment to stop.

The total duration of the resting metabolic assessment was 35 minutes, to allow for adjustment to the canopy, 20-25 minutes in a relaxed state, and the actual measurement period (Armellini, 2000; SensorMedics, Yorba Linda, CA, 1992). The valid time of measurement was determined by the stabilization of 5 data points (SensorMedics, Yorba Linda, CA, 1992). Although this occurred after about 5 to 10 minutes for most participants, only the last 10 minutes of the measurement were used to standardize the duration of (i.e., number of data points) carbon dioxide production to oxygen uptake measured.

Energy expenditure is calculated using respiratory quotient (RQ) (the ratio of VCO_2 produced to VO_2 uptake; de Boer et al., 1987; Henson, Poole, Donahoe, & Heber, 1987). The following equations were used to calculate RMR and the variants of RMR used in comparing the groups:

<u>Equations:</u>

1. Respiratory Quotient:

$$RQ = VCO_2\ (L/min) \div VO_2\ (L/min)$$

2. Energy expenditure per minute at rest from measured VO_2 (using the Weir method from McArdle, Kratch, Kratch, 2000):

$$\mathbf{RMR\ (kcal/min)} = [(1.1*RQ) + 3.9] * VO_2\ (L/min)$$

3. Energy expenditure per day at rest from measured VO_2:

$$\mathbf{kcal/day} = \mathbf{kcal/min} * 1440\ min/day$$

4. Estimated energy expenditure per day at rest from body mass (BM; kg), height (H, cm), and age (years; Harris-Benedict equations from Schofield, Schofield, & James, 1985):

$$\textbf{kcal/day} = 655 + (9.6 * BM) + (1.85 * H) – (4.7 * age)$$

5. Energy expenditure per day per kg of body mass at rest:

$$kcal/day/kg = \textbf{kcal/day} \div \text{body weight (kg)}$$

6. Energy expenditure per day per kg of lean body mass (LBM) at rest:

$$LBM \text{ (in kg)} = (100\% - \% \text{ body fat}) * \text{body weight (kg)}$$

$$kcal/day/LBM = \textbf{kcal/day} \div LBM$$

Active Metabolic Rate. The energy expenditure due to physical activity (AMR) was estimated using a constant workload exercise test on a bicycle ergometer (Fletcher et al., 2001). The participants sat on a stationary bicycle with the SensorMedics 2900/2900c (Yorba Linda, CA) mouthpiece and nose plug in place. The workload was set at 1 kg (or 1 kp) and the participant pedaled at a rate of 50 rpm (total workload equaled 50 watts) for approximately twelve minutes, which was hypothesized to be similar to daily levels of physical exertion during typical activities (e.g., walking; McArdle, Katch, & Katch, 2000). The risk associated with a work rate of 50 watts is minimal: approximately equal to 2-3 METS (or two to three times resting energy expenditure; 3.5-5.4 calories per minute; Lockwood, Yoder, & Deuster, 1997; McArdle, Katch, & Katch, 2000). However, a physician from the Department of Family Medicine was on-call in the event of an emergency. Heart rate was recorded using the Polar Heart monitor. All of the participants' heart rates remained below 150 beats per minute as expected (Lockwood, Yoder, & Deuster, 1997).

This assessment was conducted in the Human Performance Laboratory (HPL) at the Uniformed Services University under the supervision of Patricia Deuster, Ph.D., Director of the HPL immediately after the RMR assessment. Dr. Deuster's laboratory regularly conducts fitness assessments on a variety of populations. The bicycle was within 5 feet of the medical exam table used for the RMR measured.

AMR was calculated using air samples [carbon dioxide (CO_2) and oxygen (O_2)] continuously collected by the mouthpiece while the participant was riding the bicycle (Lichtman et al., 1992; Weststrate, 1993). AMR was calculated based on the ratio of CO_2 expended to O_2 consumed (de Boer et al., 1987; Henson, Poole, Donahoe, & Heber, 1987). The last five minutes of the assessment were used in the calculations of AMR to allow the participants to reach steady rate of aerobic metabolism (McArdle, Katch, & Katch, 2000). The following equations were used to calculate AMR and the variants of AMR used in comparing the groups:

Equations:

1. Respiratory Quotient:

$$\textbf{RQ} = VCO_2\ (L/min) \div VO_2\ (L/min)$$

2. Milliliters of oxygen uptake during bicycle riding:

$$LO_2 = \text{measured}$$

3. Energy expenditure per minute while riding the bicycle:

$$\textbf{AMR (kcal/min)} = [(1.1*RQ) + 3.9] * VO_2\ (L/min)$$

4. Energy expenditure per minute per kg of body mass while riding the bicycle:

$$\text{AMR (kcal/min/kg)} = \textbf{kcal/min} \div \text{body weight (kg)}$$

5. Net energy expenditure (ΔEE) attributable solely to bicycle riding per min:

$$\Delta EE\ (kcal/min) = \textbf{AMR (kcal/min)} - RMR\ (kcal/min)$$

6. Net energy expenditure (ΔEE) attributable solely to bicycle riding per min per kg of body mass:

$$\Delta EE\ (kcal/min/kg) = \mathbf{\Delta EE\ (kcal/min)} \div body\ weight\ (kg)$$

7. Energy expenditure per minute per kg of lean body mass (LBM) while riding the bicycle:

LBM (in kg) = (100% - % body fat) * body weight (kg)

AMR kcal/min/LBM = **kcal/min** ÷ LBM

8. Mechanical Work Efficiency:

distance = 50 rpm * 1 min. * 6m circumference

Frictional resistance = set at 1kg

mechanical work (kg-m) = **frictional resistance** * **distance**

mechanical work = 300 kg-m

energy input = LO_2 * 5 kcal * 426.4 kg-m

mechanical work efficiency = (mechanical work ÷ energy input) *100

Dietary Induced Thermogenesis. Dietary Induced Thermogenesis (DIT) is the energy expenditure increase following the ingestion of food. In this study, a liquid meal was chosen to induce DIT. The participants were given 5 minutes to consume 8 fluid ounces of Ensure Plus (Abbott Laboratories, Illinois, 1996). The use of liquid meals in assessing DIT is optimal because they are less likely to cause the same delay in peak postprandial thermogenesis that is caused by digestion of solid foods (P. Deuster, personal communication, November 14, 2001). Many liquid meal supplements are currently on the market, including Ensure (Abbott Laboratories, Illinois, 1996), Ensure Plus (Abbott Laboratories, Illinois, 1996), Nestle NuBasics (Nestle Clinical Nutrition, 2002), Slim Fast (Unilever, NJ), Carnation Instant Breakfast (Nestle Clinical Nutrition, 2002), and a number of protein shakes. Ensure Plus (Abbott Laboratories, Illinois, 1996) was chosen over the alternatives for several reasons. First, it contains a nutritional content similar to the USDA recommendations for daily macronutrient intake (USDA, 2001). One serving of Ensure Plus (8 fluid ounces; Abbott Laboratories, Illinois, 1996) provides 360 kilocalories comprised of 55.5% carbohydrates, 27.5% fat, and 14.4% protein. Second, Ensure Plus (Abbott Laboratories, Illinois, 1996) is available in several flavors (vanilla, chocolate, cappuccino, strawberry, and butter pecan) and is gluten and lactose-free, kosher, and low in cholesterol. Third, it is cost effective at $1.50 per serving. Finally, one serving can be consumed in a short period of time.

Metabolic rate was measured with the participants lying in the supine position using the SensorMedics Deltatrac (Yorba Linda, CA, 1992) metabolic cart and canopy. The measurement lasted at least 50 minutes for most participants to increase the likelihood of capturing the peak postprandial response. The following equations were used to calculate DIT and the variants of DIT used in comparing the groups:

<u>Equations:</u>

1. Peak post-prandial energy expenditure (EE):

Peak = Highest level of EE after EE reaches 2 SD above RMR

2. Time to Peak Response:

Minutes from resumption of RMR to **Peak**

3. Postprandial energy expenditure per minute:

$$\textbf{DIT (kcal/min)} = [(1.1*RQ) + 3.9] * VO_2 \text{ (mL/min)}$$

4. Postprandial energy expenditure per hour[3]:

$$\textbf{DIT (kcal/hr)} = [((1.1*RQ) + 3.9) * VO_2 \text{ (mL/min)}] * 60 \text{ min/hr}$$

5. Postprandial energy expenditure per hour per kg of body mass:

$$\text{DIT (kcal/hr/kg)} = \textbf{kcal/hr} \div \text{body weight (kg)}$$

6. Net energy expenditure (ΔEE) attributable solely to the meal per hr:

$$\boldsymbol{\Delta}\textbf{EE (kcal/hr)} = \textbf{DIT (kcal/hr)} - \text{RMR (kcal/hr)}$$

7. Net energy expenditure (ΔEE) attributable solely to the meal per hour per kg of body mass:

$$\Delta\text{EE (kcal/hr/kg)} = \boldsymbol{\Delta}\textbf{EE (kcal/hr)} \div \text{body weight (kg)}$$

8. Energy expenditure per hour per kg of lean body mass (LBM) after a meal:

$$\text{LBM (in kg)} = (100\% - \%\text{ body fat}) * \text{body weight (kg)}$$

$$\text{DIT kcal/hr/LBM} = \textbf{kcal/hr} \div \text{LBM}$$

Eating Disorders Examination- Self-Report Questionnaire. The Eating Disorder Examination-Self-Report Questionnaire (EDE-Q; Fairburn & Beglin, 1994) was used to assess for eating disorders (such as Anorexia Nervosa) and to assess eating patterns. Participants were mailed the EDE-Q upon meeting the requirements of the study during the phone screen. The EDE-Q was scored by the principal investigator, trained under the supervision of Tracy Sbrocco, Ph.D. (a clinical psychologist), Department of Medical and Clinical Psychology. No participants who were eligible based on the phone screen were excluded based on the EDE-Q.

[3] DIT energy expenditure analyzed per hour rather than per minute to allow for more meaningful data analysis

The EDE-Q (Fairburn & Beglin, 1994) is based on the Eating Disorder Examination, which as a structured interview is considered to be the “gold standard” for assessing eating disorders (Black & Wilson, 1996; Carter, Aime, & Mills, 2001; Luce & Crowther, 1999; Rock et al., 2000; Wilfley, Schwartz, Spurrell, & Fairburn, 1997). The EDE-Q is a validated, standardized measure of eating disorders significantly correlated with all three scales of the EDE (dietary restraint: r = 0.75, weight concern: r = 0.85, shape concern: r = 0.84; Fairburn & Beglin, 1994). The questionnaire takes approximately one half hour to complete and is designed to assess DSM-IV eating disorders (Schoemaker, Verbraak, Breteler, & der Staak, 1997). The EDE-Q was chosen over the EDE to reduce the amount of burden to the participants, who would be required to come to the university for the 40-minute interview.

Beck Depression Inventory-II. The Beck Depression Inventory-II (BDI-II; Beck, Steer, Ball, & Ranieri, 1996) was chosen to screen out those volunteers who might have clinical levels of depression. It was mailed to eligible participants in the screening packet. Again, after completion, they mailed the packet back to the principal investigator and the BDI-II was scored and examined for each volunteer. This questionnaire takes approximately 15 minutes to complete. The BDI-II was used to assess depressive symptomatology. Depressive symptomatology has been shown to be co-morbid with a number of eating disorders, including binge-eating disorder (e.g., Cartiglia, 1997; De Chouly De Lenclave, Florequin, & Bailly, 2001; Troop, Serpell, & Treasure, 2001). Volunteers were deemed ineligible is their scores were in the clinically significant range (greater than 16) and/or they endorsed suicidal intentions/thoughts on the BDI-II. No participants reported suicidal ideation or intent. Those participants indicating significant depression (i.e., BDI-II greater than 16) were offered referrals to local community mental health centers.

The BDI-II was chosen because it has demonstrated to be a valid and reliable self-report measure of the somatic-affective and cognitive dimensions of depression (Steer, Ball, Ranieri, & Beck, 1997; Steer, Ball, Ranieri, & Beck, 1999; Steer, Clark, Ranieri, & Beck, 1999). Furthermore, questions directly related to eating patterns are included in the BDI-II making it more useful in this study. The BDI-II is also frequently used in research on eating behaviors (e.g., Ricca et al., 2001; Sbrocco, Nedegaard, Stone, & Lewis, E.L., 1999; Troop, Serpell, & Treasure, 2001), in screening for some eating disorders (Ricca et al., 2000), and has demonstrated to be useful in helping to distinguish symptomatic from asymptomatic eating disorder groups (Petersen, 2001).

Eating Inventory. The Eating Inventory (EI; Stunkard & Messick, 1985) was chosen as an additional measure of eating pathology. It is frequently used in both clinical and research settings for assessing aspects of obesity treatment (such as compliance, attrition, and outcome; Clark, Marcus, Pera, & Niaura, 1994; Foster, Wadden, Swain, Stunkard, Platte, & Vogt, 1998). The EI has also been used in the study of disordered eating behavior in non-clinical samples (Bond, McDowell, & Wilkinson, 2001). The questionnaire takes approximately 15-20 minutes to complete and was also administered during the lab visit. All three subscales, dietary restraint, disinhibition, and hunger cues, were of interest in this study. The two most recently defined subscales, rigid and flexible control of eating behavior, were also examined (Westenhoefer, Stunkard, & Pudel, 1999). Higher scores on the rigid subscale have been associated with higher BMI, higher scores of disinhibition, and more frequent and more severe binge episodes (Westenhoefer, Stunkard, & Pudel, 1999).

The EI is a valid and reliable self-report measure of eating behaviors and cognitions (Westenhoefer, Stunkard, & Pudel, 1999). The EI adds to the information provided by the EDI-2 because of the emphasis on restraint, which may be present in both clinical and non-eating disordered populations (van Strein, 1997). It has been hypothesized that among high-restrained eaters, there may be two subpopulations: those with high susceptibility to failure of restraint and those with low susceptibility (van Strein, 1997). There is support for the hypothesis that those with a high susceptibility toward failure of restraint (as measured by the EI) are more likely to binge eat (van Strein, 1997).

Sample means used for comparison were taken from Westenhoefer, Stunkard, & Pudel (1999). The normal weight comparison sample had a mean BMI of 24.4 +/- 3.9 kg/m^2 and a mean age of 41.8 +/- 17.3 years (Westenhoefer, Stunkard, & Pudel; 1999). The overweight comparison sample had a mean BMI of 27.2 kg/m^2 and a mean age of 43.6 +/- 12.7 years (Westenhoefer, Stunkard, & Pudel; 1999).

Eating Disorders Inventory-2. The Eating Disorders Inventory-2 (EDI-2; Garner, 1991) was chosen as a measure of eating pathology. The subscales of interest were drive for thinness, bulimia, and body dissatisfaction (although all of the other subscales were scored) since these subscales may be an indication of the disordered eating attitudes behind disordered eating behaviors. This questionnaire takes approximately 15-20 minutes to complete. The participants were administered the EDI-2 during the lab visit.

The EDI-2 is a valid and reliable self-report measure of disordered eating patterns (Schoemaker, Verbraak, Breteler, & van der Staak, 1997). It has demonstrated useful in helping to distinguish eating disordered from non-eating disordered patient populations (Schoemaker, Verbraak, Breteler, and van der Staak, 1997) and between symptomatic and asymptomatic eating disordered groups (Petersen, 2001). The EDI-2 is also regularly used in clinical and research settings for the further understanding of the outcomes of eating disorder treatments (e.g., Bean & Weltzin, 2001; Lindeman, Stark, & Keskivaara, 2001) and estimating populations at risk for eating disorders (Engstrom & Norring, 2002).

Sample means used for comparison were taken from Garner (1990). The non-eating disordered comparison sample had a mean weight (as percent of average) of 99.6% +/- 14.3 and a mean age of 19.9 +/- 3.0 years (Garner, 1990). The eating disordered comparison sample had a mean weight (as percent of average) of 81.4% +/- 9.9 and a mean age of 24.2 +/- 8.6 years (Garner; 1990).

Procedure

Recruitment

The participants were recruited through local newspaper advertisement (Washington Post, Montgomery County Gazette, NIH Record, and the Washington City Paper) and flyers (at the Uniformed Services University) for participation in a study on the effects of metabolism on weight. Gorgers were specifically targeted for recruitment by advertising for women who might call themselves “late-day eaters.” Please see Appendix B for copies of the advertisements.

Screening: Phone Screen and Screening Packet

All participants were screened by phone for age, height, weight, eating habits, and psychological status, and health conditions. Women younger than age 18 and post-menopausal women were excluded from participation. As were those women with psychological or medical conditions known to impact weight and/or metabolism (such as thyroid disease or diabetes). Please see the section "Inclusion/Exclusion Criteria" (page 65) for a more detailed explanation. A copy of the phone screen script and form are in Appendix I. Eligible participants were mailed the screening packet (the Screening Informed Consent Form, the EDE-Q, the BDI-II, and the Medical Information Form). The volunteers were then asked to return the completed questionnaires and the Screening Informed Consent Form by mail (several participants hand-carried to USUHS Room B1022 because they worked at USUHS). Upon receipt of the completed screening packet (including the Screening Informed Consent Form), the principal investigator, trained under the direction of Tracy Sbrocco, Ph.D., Department of Medical and Clinical Psychology, scored the EDE-Q and the BDI-II. A score in the clinically significant range (greater than 16) on the BDI-II resulted in exclusion from participation and a referral to a local mental health provider. While no volunteers indicated suicidal intentions, this was also an exclusionary criterion.

Three participants scored above the established cut-off of 16 (none of which met criteria for any eating disorders or indicated suicidal intentions) and were excluded from participation. These participants were called and offered referrals to local mental health providers. All three participants declined referrals or provider contact information.

The remainder of the study consisted of four components: orientation, laboratory assessments, one-week food and exercise monitoring, and computer collection and payment. An overview of the study procedure is summarized in Table 1.

Table 1

Summary of the Study

Step	Description	Time
Screening	1. Phone Screen	
	2. Screening Packet: Screening Informed Consent, Medical Information, EDE-Q and BDI-II	40 – 60 min.
Orientation and Diary Instruction	1. Study Informed Consent Form	
	2. Measure stride length and review pedometer use	
	3. Review Palm Pilot use and begin 1-week food and activity diaries (Each participant was called within 1 day to ask if they had any questions about the diaries).	
	4. Schedule appointments for remaining visit(s).	1- 1 _
Laboratory Visit: Individual Body and Health Assessments	1. Resting metabolic rate/body composition (35 min.)	
	2. Active metabolic rate (15 min.)	
	3. Standardized meal (5 min.)	
	4. Dietary Induced Thermogenesis assessment (60 min.)	2_ - 3 hrs
	5. EI and EDI-2 (15-30 min.)	hours
Feedback and Payment	1. Return computers (payment and feedback were mailed)	10 minutes
Optional Lecture		(1_ hours)
	Total Time: 4 hrs 20 min.-5 hrs 40 min.	

Orientation and Diary Instruction

At orientation participants were informed of the procedures of the study, provided palm pilot computers and pedometers, scheduled future visits, and completed the Study Informed Consent Form (Appendix C) and the Demographics and Payment Forms (Appendix E). Orientations were initially done in a group format. However, after three group orientations with just over a 50% turnout, it was decided that the activities accomplished during the orientation could be accomplished during the lab visit (which had a 97% turn-out). Therefore, the remaining participants (approximately 1/3) completed orientation tasks during the lab visit. These tasks consisted of completing the Study Informed Consent Form and Demographics Questionnaire, measuring stride length and reviewing pedometer use, reviewing Palm Pilot (Santa Clara, CA, 2000) use and beginning 1-week food and activity diaries.

All participants were consented and required to sign and date the Study Informed Consent Form before any further information was collected. To increase the likelihood of proper pedometer use, individual stride distances for walking were measured using the previously described procedures. The participants were then instructed on the use of the pedometer and the monitoring form. See Appendix G for the daily activity monitoring form. A column labeled “jogging/running” was available for those participants who ran outdoors and needed to use the pedometer to calculate the number of miles run. No participants used this column. Those participants who regularly ran on treadmills or on standard tracks recorded their exercise in the Palm Pilot. The procedures for entering meals into the Palm Pilot (Santa Clara, CA, 2000) were then reviewed with the participants (see Appendix J for the Palm Pilot Borrowing Form). A sample meal and exercise routine were entered to allow the participants to practice and ask questions. To improve compliance, each participant was called within one day of beginning the food and exercise diaries to answer any questions.

Of the 56 participants, 2 participants did not complete their food diaries due to reported time conflicts (1 OG and 1 ON), 2 participants had difficulties entering their foods and required further instruction, 1 participant wrote out her food diary, which was then entered by the primary investigator, and 2 participants entered 5 of 7 days (1 OG and 1 NG). The latter two participants were called and questioned about the missing days. Specifically, they were queried about the uniqueness of the two days that were not recorded. Both reported that the non-recorded days were similar to the recorded days, but the foods eaten were not recorded due to time constraints. Since the participants did not endorse failure to report on these days due to perceived undesirable food choices and records of 3-5 days have demonstrated to be valid representations of typical dietary intake (Block & Hartman, 1989), the data reported were deemed valid and were entered into the database for analysis.

Individual Body and Health Assessments (*Lab Visit)*

The participants also completed self-report questionnaires, RMR, AMR, and DIT, and body composition measures during the lab visit. The final component of the study consisted of one week of food and exercise diaries. After one week, the participants returned the Palm Pilot, were paid, and received individualized feedback.

Participants were scheduled for a 3-3_ hour visit that began at 7:00 a.m. During this visit, they completed a body fat assessment, a comprehensive metabolic assessment (including RMR, AMR, TEF), and two questionnaires (EDI and EI). About 1/3 of the participants (those who did not attend the group orientation) were also instructed on how to use and keep the eating an exercise diaries at their visit. When each participant arrived, she was asked to void (to avoid discomfort during the metabolic assessment). Each of the metabolic assessments was conducted by the principal investigator trained under the direction of Patricia Deuster, Ph.D., Director of the Human Performance Lab. The procedures for each of the assessments are described further in the subsequent sections. Each participant was given the following instructions to prepare for the visit:

Participant instructions for the individual visit: The participants were scheduled for the lab visit so that it occurred between the 5th and 9th day after the start of their period. This was to ensure that all of the participants were approximately midway through the follicular phase in their menstrual cycles. To prepare for the individual visit, the participants were asked to wear exercise clothing (including a bra without under wire), drink at least 64 ounces of water the day before the visit, and to abstain from eating, drinking caffeine or alcohol, and exercise for 12 hours before the lab visit. The participants were scheduled to arrive at 7:00 a.m. to help control for any potential time-of-day effects on metabolism. They were asked to drive to USU immediately after waking and to avoid fast-paced walking or excess stress (e.g., traveling during rush hour traffic) before arriving. See Appendix H for the Metabolic Assessment Compliance Form used by the body assessment administrator to ensure that all participants complied with these instructions.

1. **Body Fat Assessment:** Before beginning the metabolic testing portion of the lab visit, body composition was assessed. Two electrodes were attached to the foot and two to the hand. The quick, painless, and harmless measurement was taken. This took approximately 5 minutes to complete.
2. **Resting Metabolic Rate:** The participants were asked to lie as still as possible in the supine position under the hood canopy. As previously described, the respiratory gases (CO_2 and O_2) were continuously collected. This portion of the visit lasted 35 minutes.
3. **Active Metabolic Rate:** After completing the RMR assessment, the participants then completed the active metabolic rate (AMR) assessment. The participant was led from the table to the stationary bicycle (approximately 5 feet away). The participant was instructed on how to wear the mouthpiece and nose plug. The workload was set at 1 kg (or 1 kp) and the participant pedaled at a rate of 50 rpm (total workload equaled 50 watts) for approximately twelve minutes. To allow the participants to reach steady rate, only the last five minutes of the AMR assessment were used in the data analysis. The risk associated with a work rate of 50 watts is minimal; approximately equal to 2-3 METS (or three times resting energy expenditure) (3.5-5.4 calories per minute; Lockwood, Yoder, & Deuster, 1997; McArdle, Katch, & Katch, 2000). However, a physician from the Department of Family Medicine was on-call in the event of an emergency. AMR is assessed using the respiratory quotient (VCO_2 output and VO_2 intake). To help assess exertion, the participant's heart rate was measured using a Polar Heart Rate

monitor. No participant's heart rate rose above 150 beats per minute during the AMR assessment.

4. **Post-Exercise Assessment.** The participants were then asked to sit on the table with the mouthpiece and nose plug in place (to obtain continuous data). After 2-3 minutes, they were asked to remove the mouthpiece and nose plug and to lie in the supine position on the table. To ensure that the participants returned to a baseline relaxation, they were asked to lie still under the hood canopy for a minimum of 25 minutes. The participants were monitored post-exercise until they reached their baseline RMR. Most of the participants achieved their baseline relaxation after about 10 minutes. No one required more than 25 minutes to return to baseline.
5. **Standardized Meal:** After 25 minutes, each participant was asked to drink the standardized meal of 8 oz. of Ensure Plus (Abbott Laboratories, Illinois, 1996). She was given 5 minutes to finish the 8 ounces. All of the participants consumed the same amount of Ensure Plus (Abbott Laboratories, Illinois, 1996).
6. **Dietary Induced Thermogenesis (DIT):** Upon completion of the 8 ounces of Ensure Plus (Abbott Laboratories, Illinois, 1996) or after 5 minutes (which ever was longer), the participants were asked to again lie still on the table. The respiration gases (CO_2 produced to O_2 uptake) were continuously measured for 60 minutes to increase the likelihood postprandial peak would be measured.

7. **Questionnaires:** Following the completion of the DIT, the participant was asked to complete the Eating Inventory (EI; Stunkard & Messick, 1985) and the Eating Disorders Inventory-2 (EDI-2; Garner, 1991). The self-report questionnaires took approximately 15 to 30 minutes to complete.
8. **Food and Exercise Diaries.** At this point in the laboratory visit, the one-third of the participants who had not yet completed the food and exercise diaries were instructed on how to use the Palm Pilot m100 and the pedometer. About half of the participants had completed their food and exercise diaries prior to their laboratory visit. However, some participants had not finished their food and exercise diaries because they could not attend the group orientation or because their laboratory assessment was scheduled within a day or two after the orientation.

Computer Collection, Payment, and Feedback

When the participants completed the lab visit and turned in the completed diaries, they were mailed a $50 check and detailed feedback about their eating and exercise habits, body composition, and metabolic rate. Please see Appendix K for an example of the feedback that a participant might have received. In addition, all of the participants were invited to a lecture, given by the principal investigator, on metabolism and healthy eating patterns. Approximately 15 participants expressed interest in the lecture, but only 8 of the 56 participants attended. Please see Appendix L for an outline of the lecture topics. The participants were not required to attend this lecture.

The length of the study for each participant ranged from one week to six weeks. The increase in time for some of the participants was due to the time required from the initial phone screen to the individual assessment, which was based on their own menstrual cycle. For some participants, the lab visit was scheduled within 7 days of the phone screen because they turned in their screening packet and their menstrual cycle allowed for quick scheduling. The actual time commitment for each participant was approximately 5-6 hours. This included the time for the group orientation (if they attended), the individual assessment, and the food and exercise diaries. For some individuals, this time may have been longer if they had difficulties with the palm pilot. However, when questioned, most participants reported being able to enter foods more quickly after the first day or two of monitoring.

Results

Throughout the statistical analysis of the data collected in this study, a p-value of 0.05 was used as the cut-off for statistical significance. The groups were matched for age but not for ethnicity.

Anthropomorphic and Demographic Data

For all continuous demographics variables, a 2 X 2 ANOVA was used to explore between group differences. These data are presented in Table 2. For categorical data, Chi-Square analyses were used to explore group differences. When necessary, categories were collapsed to eliminate cells with frequencies of less than 5. The categorical data are presented in their original categories in Table 3. Detailed analyses of these data and the collapsed categories used in the Chi-Square analyses are presented in Appendix M. The results presented below are general group descriptions and significant findings only.

As expected, the obese group had significantly higher body mass [$F(1,46) = 64.94$, $p = 0.0005$], BMI [$F(1,46) = 130.02$, $p = 0.0005$], and body fat percentage [$F(1,46) = 110.05$,

p = 0.0005]. The obese group's mean BMI was above the established cut-off of 30 kg/m^2. The normal weight group's mean BMI was within the established range for normal weight at approximately 23 kg/m^2.

Across demographic variables, the groups were very similar. The sample was approximately 32 years old, approximately 67% had at least a college education, approximately half were married, and approximately 84% worked full-time. The dissimilarities between the groups included differences in income, ethnicity, and oral contraceptive use. Although 55% of the total group had an annual income greater than $40,000, the obese group had significantly more participants with an annual household income greater than $40,000 [$\chi^2$ (1, N = 51) = 9.23, p = .002].

Nearly 40% of the participants were ethnic minorities. Of the ethnic minority participants, 55% were African American, 30% were Asian, 10% were Hispanic, and 5% were "other." However, the non-gorging group had significantly more Caucasians (19 or 37.3%) than ethnic minorities [6 or 11.6%]. The non-gorging group also had more Caucasians than the gorging group [12 of 26 participants; χ^2 (1, N = 51) = 4.76, p = 0.03]. Finally, most (74.5%) of the participants did not use oral contraceptives. There was a trend for more normal weight women to use oral contraceptives [χ^2 (1, N = 51) = 3.42, p = 0.07] and the non-contraceptive users (34.42 +/- 7.88 years) were significantly older than the contraceptive users [26.31 +/- 4.34; F(1, 49) = 12.13, p = 0.001].

Table 2

Age and Anthropomorphic Data for Eating Pattern Groups by Weight Groups

	Gorger		Non-gorger	
	Obese	Normal Weight	Obese	Normal Weight
n	12	14	11	14
	M (SD)	M (SD)	M (SD)	M (SD)
Age (years)	36.8 (7.2)	31.6 (8.3)	31.3 (6.7)	30.1 (8.7)
Weight (kg)	97.4 (23.1)	60.1 (9.0)	92.2 (15.2)	63.1 (5.6)
Height (m)	1.6 (0.1)	1.6 (0.1)	1.6 (0.1)	1.6 (0.04)
BMI (kg/m^2)	36.7 (5.2)	22.6 (2.6)	35.8 (7.0)	23.5 (1.8)
Body Fat %	44.2 (5.9)	28.6 (4.7)	43.3 (5.6)	26.9 (5.1)

Table 3

Demographics Data by Original Category

	Gorger			Non-gorger		
	Obese 12	Normal Weight 14	Total (26)	Obese 11	Normal Weight 14	Total (25)
Marital Status						
Married (27; 52.9%)	5 (41.7%)	7 (50.0%)	12 (46.2%)	7 (63.6%)	8 (57.1%)	15 (60.0%)
Single, Never Married (18; 35.3%)	7 (58.3%)	4 (28.6%)	11(42.3%)	3 (27.3%)	4 (28.6%)	7 (28.0%)
Divorced (5; 9.8%)		2 (14.3%)	2 (7.7%)	1 (9.0%)	2 (14.3%)	3 (12%)
Separated (0; 0%)						
Widowed (1; 2.0%)		1 (7.0%)	1 (3.8%)			
Education						
Less than High School (0; 0%)						
High school (1; 2.0%)	1 (8.3%)		1 (3.8%)			
Some college (14; 27.5%)	3 (25.0%)	5 (35.7%)	8 (30.8%)	2 (18.2%)	4 (28.6%)	6 (24%)
Completed college (14; 27.5%)	1 (8.3%)	4 (28.6%)	5 (19.2%)	6 (54.5%)	3 (21.4%)	9 (36%)
Partial or grad/prof school (11; 17.6%)	4 (33.3%)	1 (7.0%)	5 (19.2%)	2 (18.2%)	4 (28.6%)	6 (24%)
Completed grad/prof school (11; 21.6%)	3 (25.0%)	4 (28.6%)	7 (26.9%)	1 (9.0%)	3 (21.4%)	4 (16%)
Employment Status						
Full-time (43; 84.3%)	11 (91.7%)	10 (71.4%)	21 (80.8%)	9 (81.8%)	13 (92.9%)	22 (88%)
Part-time (5; 9.8%)	1 (8.3%)	3 (21.4%)	4 (15.4%)		1 (7.0%)	1 (4.0%)
Homemaker (1; 2.0%)				1 (9.0%)		1 (4.0%)
Disabled (1; 2.0%)		1 (7.0%)	1 (3.8%)			
Unemployed (1; 2.0%)				1 (9.0%)		1 (4.0%)
Income						
Below 20K (9; 17.6%)		6 (42.9%)	6 (23.1%)	1 (9.0%)	2 (14.3%)	3 (12%)
20K-30K (3; 5.9%)		1 (7.0%)	1 (3.8%)	1 (9.0%)	1 (7.0%)	2 (8.0%)
30K-40K (11; 21.6%)	1 (8.3%)	2 (14.3%)	3 (11.5%)	2 (18.2%)	6 (42.9%)	8 (32.0%)
40K-50K (3; 5.9%)				1 (9.0%)	2 (14.3%)	3 (12%)
50K-60K (5; 9.8%)	2 (16.7%)	1 (7.0%)	3 (11.5%)	1 (9.0%)	1 (7.0%)	2 (8.0%)
60K-70K (7; 13.7%)	4 (33.3%)		4 (15.4%)	3 (27.3%)		3 (12%)
Above 70K (13; 25.5%)	5 (41.7%)	4 (28.6%)	9 (34.6%)	2 (18.2%)	2 (14.3%)	4 (16%)
Ethnicity						
Caucasian (31; 60.8%)	5 (41.7%)	7 (50.0%)	12 (46.2%)	8 (72.7%)	11 (78.6%)	19 (76%)
Hispanic (2; 3.8%)					2 (14.3%)	2 (8.0%)
African American (11; 21.6%)	6 (50.0%)	2 (14.3%)	8 (30.8%)	3 (27.3%)		3 (12%)
Asian (6; 11.8%)	1 (8.3%)	5 (35.7%)	6 (23.1%)			
Other (1; 2.0%)					1 (7.0%)	1 (4.0%)

Note. Data were not analyzed using the categories in this table. Please see subsequent sections and Appendix M for collapsed categories and statistical analyses.

Daily Physical Activity

Since daily physical activity is an important component of total daily energy expenditure, the groups' reported daily physical activity and exercise were examined. Daily physical activity was estimated through recorded number of steps and miles walked per day. The mean number of steps and miles walked per day are presented in Table 4. The groups did not differ in reported steps or miles walked. More detailed statistical data are presented in Appendix M.

Energy expended through daily physical activity was estimated by calculating METs per day and kilocalories per day. Total body weight was covaried since the energy cost of movement increases with body weight. There were no interaction effects for energy in MET * min/day [$F(1, 47) = 0.96$, $p = 0.33$] or kcal/day [$F(1, 47) = 1.45$, $p = 0.24$] expended through daily walking. The eating pattern groups did not differ in daily energy expenditure calculated in MET * min/day [$F(1, 47) = 0.62$, $p = 0.44$] or kcal/day [$F(1, 47) = 0.30$, $p = 0.58$]. The obese group expended more energy through daily walking calculated in kcal/day [$F(1, 47) = 7.26$, $p = 0.01$], but not MET * min/day [$F(1, 47) = 0.17$, $p = 0.68$] even after controlling for body weight.

Table 4

Daily Physical Activity

	Gorger		Non-Gorger	
	Obese	Normal Weight	Obese	Normal Weight
	12	14	11	14
	M(SD)	M(SD)	M(SD)	M(SD)
Steps	8634.4 (3067.0)	7610.4 (3847.6)	8465.8 (2971.4)	8822.4 (2587.7)
Miles	3.2 (1.2)	3.0 (2.0)	3.1 (1.2)	3.7 (1.4)
MET*min*day^{-1}	220.6 (82.3)	204.0 (135.8)	215.0 (85.4)	255.9 (97.7)
Energy expended (kcal/ day)	363.8 (143.5)	214.9 (141.8)	338.9 (146.1)	281.9 (112.1)

Exercise Patterns

In addition to typical daily activities, 28 participants reported participating in structured exercise (at least one day per week). Figure 3 displays the number of participants reporting at least one day of exercise. The groups were first compared using a chi-square analysis to determine the proportion of participants reporting any exercise during the week. Significantly more normal weight participants (78.6%) reported exercising than obese (26.1%) participants [χ^2 (1, N = 51) = 14.05, p = 0.0005]. There was a trend for more non-gorgers (68.0%) to report exercising than gorgers [42.3%; χ^2 (1, N = 51) = 3.40, p = 0.07]. The exercisers had a greater percentage of lean body mass [69.1% +/- 8.3% vs. 60.7% +/- 8.4%] and a lower body fat percentage than the non-exercisers [30.9 +/- 8.3% vs. 39.3 +/- 8.4%; t(1,48) = -3.56, p = 0.001].

Figure 3. Number of Participants Reporting at Least One Day of Exercise

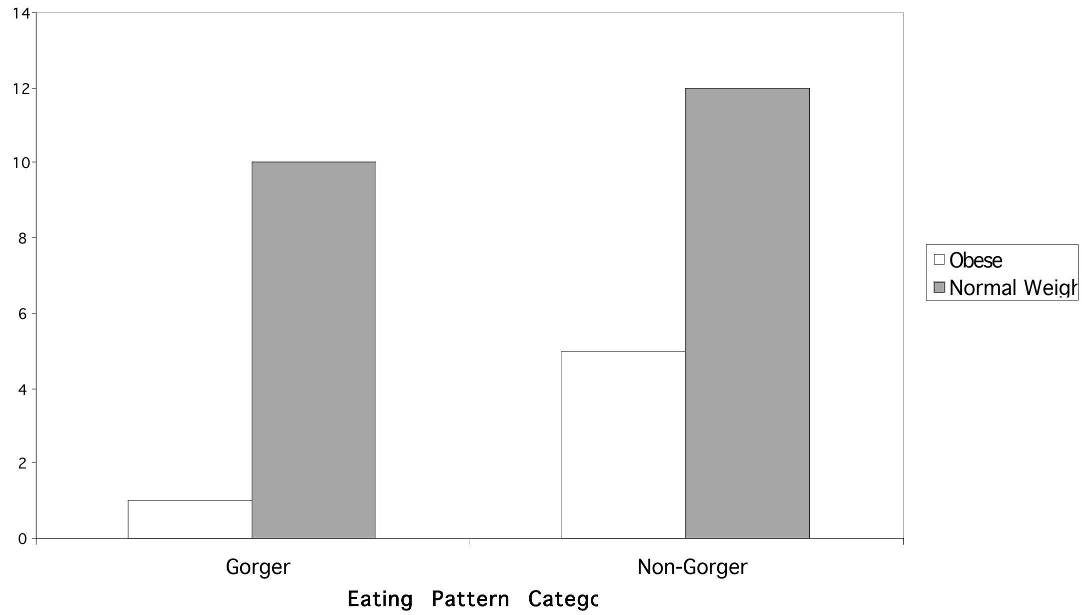


Table 5 presents the reported hours per week of purposeful exercise and expended energy in purposeful exercise (in kilocalories per day of exercise). The reported time exercised and estimated energy expended *during exercise* for exercisers were compared using a 2 (gorging, non-gorging) X 2 (obese, normal weight) MANCOVA,

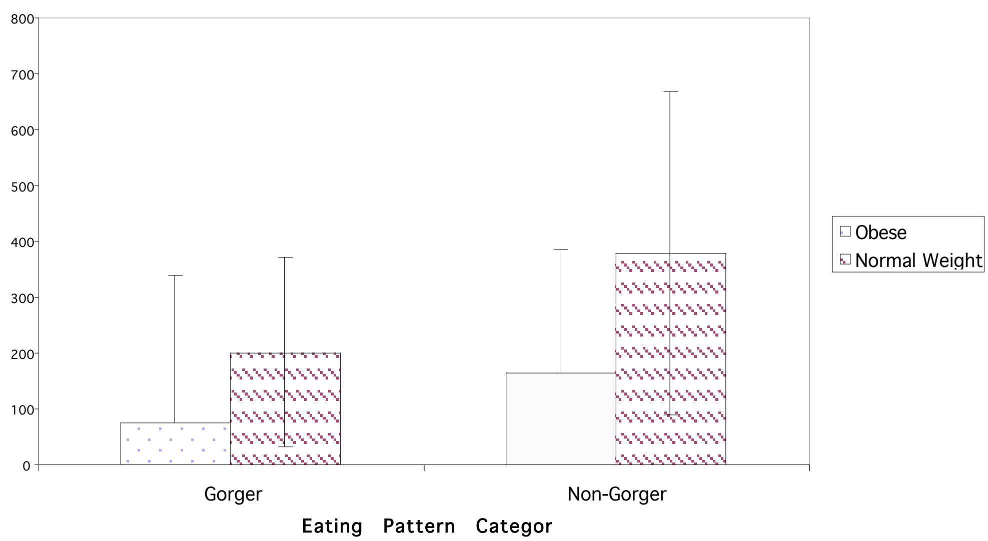
Table 5. *Purposeful Exercise per Week*

	Gorging		Non-Gorging	
	Obese	Normal weight	Obese	Normal Weight
n	1	10	5	12
	M (SD)	M (SD)	M (SD)	M (SD)
Hours per week	0.3 (1.2)	2.1 (2.2)	1.0 (1.5)	3.6 (3.2)
Energy Expended (kcal/day of exercise)	265.00 (0.00)*	151.8 (137.3)	159.6 (98.0)	181.4 (164.5)

Note. Only one obese gorger reported purposeful exercise.

controlling for lean body mass (LBM). Figure 4 displays the estimated energy expended *per week* from exercise. For exercisers in the gorging and non-gorging eating pattern groups, there were no significant differences in the time spent exercising [$F(1,27) = 0.01$, $p = 0.92$] or the amount of energy expended during exercise [$F(1,27) = 0.26$, $p = 0.62$]. The same was true for the exercisers in the obese and normal weight groups; there were no significant differences in the time spent exercising [$F(1,27) = 0.10$, $p = 0.75$] and the amount of energy expended during exercise [$F(1,27) = 0.003$, $p = 0.96$].

Figure 4. Estimated Mean Energy Expended per Week in Purposeful Exercise



AIM #1: The relationship of eating pattern and metabolic rate

A 2 (gorgers, non-gorgers) X 2 (obese, normal weight) ANCOVA was used to compare RMR, adjusting for lean body mass (LBM). LBM has been shown to account for 85% of individual variance in RMR (Cunningham, 1991) and, therefore, needs to be controlled in order to assess the contributions of other factors to differences in RMR.

A number of interrelated variables were examined and consider as confounding variables. These were controlled both by the study design, as explained below and statistically, as needed. These include body mass, body fat percentage, age, and daily physical activity. A Pearson correlation confirmed positive relationships between RMR and total body mass ($r^2 = 0.65$; $p = 0.0005$, $N = 51$), RMR and body fat percentage ($r^2 = 0.26$; $p = 0.07$), and RMR and lean body mass ($r^2 = 0.72$; $p = 0.0005$), but did not confirm relationships between age and RMR ($r^2 = 0.02$; $p = 0.87$), daily physical activity and RMR ($r^2 =0.06$; $p = 0.67$), or exercise and RMR ($r^2 = -0.004$; $p = 0.98$).

Total body mass and age were controlled methodologically by matching the eating pattern groups by BMI and age, respectively. Body fat percentage was not intentionally controlled methodologically or statistically since it was a dependent variable of interest addressed in Aim #2. However, as presented in the Anthropomorphic and Demographics Data section (pages 102-105), the eating pattern groups did not differ by body fat percentage. Finally, the impact of recent physical activity on metabolic measurements was controlled methodologically by having participants restrict physical activity for 12 hours prior to metabolic testing time, conducting the measurements in the morning to reduce the influence of daily activities, and including a pre-testing rest period of approximately 10-30 minutes.

Given the increased potential for a Type I error, the interrelationship between RMR, AMR, and DIT was assessed. RMR was found to have positive correlations with both AMR ($r^2 = 0.32$, $p = 0.02$) and DIT peak ($r^2 = 0.44$, $p = 0.01$), confirming the measures are not independent. This was addressed by examining the rise in metabolic rate above RMR during activity and following a meal.

Resting Metabolic Rate.

Table 6 displays the RMR values for the groups in kilocalories per day (kcal/day), kilocalories per minute (kcal/min), kilocalories per kilogram of body mass per day (kcal/kg/day), and kilocalories per kilogram of lean body mass per day (kcal/kgLBM/day). The data were first analyzed using an unadjusted 2 (gorging, non-gorging) X 2 (obese, normal weight) MANOVA; then LBM was added as a covariate (MANCOVA). As recommended in Keppel (1991), post-hoc power and effect size analyses were conducted for each of the statistical tests. Interaction effects and each hypothesis will be addressed in the following sections.

Interaction Analyses for RMR: Unadjusted analysis for RMR in kcal/day and adjusted analyses (with LBM as a covariate) did not reveal a weight group by eating category group interaction effect [$F(1,47) = 0.54$, $p = 0.47$; $F(1,46) = 0.06$, $p = 0.80$], which might be expected given a small effect size ($f = 0.04$).

Hypothesis 1.a.1. *The RMR of the gorgers is significantly lower than that of the non-gorgers.* This hypothesis was not supported by the data. The gorging and non-gorging groups' RMR's did not significantly differ in kcal/day [$F(1,47) = 0.49$, $p = 0.49$]. The effect size for this comparison was small at 0.1.

Hypothesis 1.a.2. *The differences between the gorging and non-gorging groups are expected to remain significant after adjusting for LBM such that the gorging group would have lower RMR's.* There continued to be no significant differences between the eating pattern groups' RMR's after controlling for LBM [$F(1,46) = 0.86$, $p = 0.36$]. Again, the effect size for this comparison was small at 0.14.

Hypothesis 1.a.3: *The RMR of the obese group is significantly higher than that of the normal weight individuals.* There was a main effect for weight group on RMR in kcal/day in the predicted direction [$F(1,47) = 3.96$, $p = 0.05$].

Hypothesis 1.a.4: *The differences between the obese and normal weight groups are not expected to remain significant after adjusting for LBM.* This hypothesis was supported by the data. There were no longer differences between the obese and normal weight groups' RMR's after covarying LBM [$F(1,46) = 0.34$, $p = 0.56$)].

Table 6.

Resting Metabolic Rates

	Gorger		Non-gorger	
	Obese 12	Normal Weight 14	Obese 11	Normal Weight 14
	M (SD)	M (SD)	M (SD)	M (SD)
RMR (kcal/day)	1470.9 (295.2)	1292.0 (135.2)	1468.6 (196.3)	1386.7 (270.2)
RMR (kcal/min)	1.0 (0.2)	0.9 (0.1)	1.0 (0.1)	1.0 (0.2)
RMR (kcal/kg body mass/day)	15.6 (1.4)	20.0 (2.1)	16.9 (1.0)	21.0 (1.9)
RMR (kcal/kg lean body mass/day)	28.2 (3.4)	28.0 (2.0)	29.0 (2.3)	28.7 (1.7)

Active Metabolic Rate.

It was hypothesized that the gorgers would have suppressed AMR's when compared to the non-gorgers. The means and standard deviations of Active Metabolic Rates are presented in Table 7 as 5 variables; (1) liters of O_2 consumed per minute, (2) kilocalories per minute (kcal/min), (3) rise in metabolic rate (change from RMR) per minute (Δ kcal/min), (4) the rise in metabolic rate (change from RMR) per kilogram of lean body mass per hour (Δ kcal/kg/min), and (5) mechanical efficiency.

Table 7

Active Metabolic Rates

	Gorger		Non-gorger	
	Obese 12	Normal Weight 14	Obese 11	Normal Weight 14
	M (SD)	M (SD)	M (SD)	M (SD)
1. O_2 consumption in L/min	0.8 (0.2)	0.6 (0.1)	0.7 (0.2)	0.6 (0.1)
2. AMR in kcal/min	4.0 (0.8)	3.1 (0.5)	3.7 (0.8)	2.8 (0.7)
3. Rise MR (Δ kcal/min)	2.8 (0.7)	2.1 (0.5)	2.5 (0.7)	1.8 (0.7)
4. Rise MR (Δ kcal/kg LBM/min)	0.06 (0.02)	0.05 (0.01)	0.05 (0.01)	0.04 (0.02)
5. Mechanical Efficiency (%)	18.5% (3.6)	23.7% (4.4)	19.8% (3.6)	27.9% (10.4)

Interaction Effects: There were no group by eating pattern interactions for the AMR variables: liters of oxygen consumed per minute [$F(1, 47) = 0.00$, $p = 0.99$], AMR in kcal/min [$F(1, 47) = 0.01$, $p = 0.93$], or the rise in metabolic rate (change from RMR) per minute [$F(1, 47) = 0.36$, $p = 0.55$]. There was not interaction after covarying LBM: liters of O_2 consumed per minute [$F(1, 47) = 0.34$, $p = 0.57$], AMR in kcal/min [$F(1, 47) = 0.26$, $p = 0.61$], or the rise in metabolic rate (change from RMR) per minute [$F(1, 47) = 2.05$, $p = 0.16$].

Hypothesis 1.b.1: *The AMR of the gorgers is significantly lower than that of the non-gorgers.* Contrary to the hypothesis, the groups did not differ in AMR as measured by liters of O_2 consumed per minute [$F(1, 47) = 2.03$, $p = 0.16$] or AMR in kcal/min [$F(1, 47) = 2.13$, $p = 0.15$]. There was a trend for the gorging group to have a greater rise in metabolic rate (change from RMR) per minute [$F(1, 47) = 3.32$, $p = 0.08$]. The effect size for this comparison was small ($f = 0.20$).

Hypothesis 1.b.2. *The differences between the gorging and non-gorging groups are expected to remain significant after adjusting for LBM such that the gorging group would have lower AMR's.* Contrary to the hypothesis, there was not an eating pattern group main effect on liters of O_2 consumed per minute [$F(1, 47) = 2.31$, $p = 0.14$] or AMR in kcal/min [$F(1, 47) = 2.45$, $p = 0.12$]. There was, however, a trend for the gorging group to experience a greater rise in metabolic rate from RMR to AMR [$F(1, 47) = 3.47$, $p = 0.07$]. The effect size for these comparisons was small ($f = 0.22$).

Hypothesis 1.b.3: *The AMR of the obese group is significantly higher than that of the normal weight individuals.* This was confirmed. There was a weight group main effect on liters of O_2 consumed per minute [$F(1, 47) = 15.25$, $p = 0.0005$], AMR in kcal/min [$F(1, 47) = 16.57$, $p = 0.0005$], and the rise in metabolic rate (change from RMR) per minute [$F(1, 47) = 10.12$, $p = 0.003$]. The effect size for this comparison was moderate ($f = 0.40$).

Hypothesis 1.b.4: *The differences between the obese and normal weight groups are not expected to remain significant after adjusting for LBM.* Contrary to this hypothesis, after adjusting for LBM the obese group continued to consume more O_2 (liters per minute) [$F(1, 47) = 9.98$, $p = 0.003$], had higher AMR's in kcal/min [$F(1, 47) = 10.16$, $p = 0.003$], and had a greater rise in metabolic rate (change from RMR) per minute [$F(1, 47) = 8.65$, $p = 0.005$].

Post hoc analyses were conducted to compare the exercising and non-exercising groups. The AMR (in kcal/min) was lower for exercisers [3.07 +/- 0.81 versus 3.62 +/-

0.75; $F(1, 47) = 4.27$, $p = 0.04$]. Additionally, post hoc analysis revealed a negative correlation between hours exercised per week and AMR (in kcal/min; $r^2 = -0.28$, $p = 0.05$). AMR (in kcal/min) was positively correlated with BMI ($r^2 = 0.71$, $p = 0.0005$) and LBM ($r^2 = 0.49$, $p = 0.0005$). The rise in metabolic rate due to activity was also positively correlated with BMI ($r^2 = 0.63$, $p = 0.0005$) and LBM ($r^2 = 0.39$, $p = 0.005$).

Post-hoc Analyses of Mechanical Efficiency. Differences in mechanical efficiency were examined in post hoc analyses. (Given that this was examined post-hoc, no hypotheses regarding these data are presented.) There was no weight group by eating pattern group interaction effect for mechanical efficiency [$F(1, 46) = 0.59$, $p = 0.45$]. There was a weight group main effect such that the obese group was less mechanically efficient than the normal weight group [$F(1, 46) = 13.5$, $p = 0.001$]. There was no main effect for eating pattern group [$F(1, 46) = 2.36$, $p = 0.13$]. This analysis revealed one outlier (normal weight, non-gorger) with a calculated mechanical efficiency more than 2 standard deviations above the mean (55.0%). The data were analyzed both with and without the outlier with no changes in the statistical findings. The non-exercising group was found to have a lower mechanical efficiency than the exercising group [20.21% +/- 4.13 versus 24.88% +/- 0.81; $F(1, 47) = 4.29$, $p = 0.04$]. Analyses on mechanical efficiency were repeated with LBM as a covariate with no differences in the outcomes: no interaction effect [$F(1, 46) = 0.75$, $p = 0.39$] or an eating pattern main effect [$F(1, 46) = 2.32$, $p = 0.14$]. There continued to be a weight group main effect [$F(1, 46) = 8.40$, $p = 0.006$] such that the obese group was less mechanically efficient.

Dietary Induced Thermogenesis.

Finally, it was hypothesized that the gorgers would have a suppressed DIT (or TEF) such that their metabolic response to food would be less than that of the matched non-gorging participants as measured by three variables (1) time to peak response, (2) DIT peak in kilocalories per minute (kcal/min), and (3) change in metabolic rate from RMR per hour (Δ kcal/hr). The means and standard deviations of these variables can be found in Table 8. Four other variables are depicted in Table 8 for informational purposes; DIT peak per hour per kilogram of body weight (kcal/hr/kg), peak response per hour per kilogram of lean body mass (kcal/hr/kg LBM), change in metabolic rate from RMR per hour per kilogram of body weight (Δ kcal/hr/kg), and change in metabolic rate from RMR per hour per kilogram of body weight of lean body mass (Δ kcal/hr/kg LBM). Interaction effects and each hypothesis will be addressed in the following sections.

<u>Interaction effects:</u> There was not an interaction effect for time to peak response [$F(1, 47) = 0.13$, $p = 0.72$] or change in metabolic rate per hour [Δ kcal/hr; $F(1, 47) = 1.56$, $p = 0.22$]. There was a trend for an interaction effect on DIT peak (kcal/min) [$F(1, 47) = 2.92$, $p = 0.09$] such that both obese groups experienced the highest peak, followed by the normal weight non-gorgers and the normal weight gorgers. After covarying LBM, no interaction effects were found for time to peak response [$F(1, 47) = 0.15$, $p = 0.706$], peak response [$F(1, 47) = 1.24$, $p = 0.27$], or change in metabolic rate from RMR [Δ kcal/hr; $F(1, 47) = 1.24$, $p = 0.27$].

<u>Hypothesis 1.c.1:</u> *The DIT of the gorgers is significantly lower than that of the non-gorgers.* There was not an eating pattern main effect for time to peak response [$F(1, 47) = 2.52$, $p = 0.12$] or DIT peak (kcal/min) [$F(1, 46) = 0.40$, $p = 0.53$]. There was a

trend for the gorging group to experience a greater change in metabolic rate from RMR per hour [Δ kcal/hr; $F(1, 47) = 3.30$, $p = 0.08$]. The effect sizes for these comparisons was low, ranging from ($f = 0.10$ to 0.27).

<u>Hypothesis 1.c.2:</u> *The differences between the gorging and non-gorging groups are expected to remain significant after adjusting for LBM such that the gorging group would have lower DIT's.* Contrary to the hypothesis, there was not an eating pattern main effect for time to peak response [$F(1, 47) = 2.46$, $p = 0.12$] or peak response [$F(1, 47) = 0.46$, $p = 0.50$]. There continued to be a trend for the gorging group to experience a greater rise in metabolic rate from RMR [Δ kcal/hr; $F(1, 47) = 3.27$, $p = 0.08$]. The effect sizes for these comparisons was small, ranging from ($f = 0.10$ to 0.27).

<u>Hypothesis 1.c.3:</u> *The DIT of the obese group is significantly higher than that of the normal weight individuals.* There was a weight group main effect for DIT peak (kcal/min) [$F(1, 46) = 10.26$, $p = 0.002$] and change in metabolic rate from RMR per hour [Δ kcal/hr; $F(1, 47) = 6.62$, $p = 0.01$] such that the normal weight group had lower overall postprandial peaks (in kcal/min) but experienced a greater rise in DIT from baseline RMR. Both weight groups experienced a peak response at approximately 40 minutes after consuming the liquid meal [$F(1, 47) = 0.12$, $p = 0.73$]. The effect sizes for these comparisons ranged from small ($f = 0.1$) to medium ($f = 0.27$).

<u>Hypothesis 1.c.4:</u> *The differences between the obese and normal weight groups are not expected to remain significant after adjusting for LBM.* As expected, there was not a weight group main effect for time to peak response [$F(1, 47) = 0.13$, $p = 0.72$], peak response [$F(1, 47) = 2.42$, $p = 0.13$]. However, there continued to be a trend for the

normal weight group to experience a greater rise in metabolic rate from RMR per hour [Δ kcal/hr; $F(1, 47) = 3.34$, $p = 0.07$].

Post hoc analyses of the relationship between LBM and DIT revealed a positive correlation with peak DIT ($r^2 = 0.58$, $p = 0.0005$) and a negative correlation with rise in metabolic rate to DIT ($r^2 = -0.30$, $p = 0.03$).

Table 8

Dietary Induced Thermogenesis

	Gorger		Non-gorger	
	Obese 12	Normal Weight 14	Obese 11	Normal Weight 14
	M (SD)	M (SD)	M (SD)	M (SD)
Time to Peak Response (min.)	42.8 (9.1)	40.7 (9.7)	37.0 (12.2)	37.1 (11.3)
DIT Peak response (kcal/min)	1.3 (0.3)	1.1 (0.1)	1.3 (0.2)	1.2 (0.2)
DIT Peak (kcal/hr/kg BM)	0.76 (0.10)	1.00 (0.10)	0.81 (0.07)	1.00 (0.09)
DIT Peak (kcal/hr/kg LBM)	0.43 (0.25)	0.40 (0.10)	0.43 (0.32)	0.40 (0.28)
DIT (Δ kcal/min)	1.40 (0.28)	1.10 (0.13)	1.33 (0.23)	1.24 (0.22)
DIT (Δ kcal/hr)	83.99 (16.60)	66.00 (7.61)	80.03 (13.53)	74.56 (13.40)
DIT (Δ kcal/hr/kg)	0.89 (0.16)	1.11 (0.14)	0.91(0.16)	1.19 (0.24)
DIT (Δ kcal/hr/kg LBM)	1.60 (0.30)	1.56 (0.16)	1.58 (0.25)	1.63 (0.30)

AIM #2: The relationship between eating pattern and body composition.

A 2 (gorger, non-gorger) X 2 (obese, normal weight) ANOVA was used to test the relationship between eating pattern and body composition according to the following hypotheses:

Interaction effects: There was not a weight group by eating pattern group interaction effect for body fat percentage [$F(1, 47) = 0.04$, $p = 0.85$].

Hypothesis 2.a. *The gorgers have higher body fat percentages than the non-gorgers.* Contrary to the hypothesis, the eating pattern groups did not differ in body fat percentage [$F(1,47) = 1.02$, $p = .32$]. The gorgers had a mean body fat percentage of 35.61% +/- 9.31 and the non-gorgers had a mean body fat percentage of 33.76% +/- 9.37.

Hypothesis 2.b: *The obese group has higher body fat percentages than the normal weight group.* As expected, there was a weight group effect for body fat percentage [$F(1, 47) = 110.05$, $p = 0.0005$], such that the obese group had a higher body fat percentage than the normal weight group (43.17% +/- 5.50 versus 27.74% +/- 4.88).

AIM #3: The relationship of eating pattern and energy intake

The food diary information (energy intake, fat intake, and percent fat intake) for the total group was analyzed to assess weight group by eating group interaction effects.

The food diary information for the gorging group was also examined separately to assess additional information about the eating patterns of the gorging group. The food diary information (energy intake, fat intake, and percent fat intake) was analyzed using a 2 (gorging, non-gorging) X 2 (obese, normal weight) MANOVA. The macronutrient data for the study sample is presented in Table 9. Interaction effects and hypotheses are presented in the following section.

Table 9

Macronutrient Intake for All Groups

	Gorger		Non-Gorger	
	Obese	Normal Weight	Obese	Normal Weight
	12	14	11	14
	M(SD)	M(SD)	M(SD)	M(SD)
Energy Intake (kcal)	1396.2 (493.7)	1215.0 (296.2)	1883.1 (627.1)	1728.0 (435.2)
Fat Intake (gm)	46.2 (20.92)	41.3 (13.3)	74.14 (37.1)	47.5 (18.2)
Percent Fat Intake	30.3% (10.0)	30.2% (6.4)	33.7% (6.6)	25.2% (7.7)

Interaction effects: A weight group by eating pattern group interaction effect was not found for energy intake [$F(1,47) = 0.01$, $p = 0.92$].

Hypothesis 3.a. *The energy intake of the gorgers is significantly lower than that of the non-gorgers.* As expected, the gorgers reported a lower total energy intake [$F(1,47) = 14.50$, $p = 0.0005$] than the non-gorgers. There was not a main effect for weight group on energy intake [$F(1,47) = 1.64$, $p = 0.21$].

Hypothesis 3.b. *The gorgers consume significantly more fat than the non-gorgers.* Fat intake was examined as both percent fat and fat grams. A trend for an eating pattern group by weight group interaction was found for percent fat intake [$F(1,47) = 3.71$, $p = 0.06$]. As depicted in Table 9, the obese non-gorgers consumed the highest percentage of fat while the normal weight non-gorgers consumed the lowest percentage of fat. The gorging groups did not differ from each other. An examination of the change terms revealed a significant difference between the obese and normal weight non-gorging groups [$t(23) = 2.92$, $p = 0.008$] not seen between the gorging groups [$t(24) = 0.03$, $p = 0.98$]. Also found was a trend for a significant difference between the gorging and non-gorging normal weight groups [$t(26) = 1.89$, $p = 0.07$] not seen between the obese groups [$t(21) = 0.95$, $p = 0.36$]. Examining fat intake in grams per day demonstrated similar findings and no additional information for support or failure to support this hypothesis. Detailed analyses can be found in Appendix M.

Post hoc analyses revealed several relationships between body composition and energy consumption. Total fat intake (grams per day) was positively correlated with BMI ($r^2 = 0.37$, $p = 0.01$) and body fat percentage ($r^2 = 0.35$, $p = 0.01$). A trend for a positive relationship between kilocaloric intake and BMI was found ($r^2 = 0.37$, $p = 0.01$). Kilocaloric intake was positively correlated with RMR ($r^2 = 0.31$, $p = 0.03$) and fat intake ($r^2 = 0.78$, $p = 0.0005$).

AIM #4: The Association of Eating Attitudes and Meal Pattern

The BDI and the EDE were used to screen out those participants with potentially clinical levels of depression or eating disorders. Therefore these data are presented merely for descriptive purposes. Further data analyses can be found in Appendix M. Please see Table 10 for a display of the means and standard deviations of the subscale scores on the EDE-Q. The obese group reported significantly higher shape concerns [$F(1,47) = 5.24$, $p = 0.03$]. There was a trend for the obese group to have more weight concerns [$F(1,47) = 3.59$, $p = 0.06$] and a higher global score [$F(1,47) = 3.55$, $p = 0.07$]. The eating pattern groups did not significantly differ on any of the subscales [restraint: $F(1,47) = 0.63$, $p = 0.43$; eating concerns: $F(1,47) = 0.21$, $p = 0.65$; shape concerns: $F(1,47) = 1.61$, $p = 0.21$; weight concerns: $F(1,47) = 1.70$, $p = 0.20$] or the global scale

[F(1,47) = 1.50, p = 0.23]. No participants met criteria for any eating disorders based on the EDE-Q. However, all of the means were higher than those presented by Fairburn & Wilson (1993) for normal controls, restrained controls, dieters, and overweight participants (p. 328).

Table 10

Self-Report EDE-Q Scores by Weight and Eating Pattern Group

	Gorging		Non-Gorging	
Subscale	Obese	Normal Weight	Obese	Normal Weight
n	12	14	11	14
	M (SD)	M (SD)	M (SD)	M (SD)
Restraint	5.3 (7.0)	6.6 (8.6)	9.4 (6.5)	5.8 (6.6)
Eating Concerns	3.0 (4.5)	3.4 (5.4)	5.4 (4.3)	2.1 (3.1)
Shape Concerns	15.0 (8.6)	12.4 (10.2)	23.6 (12.8)	11.8 (12.6)
Weight Concerns	8.8 (5.0)	5.9 (6.7)	12.0 (7.4)	7.7 (7.5)
Global Score	8.0 (4.7)	7.1 (7.4)	12.6 (5.9)	6.9 (6.5)

BDI

A Univariate 2 (gorging, non-gorging) X 2 (obese, normal weight) ANOVA was used to compare the BDI scores of the groups. Please see Table 11 for the means and standard deviations of the BDI for all of the participants. There was a weight group by eating pattern group interaction effect [F(1,47) = 3.95, p = 0.05]. The obese non-gorging group scored the highest on the BDI-II, the normal weight non-gorging group scored the lowest, and the two gorging groups scored between them. There were no weight group [F(1,47) = 0.68, p = 0.42] or eating pattern group main effects [F(1,47) = 0.40, p = 0.53]. All of the groups' means fell within the range of minimal to no depressive symptoms.

Table 11

BDI Score by Weight and Eating Pattern Group

	Gorging		Non-Gorging	
	Obese	Normal Weight	Obese	Normal Weight
n	12	14	11	14
	M (SD)	M (SD)	M (SD)	M (SD)
	1.8 (3.4)	3.0 (2.3)	4.5 (4.3)	1.6 (4.0)

Eating Disorders Inventory and Eating Inventory

Eating Inventory

A 2 (gorging, non-gorging) X 2 (obese, normal weight) MANOVA was used to analyze the data from the Eating Inventory. Please see Table 12 for the EI means and standard deviations. Pathological eating/body image attitudes were operationalized using the dietary restraint, disinhibition, and cues for hunger subscales of the EI (Stunkard & Messick, 1985). Interaction effects and hypotheses are presented below.

Interaction effects: There were no interaction effects for the restraint subscale [$F(1,46) = 0.56$, $p = 0.46$], the disinhibition subscale [$F(1,46) = 0.15$, $p = 0.70$], or the cues to hunger subscale [$F(1,46) = 0.03$, $p = 0.86$].

Hypothesis 4.a: *The gorging group has greater pathology in eating/body image attitudes than the non-gorgers.* This hypothesis was not supported by the data. There were no eating pattern group main effects for the restraint subscale [$F(1,46) = 0.73$, $p = 0.40$], the disinhibition subscale [$F(1,46) = 1.36$, $p = 0.25$], or the hunger subscales [$F(1,46) = 1.89$, $p = 0.18$].

Hypothesis 4.b: *The obese group has greater pathology in eating/body image attitudes than the normal weight group.* The data did not support this hypothesis. There were no weight group main effects for the restraint subscale [$F(1,46) = 0.31$, $p = 0.58$], the disinhibition subscale [$F(1,46) = 2.19$, $p = 0.15$], or the hunger subscales [$F(1,46) = 0.35$, $p = 0.56$].

Table 12

EI Scores by Weight and Eating Pattern Group

	Gorging		Non-Gorging		Normal Weight Sample*	Overweight Sample*
Subscale	Obese	Normal Weight	Obese	Normal Weight	n = 954	n = 46,128
n	12	14	11	14		
	M (SD)	M (SD)	M (SD)	M (SD)	M (SD)	M (SD)
Cognitive Restraint	10.6 (4.8)	8.9 (5.0)	8.5 (4.2)	8.7 (4.9)	8.8 (5.0)	12.0 (4.5)
Disinhibition	6.6 (3.9)	5.4 (3.6)	8.4 (5.2)	6.3 (2.9)	5.5 (3.6)	8.4 (3.6)
Cues to Hunger	4.6 (3.4)	4.0 (2.5)	5.6 (3.4)	5.3 (2.5)	5.0 (3.5)	N/A**

Note. *Norms taken from Westenhoefer, Stunkard, & Pudel, 1999. The mean BMI for the normal weight sample was 24.4 (3.9) kg/m^2, mean age was 41.8 (SD = 17.3) years; the mean BMI for the overweight sample was 27.2 (SD = 3.8) kg/m^2, mean age was 43.6 (SD = 12.7) years. **Data not available.

Eating Disorders Inventory-2

A 2 (gorging, non-gorging) X 2 (obese, normal weight) MANOVA was used to analyze the data from the EDI-2. Please see Table 13 for the means and standard deviations of the EDI-2 for all of the participants. Pathological eating/body image attitudes were operationalized using the drive for thinness, bulimia, and body dissatisfaction subscales on the EDI-2 (Garner, 1991).

Interaction effects: There were no weight group by eating pattern group interaction effects for the drive for thinness [$F(1,46) = 0.13$, $p = 0.72$], bulimia [$F(1,46) = 0.58$, $p = 0.46$], or body dissatisfaction [$F(1,46) = 0.11$, $p = 0.74$].

Hypothesis 4.a: *The gorging group has greater pathology in eating/body image attitudes than the non-gorgers.* Contrary to the hypothesis, there were no eating pattern group main effects for the drive for thinness [$F(1,46) = 0.07$, $p = 0.80$], bulimia [$F(1,46) = 0.56$, $p = 0.46$], or body dissatisfaction [$F(1,46) = 0.43$, $p = 0.51$]. The group means for each of the subscales are comparable to the means for a normal population and below the means for an eating disordered population (Garner, 1991).

Hypothesis 4.b: *The obese group has greater pathology in eating/body image attitudes than the normal weight group.* Contrary to the hypothesis, there were no weight group main effects for the drive for thinness [$F(1,46) = 0.50$, $p = 0.48$] or bulimia [$F(1,46) = 0.91$, $p = 0.35$]. As expected, the obese group scored significantly higher on the body dissatisfaction scale [$F(1,46) = 17.81$, $p = 0.0005$].

Table 13

EDI-2 Scores by Weight and Eating Pattern Group

	Gorging		Non-Gorging		Non-Eating Disordered*	Eating Disordered*
Subscale	Obese	Normal Weight	Obese	Normal Weight		
n	12	14	11	14	770	889
	M (SD)	M (SD)	M (SD)	M (SD)	M (SD)	M (SD)
Drive for Thinness	3.5 (4.9)	2.9 (6.3)	4.4 (3.9)	2.8 (5.1)	5.5 (5.5)	14.5 (5.6)
Bulimia	1.5 (3.6)	1.3 (4.0)	1.5 (1.9)	0.1 (0.3)	1.2 (1.9)	10.5 (5.5)
Body Dissatisfaction	16.1 (8.3)	6.1 (7.8)	13.9 (10.3)	5.4 (3.9)	12.2 (8.3)	16.6 (8.3)

Note. Norms taken from Garner, 1990.

Furthering the Definition of Gorging

The food diaries were examined post hoc to assess any prominent eating patterns among the groups. The gorging group was then specifically examined for trends or patterns within the gorging group's reported food intake.

Accuracy in Self-Reported Energy Intake: Who Underreports?

Energy intake requirements were estimated from the RMR data collected in the current study. These data were then compared to reported food-intake to examine accuracy in reporting. The Weir method was chosen to estimate RMR from measured carbon dioxide and oxygen (McArdle, Katch, & Katch, 2000). To account for energy expenditure from daily activity and purposeful exercise, RMR was multiplied by 1.3. A factor of 1.2 to 1.5 is typically used to estimate daily activity energy requirements, except for very active individuals. To determine the most appropriate activity factor, daily activity and purposeful exercise were examined. Depending on weight, walking approximately 3 miles per day averages to 250-375 kilocalories expended for this group. Accounting for purposeful exercise in the normal weight group, an additional 40 to 63 kilocalories per day are expended. Among the 6 of 23 obese participants who reported exercising an additional 52-76 kilocalories were expended per day. The estimated range of energy expended in excess of RMR was 290 to 451 kilocalories. Based on these estimates, the daily activity of the participants was categorized to be sedentary to light. Therefore, an activity factor of 1.3 was considered a reasonable estimate of the total daily energy expenditure.

Estimated and predicted energy intakes are presented in Table 14 along with the difference between these two values (predicted – expected). All of the groups' reported energy intakes were below estimated needs and less than the intake required to maintain current weight. Unfortunately, body weight was not assessed before and after food-intake monitoring. This would have provided information on whether individuals lost or gained weight during this monitoring period.

A 2 (gorger, non-gorger) X 2 (obese, normal weight) MANOVA was used to compare the predicted and reported energy intakes of the groups. For predicted energy intake, there was no interaction [$F(1,47) = 0.54$, $p = 0.47$] or eating pattern main effect [$F(1,47) = 0.49$, $p = 0.49$]. As expected, the obese group had higher predicted energy intake than the normal weight group [$F(1,47) = 3.96$, $p = 0.05$].

For the difference between expected and predicted estimates, there was no interaction [$F(1,47) = 0.13$, $p = 0.72$]. There was a main effect for eating pattern such that the gorgers underreported food intake more than the nongorgers [$F(1,47) = 10.44$, $p = 0.002$]. There was not a main effect for weight group [$F(1,47) = 0.001$, $p = 0.995$].

Table 14

Predicted and Expected Energy Intakes

	Gorger		Non-Gorger	
	Obese	Normal Weight	Obese	Normal Weight
	12	14	11	14
	M(SD)	M(SD)	M(SD)	M(SD)
Reported Kcal/day	1396.2 (493.7)	1215.0 (206.2)	1883.1 (627.1)	1727.1 (522.1)
Predicted Kcal/day	1912.1 (383.8)	1680.4 (175.8)	1909.2 (255.2)	1802.7 (351.3)

Difference (Predicted-Expected)	515.9 (592.6)	465.4 (318.6)	26.1 (570.5)	74.7 (444.9)

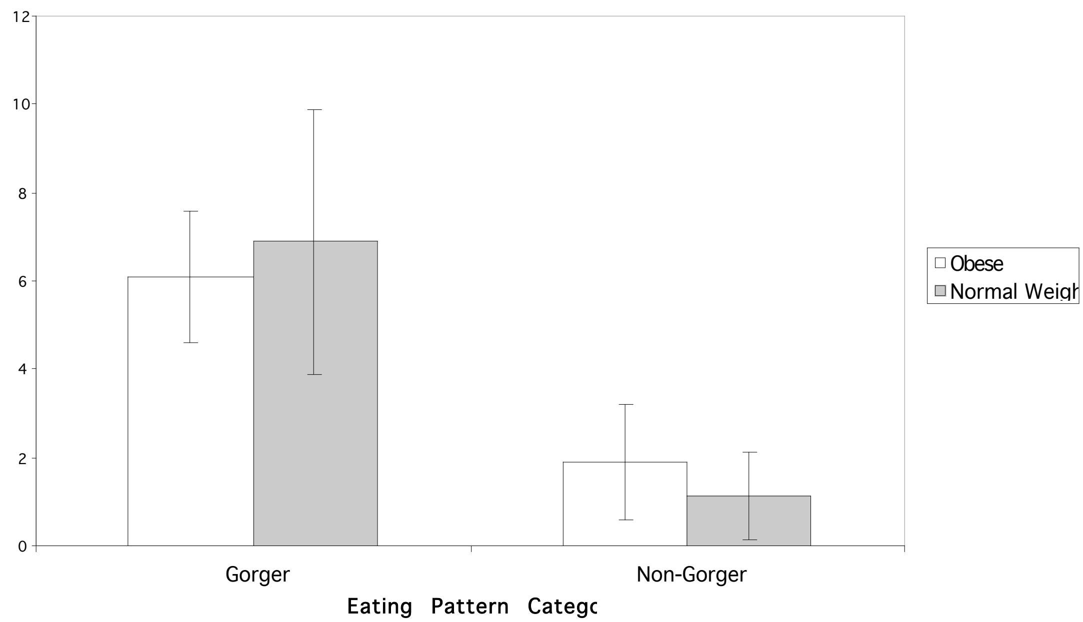
Note. Predicted energy intake calculated using the Weir Method (from measured respiratory gases) multiplied by 1.3 METs (McArdle, Katch, & Katch, 2000).

Time to first eating episode

The operational definition of gorging used in this study was primarily based on time to first meal. Figure 5 displays the mean time to first eating episode (in hours) by group. A 2 (gorging, non-gorging) X 2 (obese, normal weight) ANOVA was used to examine differences in time to first eating episode. Given gorging was an independent variable, the finding that the gorgers delayed eating significantly longer than the non-gorgers (6.58 vs 1.47 ; $F(1,47) = 88.34$, $p = 0.0005$] was expected. There was no weight group by eating pattern interaction [$F(1,47) = 2.11$, $p = 0.15$] or a main effect for weight group [$F(1,47) = 0.001$, $p = 0.97$].

Further analyses (2 X 2 ANOVA) were done to examine time to first meal on *non-gorging* days only. Even on non-gorging days, the gorgers delayed eating significantly longer than the non-gorgers: 2.95 +/- 1.54 hours versus 1.47 +/- 1.21 hours [$F(1, 46) = 13.15$, $p = 0.001$]. There was no interaction [$F(1, 46) = 0.78$, $p = 0.382$] or weight group main effect [$F(1, 46) = 1.09$, $p = 0.303$].

Figure 5. Mean Time to First Meal on All Days by Group



The Gorgers Meal Patterns

The obese and normal weight gorging groups' meal patterns were compared by type of day (gorging; non-gorging) and across days using a MANOVA's. Dependent variables included time to first meal, kilocalorie intake, fat intake, and percent fat intake. Analyses were conducted separately for gorging days, non-gorging days, and all days. Table 15 for a summary of the macronutrient intake of the gorgers. The obese and normal weight gorgers did not differ in their intake of daily kilocalories, daily fat grams, or percent daily fat for the 3 time periods assessed (gorging days, non-gorging days, all days) (all p's>.13). These analyses can be found in Appendix M. There were no differences in the frequency of gorging between the normal weight and obese gorgers [obese =3.92 (SD= 1.17);normal weight = 4.07 (SD = 1.27); $t(24) = -0.32$, $p = 0.75$]. Since the food diary data did not differ for the normal weight and obese gorgers, these groups were collapsed and intake was measured between type of day (gorging; non-gorging).

Table 15

Macronutrient Content by Type of Day for Gorgers

Type of Day	Gorging Days		Non-gorging Days	
	Obese	Normal Weight	Obese	Normal Weight
n	12	14	11	14
	M (SD)	M (SD)	M (SD)	M (SD)
Energy Intake (kcal)	1386.4 (499.0)	1192.8 (298.1)	1449.7 (634.6)	1271.7 (356.1)
Fat Intake (gm)	45.5 (21.4)	37.7 (12.3)	47.7 (24.2)	43.6 (16.9)
Percent Fat Intake	30.5% (12.7)	28.2% (5.7)	30.2% (10.1)	30.3% (7.4)

A summary of the macronutrient data for the gorging and non-gorging days can be found in Table 16. There were no significant differences found between the gorgers' meal patterns on gorging days and non-gorging days for kcal/day [$t(24) = -1.06$, $p = 0.30$], fat grams [$t(24) = -1.66$, $p = 0.11$], or the percentage of fat [$t(24) = -0.58$, $p = 0.57$].

Table 16

Macronutrient Content of Gorgers' Food Intake on Gorging and Non-Gorging Days

	Gorging Days Only	Non-Gorging Days Only
	M (SD)	M (SD)
Energy Intake (kcal)	1285.7 (410.2)	1357.1 (506.1)
Energy Intake (kJ)	5379.5 (1716.4)	5678.2 (2117.7)
Fat Intake (gm)	41.4 (17.3)	45.5 (21.4)
Percent Fat Intake	29.3% (9.6)	30.3% (8.6)

Power Analysis

Calculations for effect size for expected differences between the kilocaloric intakes and RMR of gorgers versus non-gorgers were based on previous research, including Felig et al. (1983) and Metzner et al. (1977). Felig et al. (1983) presented data on the RMR of obese (n = 10; 4.8 +/- 0.2 kJ/min) and normal weight women (n = 10; 3.8 +/- kJ/min). The means were significantly different with a large effect size (Cohen's = f 0.4) before lean body mass was accounted for (Felig et al., 1983). After accounting for lean body mass, the RMR's for the two groups were no longer significantly different (Felig et al., 1983).

No data showing significant differences in RMR between different eating pattern groups were available. Since the effect of eating pattern on body composition and RMR was estimated to be similar, Iwao et al. (1996)'s data was used to estimate the effect of eating pattern on RMR. Iwao et al. (1996) found that under a restrictive caloric intake, those individuals eating 2 meals per day (3.5 +/- 0.3 kg) experienced greater losses in lean body mass than those eating 6 meals per day (2.4 +/- 0.3 kg). Since changes in lean body mass directly effect RMR, a large effect size (Cohen's f = 0.4) was used for power calculations involving metabolic differences between gorgers and non-gorgers.

Power calculations were conducted using alphas of 0.05 and 0.0125 (using a Bonferroni correction to account for the four presented hypotheses). Based on large effect sizes for both metabolic rate and weight group and α = 0.05, power calculations based on a 2 X 2 ANCOVA full-factorial design revealed that to achieve a power of 0.82, the required sample size for each cell is 14. The total sample size required for the proposed study is 56. Furthermore, to account for an estimated 25% attrition rate, 72 subjects (4 extra subjects per cell) would need to be recruited. Reducing alpha to 0.0125 and achieving a power of 0.80 increases the sample size to 19 per cell for a total of 76 subjects. Accounting for a 25% attrition rate, 95 subjects would need to be recruited. Post hoc effect size analyses for the current study revealed low to moderate effect sizes for many of the comparisons and consequent low power due to an insufficient number of participants. Unplanned post hoc analyses of much of the data were conducted to explore the more important findings. Although this increases the likelihood of Type I errors, some liberties were taken with error to avoid losing substantial power and exposing some areas for future research."

Discussion

This is one of the first studies to comprehensively operationalize gorging behavior on four key parameters: Number of eating episodes per day; Proportion of total food eaten per episode; Time of day for first meal; and Inter-meal interval. Though future research is needed to address the validity of this categorization, this definition should be used as a starting point. Consistent definitions are critical if we are to move forward in understanding the pattern of gorging.

The present study sought to compare gorgers to non-gorgers. Non-gorgers were defined by the same four parameters and the intent was to select a normative comparison group. As noted in the introduction, this approach is different than that of many studies which have sought to compare gorgers to ‘frequent eaters’, that is those that eat 5-6 times per day or to compare those who consume food intake in one bolus with those that consume food in two separate eating episodes. With more data, such comparisons could be made.

The present study replicated existing findings on the interrelationships between body composition and metabolic rate. However, the data did not support the major study hypothesis that the metabolic rates of gorgers would be less than that of nongorgers due to the conservation effect. Surprisingly, there were trends for the gorgers to experience a greater rise in metabolic rate in response to both the meal challenge and the exercise challenge. These trends are actually in the opposite direction of what was predicted. Though it is premature to explain these findings, its is worthwhile to speculate mechanisms to account for such findings. If these findings bear out, decreases in metabolic rate may be due to suppression in RMR, which rebounds during challenges. Also worthy of future study is the oxidation rate of macronutrients by eating pattern group, which itself may be altered.

Another key issue to be addressed in future studies is the adequacy of the food an exercise challenges. The caloric content (350 kcal of Ensure) of the challenge meal may not have been a sufficient challenge and future work should consider a larger challenge such as twice that used in the present study. Similarly, the exercise challenge may need to be standardized based on the fitness level of the individual. Not surprisingly, in the present study, the overweight were less active and therefore the exercise challenge, though considered mild by anyone's standards (the equivalent of a stroll), may have been differentially challenging by group such that it was significantly more challenging for the less fit. This was confirmed with the follow up analyses comparing the exercises to the non-exercisers. These limitations and the need to address them in future studies are further discussed below.

It is particularly interesting that the clinical observations that were the genesis of this research study were borne out. Namely, we observed that individuals who did not eat during the day reporting eating less overall in their self-monitored eating diaries. The self-reported eating data in this study confirmed these clinical observations. The gorgers reported eating significantly less. Unfortunately, weight change was not examined as this would have served as a simple check on weight stability during this monitoring period. It is possible that the gorgers were dieting, despite instructions to not lose weight during the monitoring period. The use of doubly labeled water to validate food-intake and similarly exercise patterns would be important in assessing the role of dieting in these finding. It is important to note, however, that the eating pathology of the gorgers and non-gorgers did not differ. Underreporting has been linked to eating pathology. This is not the case for these findings. This suggests that it may actually be the eating pattern that impacts self-reporting or the ability to accurately assess consumption. It is possible that the greater the meal size or portion size, the less accurate the self-reported intake. Therefore, gorgers, who consume more food at one time, would be less accurate. Clearly, this finding is worth further investigation.

A major limitation of this study is the small effect sizes for the metabolic rate comparisons. Given the small effect sizes for these comparisons, adding to these data may result in more conclusive findings. Similarly, increasing the impact of the exercise and meal challenges could increase the effect size. It is clear that further research should be conducted to follow up on these results. Given that obesity and obesity-related diseases are among the leading causes of health care utilization, a significant burden on health care costs, and on the rise in the United States, it seems logical that the scientific community would follow suit with increasing investigations into primary, secondary, and tertiary treatments (e.g., Allison et al., 1999; Colditz, 1999; Flegal, Carroll, Ogden, & Johnson, 2002; Jebb & Moore, 1999). Among the many areas for investigation is the ineffectiveness of dieting to maintain weight in the normal range. The eating patterns associated with dieting are of interest since dieters often make changes to the quantity, quality, and frequency for their food intake.

One niche of this research has focused on the relationship between dieting, eating patterns, and metabolism. Eating pattern and metabolism research is centered on the possible negative implications of variable food intake common among dieters and meal skippers. The results of eating pattern research have been mixed, but the methodology and the operational definitions of the eating patterns have not been consistent among studies. These inconsistencies were the impetus for the creation of a biopsychosocial framework used as a foundation for this research. Though not all of the primary aims of this study were supported, these interrelationships were replicated.

The Need for a Biopsychosocial Framework

The proposed framework was then used to design a study that would further the body of literature on eating patterns and metabolic rate by integrating previous research to create a comprehensive definition of an important eating pattern: gorging. The integration process involved addressing, controlling, or studying each of the relationships in the proposed framework deemed important empirically and clinically. The results of this study provide support for portions of this framework including support for the link between weight regulation behaviors and body composition, the link between body composition and metabolic rate, and support for the framework as a whole.

The first relationship of interest in the framework is that of physical activity to body composition. The results of the current study provide support for the need to measure or control for physical activity when studying metabolic rate. Both the obese and normal weight groups were equally active throughout the day as were the gorgers and non-gorgers. The key difference, however, was in the participation in structured or purposeful exercise. More normal weight individuals participated in structured exercise. Those reporting exercise had more lean body mass and lower body fat percentages. The level of exercise averaged to be approximately three hours per week and the energy expended from exercise averaged to approximately one soda per day. These findings suggest that exercise, in addition to daily physical activity, is a key component in body composition, should continue to be in the proposed framework; and should be addressed in future research in this area. The findings are also clinically important in that the amount of energy expended through exercise is not dramatic when equated to a food product. Finally, these data may provide additional support for the weight management benefits of exercise. The positive implications of exercise include less body fat and more lean body mass.

The link between physical activity and metabolic rate is the next relationship addressed in the proposed biopsychosocial framework. The data in the current study provide support toward keeping this portion in the model. When examining the relationship between physical activity and metabolic rate, it is important to address total daily energy expenditure and its components (RMR, AMR, and DIT). The finding that the exercisers had a higher mechanical efficiency than non-exercisers suggests an important link between workload and energy expenditure, even at a very light workload.

No direct link was found between physical activity/exercise and RMR, but the exercisers experienced less of a rise in active metabolic rate in response to the same workload as the non-exercisers. This may be an indication that the workload chosen to induce AMR may have been more appropriate if adjusted for LBM and/or reported exercise level. The positive relationship between exercise and AMR may have been due to the activity being easier for the exerciser. These findings suggest an important link between physical activity/exercise and metabolic rate and that merely controlling for exercise the day before the metabolism assessment may not be sufficient to control for this variable.

The third relationship addressed in the proposed framework is that of eating pattern and body composition. Several findings support this as an important piece of the model. First, the obese non-gorging group ate more fat than the other groups. The obese non-gorging group's high fat consumption may be at least partially contributing to their obesity while the normal weight non-gorging group may be maintaining a normal weight by moderating fat intake. This may be an area for further exploration to support lower fat diets. Since fat intake was also correlated with caloric intake, BMI, and body fat percentage, this may also be an area for intervention and providing support for low-fat diets. Potentially, fat intake could be a target for weight reduction such that one could reduce caloric intake by reducing fat intake or consume lower fat foods and consume the same amount of energy with potentially positive outcomes. Dieting preferences and rationales were not assessed, which may be another area for further investigation. Additionally, the data provided by the food diaries may provide clinically relevant information for weight reduction treatment. Despite the physiological differences in energy needs to maintain weight, the obese group did not report greater energy intake than the normal weight group, which may be an indication of underreporting in the obese group.

The relationship between body composition and metabolic rate was most strongly supported by the current study. Body mass and LBM were positively correlated with RMR. LBM accounted for approximately 72% of the variance in RMR. Not only does this provide support in the clinical realm for increasing LBM to increase RMR, but it also reinforces the use of LBM as the normalizing variable in metabolic rate research. LBM also proved to be the most important factor in AMR and DIT. LBM and BMI were positively correlated with AMR (as measured by both oxygen consumption and rise in metabolic rate from baseline). A relationship between body composition and DIT was also found. LBM and peak DIT were positively correlated such that participants with lower body fat experienced a greater rise in metabolic rate after ingesting a meal. Again, LBM was the key factor in determining DIT.

The final portion of the framework addressed by this study was the isolation of the relationship between eating pattern and metabolic rate. Despite careful a priori power analysis, this portion of the study was largely underpowered. However, evidence suggesting the existence of a relationship was still found. Although significant differences between the gorging and non-gorging groups RMR's were not found, evidence for a relationship may be found in reported food intake. The gorging group reported less energy intake than the non-gorging group (regardless of weight status), despite the fact that the participants were matched for BMI and had similar body fat percentages. This could mean they underreport more than the non-gorgers. Or, it could mean that RMR and energy intake are positively correlated and the study was not sensitive enough to detect this relationship. Additionally, there were trends for the gorgers to have greater rises in metabolic rate from RMR to both AMR and DIT. Taken together, these data could be an indication of a small suppression of RMR that could not be detected in this study due to low power, but is corrected with activity and food consumption.

Understanding Gorging

One of the primary goals of the current study was to consolidate information and data from previous research to create a comprehensive definition of gorging that could be used in future research to assess the metabolic implications of this eating pattern. The data indicate that the operational definition used in this study is likely capturing a group of individuals whose weight-regulating behaviors are more similar than they are dissimilar. First, the gorging obese and normal weight groups did not differ demographically suggesting this eating pattern is not likely to be culturally or socio-economically bound. Second, the gorging group demonstrated subtle attempts at weight reduction including moderating kilocaloric and fat intake. Although all of the participants underreported energy intake, the gorgers had a greater discrepancy between expected and reported food intake. This could be evidence for a suppression of metabolic rate, but it could also be evidence for dieting. Additionally, the gorgers always delayed eating longer than the non-gorgers, even on their non-gorging days. Delaying eating everyday may suggest attempts to restrict energy intake. Despite not waiting as long until their first meal, the gorgers' did not change their energy or fat intake on non-gorging days. The gorgers also participated in less structured exercise than the non-gorgers which may indicate the use of food restriction rather than exercise to control weight. No differences in pathological eating attitudes were found which may mean that concerns about body image are similar to non-gorgers, but the gorgers are engaging in more dramatic means of weight regulation. The results of the current study may be important in helping to further the establishment of a comprehensive definition of gorging, to further the understanding of gorging eating patterns, and to provide a working model for addressing areas of metabolic rate research previously neglected.

Limitations

Although this study was carefully designed, there are some methodological limitations in addition to those mentioned above that restrict the generalizability of the data. First, the population studied restricts the application of the findings to other populations such as men, elderly adults, children/adolescents, and non-pre-menopausal women. Numerous factors present in these populations, such as hormonal changes, activity levels, and genetics may impact RMR in addition to or in conjunction with meal pattern and exercise changes. Studying alternate populations may provide a great deal of information about the potential effects of gorging on metabolic rate.

Second, in furthering the understanding of gorging behaviors, the history of gorging and/or dieting behaviors may be a factor worthy of study as an independent variable. In this study, participants reported consistent behaviors (whether gorging or non-gorging) over the past four weeks. The actual length of time that the participants had been practicing their reported eating habits was not collected and, therefore, the true impact of duration of eating pattern cannot be determined. It may be that gorging for many years has a greater impact on metabolic rate or the impact may be more transient in nature.

An additional limitation of this study was the method used to determine accuracy of food monitoring. Due to financial limitations, methods such as doubly-labeled water and whole-room calorimetry could not be used to measure in vivo total daily energy expenditure. To estimate daily activity level, pedometers were chosen over activity checklists to decrease the burden on participants and potentially decrease some reporting bias. Given the data collected cannot be used to determine if reporting bias occurred when recording pedometer measurements and the groups recorded similar levels of daily activity (approximately 3 miles walked per day), the pedometer was not as effective in creating an individualized activity factor as concluded a priori. Attempts were made to establish individualized activity factors for miles walked per day. However, given that estimating energy expended during an activity requires intensity and duration, creating individualized or categorical activity factors was not possible. Consequently, an activity factor of 1.3 was chosen in estimating total daily energy expenditure, which may not be completely accurate for both of the groups. Future studies should focus on a more individualized and accurate method for determining TDEE, such as a combination of activity checklists and pedometers. This may prove useful in determining if gorgers' food diaries are less accurate due to reporting bias or if the gorging and non-gorging diaries are comparably inaccurate. Since no differences were found between the groups' eating attitudes, it may be that gorgers are more inaccurate in recording food intake because estimating portion sizes becomes more difficult as the quantity of food consumed in one sitting increases rather than because of pathological eating attitudes. If, however, the gorgers are no less accurate than the non-gorgers and they are actually consuming less energy, this may provide further support for a suppression of RMR induced by gorging.

Future Directions

The relationship between eating pattern and metabolic rate may still be found in a similarly designed study with more participants or better exercise and meal challenges resulting in more statistical power. The effect size of the relationship between eating pattern and metabolic rate may continue to be small, but the relationship would continue to be clinically important. Additionally, there may be subgroups that experience alterations in metabolic rate and future work should consider such factors as dieting history in the search for subtypes. Another important factor may be ethnic differences in metabolism. Very little is known about the metabolic responses of different ethnic groups. Since obesity is more prevalent among some minority populations (African American and Hispanic American), RMR differences may exist. Assessing whether RMR was associated with ethnicity was not possible in the current study due to the design. Assessing other populations, such as other age groups or men, may also help to understand this leg of the proposed framework.

The intent in choosing a minimal exercise level of activity to induce AMR was to have a workload in which most individuals would experience similar energy output. This was not the case given that the obese were much less mechanically efficient at this activity. Therefore, as mentioned above, choosing an activity based on equivalent mechanical efficiency and measuring the resultant workload might maximize the differences between the eating pattern and/or weight groups.

As with AMR, adjusting the paradigm of methodology to equilibrate the peak postprandial response and measuring energy input might better maximize the difference between group differences. Since peak DIT was lower for the obese group, increasing their peak response to match that of the normal weight counterparts might involve increasing the energy input. Additionally, the meal provided to participants may not have been large enough to induce a significant rise in metabolic rate in the group of participants. Since the effect of DIT is small, a larger meal might have more effectively maximized the differences between the groups. Since no differences in time to peak response were found between the groups, this may support the use of liquid meals in DIT research. If after repeating the current study, between group differences are still not found, inducing a more regular eating pattern in the gorgers and studying any effects on RMR might provide additional information to dieting research. A final area of potential modification of the methods to maximize between group differences might be to provide meals to the gorgers at the time of day that more closely matches their typical meal patterns (i.e., later in the day).

The focus of this study provides important direction for furthering the understanding of the effects of dieting on weight regulation. Given the dramatic rise in overweight and obesity in the American population, much more work on the interrelationships of eating patterns, body composition and metabolism is needed. Following up this work to understand the impact of eating frequency on a number of other populations, including children and adolescents, the elderly, post-menopausal women, and men would be important. In summary, this was one of the first studies to thoroughly operationalize gorging and to examine existing eating patterns. While several of the major hypothesis were not supported, the results of this study do support the importance of the relationship between weight regulating behaviors, body composition, and metabolic rate. The findings are clearly worth further study and it is evidentr that a biopsychosocial framework is needed when examining the interrelationship of eating patterns and metabolism.

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APPENDIX

APPENDIX A: A Summary of the Time-Distribution of Meals Research

A Brief History of the Time-Distribution of Meals Research

Study	Method	Participants[ϕ]	Number of Meals	Duration	DVs[φ]	Findings
Fabry et al., 1964	Recruit	440 Adult, OW/NW, M/F	≤3, 3-4, 3-4 + 2 snacks, 3-4 + bedtime snack, ≥5	Recall by interview	BF%, weight	≤3 group sig. higher body fat % than ≥5 $p = 0.05$
Fabry et al., 1966	Manipulation	226 Children/Adol., OW/NW, M/F	3,5,7	1 yr.	kcal Intake, BF%	7 group sig. higher body fat % than 3 group $p = 0.05$
Huenemann, 1972	Recruit	122 Adol., OW/NW, M/F	Continuous	8 7-day records	Kcal intake, BF%	BF% and ml freq sig. corr.; $p = 0.05$
Metzner et al., 1977	Recruit	2000 Adult, OW/NW, M/F	Continuous	24-hr. recall	Adiposity index (AI)	AI and ml freq sig. corr.; $p = 0.05$
Jenkins et al., 1989	Manipulate	7 Adult, OW, M	3 vs. 17	2 weeks	Blood lipids and CHO tolerance	Insulin and C-peptide decreased in 17, but not 3

Kinabo & Durnin, 1990	Manipulation	18 Adult, NW, F	1 vs. 2	1 day	DIT	No sig diff's between groups
Verboeket-van de Venne & Westerterp, 1991	Manipulation	13 Adult, NW, M/F	2 vs. 7	2 days	DIT, RMR, EE	Sig. diurnal pattern for fat oxidation
Tai, Castillo, & Pi-Sunyer, 1991	Manipulation	7 Adult, NW, F	1 vs. 6	3 hr periods over 2 days	RMR	Sig. 0.05
Schlundt et al., 1992	Manipulation	52 Adult, OW, F	2 vs. 3	2-wk periods w/+1 week int.	Wt. loss, BF%, RMR	Sig. 0.06 with intx effects
Verboeket-van de Venne & Westerterp, 1992	Manipulation	14 Adult, OW, F	2 vs. 5	4 weeks	Wt., BF%, SMR, EE, DIT	No sig. diff's btwn groups
Verboeket-van de Venne, Westerterp, & Kester, 1993	Manipulation	10 Adult, OW/NW, M	2 vs. 7	1-wk periods	RMR, EE, DIT	No sig diff's between groups

Iwao et al., 1996	Manipulation	12 Adult, NW, M	2 vs. 6	2 weeks	Wt., BF%, RMR	No sig diff in RMR or wt. BF% decrease greater in 2 ml grp
Keim et al., 1997	Manipulation	10 Adult, OW, F	Large AM mls vs. Large PM mls (4 mls per day)	6 weeks each	Wt. loss, BF%, LBM	AM mls lead to greater wt loss
Taylor & Garrow, 2001	Manipulation	26 Adult, OW, F	2 vs. 6 vs. no brk vs. 2 + vs. 6 +	5 days each	EE, activity, energy intake	No sig. differences, but EE is delayed with 2 mls/day

Note. *"Recruit" indicates that the researchers recruited participants based on self-reported meal patterns. "Manipulation" indicates that the researchers manipulated the participants' meal patterns.* $^{\phi}$ *OW = overweight; NW = normal weight; M = male; F = female.* $^{\varphi}$ *DV= dependent variable, RMR = resting metabolic rate, BF% = body fat percentage, LBM = lean body mass, EE = 24 hour energy expenditure, DIT = Dietary Induced Thermogenesis, SMR = sleeping metabolic rate.*

APPENDIX B: Advertisements

Newspaper General Advertisement

Newspaper Advertisement Targeting Gorgers

USUHS Flyer

METABOLISM STUDY

Nonsmoking, pre-menopausal female volunteers without major medical problems (normal weight and overweight, ages and 18 and older) are sought for a study on eating and metabolism. Participation requires: keeping a 1-week eating diary and 2 visits (a total of 4-6 hours) including a sub-maximal exercise test, assessment of body composition and metabolic rate. Participants will receive $50, a group lecture on eating and weight management, and feedback on their food-intake, body composition, and metabolic rate. For more information please call Teresa Hughes at (301) 295-1498.

Late Day Eaters and Meal Skippers

Women who eat most of their food in the late afternoon and evening, most days of the week are sought for a study on metabolism and eating. Nonsmoking, pre-menopausal female volunteers without major medical problems (normal weight and overweight, ages and 18 and older) are sought for a study on eating and metabolism. Participation requires: keeping a 1-week eating diary and 2 visits (a total of 4-6 hours) including a sub-maximal exercise test, assessment of body composition and metabolic rate. Participants will receive $50, a group lecture on eating and weight management, and feedback on their food-intake, body composition, and metabolic rate. For more information please call Teresa Hughes at (301) 295-1498.

METABOLISM STUDY

Female volunteers are sought for a study on eating and metabolism. We are looking for pre-menopausal normal weight and overweight women ages 18 and older

---

The study requires:

- Keeping a one-week eating diary
- Two visits to the university (a total of 4-6 hours)
- A sub-maximal exercise test (equivalent to walking 2 mph for 10 minutes)
- Assessment of body composition
- Assessment of metabolic rate (energy needs).

Participants will receive $50, a group lecture on eating and weight management, and individualized feedback on their food intake, body composition, and metabolic rate.

Interested individuals please contact
Teresa Hughes at (301) 295-1498.

Metabolism Study
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APPENDIX C: Informed Consent Form

Screening Informed Consent

Study Informed Consent

UNIFORMED SERVICES UNIVERSITY OF THE HEALTH SCIENCES
F.EDWARD HEBERT SCHOOL OF MEDICINE
4301 JONES BRIDGE ROAD
BETHESDA, MARYLAND 20814-4799

Consent for Screening for a Research Study on Metabolism and Eating Patterns

Title of Project: **Understanding the Relationship between Eating Patterns and Caloric Needs**
Principle Investigator: Teresa Hughes, M.S.

You have been sent this packet because you met the initial criteria, based on the phone screen, for participation. **PLEASE CALL** the principal investigator, **Teresa Hughes at (301) 295-1498**, if you have any questions about this form or the study. Please read this form carefully and initial/date at the bottom of each page and sign/date the last page.

To determine if you meet criteria for the remainder of this study, you have been provided several screening questionnaires and a Medical Information Form. If you respond in a manner on the Medical Information Form that suggests that you may have an untreated medical condition or a condition that may put you at higher risk during the exercise test, you may not be eligible to participate.

I. The purpose of this study:

The American population is now more overweight than ever before. Since being overweight increases the risk for a number of health related problems, including high blood pressure, heart disease, and diabetes mellitus, researchers are focusing on the ways in which we can change our behaviors to achieve and maintain a normal weight. Metabolic rate, the rate at which the body converts food into energy, is known to affect our weights and to be affected by our behaviors. There are some factors of metabolic rate that we cannot change, such as our gender, age, and genetics. But, there are other factors that affect metabolic rate that we can change, such as our eating patterns, our muscle mass, and how much we exercise.

We are also interested in some types of eating patterns. Some people will not qualify because they do not have one of the eating patterns that we are interested in. If you have an eating pattern that you find troublesome and you would like help changing, we will provide you a list of places where you can get help.

Similarly, we are also interested in some attitudes and moods and how they impact eating patterns. Some people may be excluded because they report certain symptoms or distress that may interfere with their ability to participate in this study. If you report symptoms of distress that are determined to be at a clinical level and that you would like help with, whether or not you qualify for the study, we will provide you a list of places where you can get help. You will be notified whether or not you meet the criteria for the second part of the study.

After you return this packet, you will be notified whether or not you meet the criteria for the second part of this study.

II. The purpose of this screening packet:

The purpose of this screening packet is to ensure that individuals interested in this study meet certain medical criteria and to assess eating patterns. In this packet, you will find a Medical Information Form and two questionnaires (the EDE-Q and the BDI-II). Please answer all of the questions to the best of your ability. For the EDE-Q, choose the answers that apply to you MOST OFTEN in the last month. For the BDI-II, please choose the answers that apply to you most often in the last 2 weeks. There are no right or wrong answers to any of the questions. When you have finished all of these forms, please mail them back to us in the provided self-addressed envelope. You may also fax the EDE-Q and BDI-II to (301) 295-3034.

When we receive these completed forms from you, the Medical Information Form and the scores on the EDE-Q and BDI-II will be reviewed to determine if you are eligible to participate in the second part of the study on metabolism and eating patterns. After completing these forms, some individuals will be eligible to participate. These individuals will be invited to participate in the second part of the study on metabolism and healthy eating patterns. You will be notified whether or not you are eligible to participate in the second part of the study after we receive these forms.

Inclusion/Exclusion Criteria:

We are interested in non-smoking, pre-menopausal, adult women for this study. You will be asked to continue to participate if you meet these criteria and do not report high levels of depression or symptoms that may meet criteria for an eating disorder.

Those individuals who report high levels of depression that could impact their eating patterns or metabolism will be excluded from participation. Some people with untreated depression eat much more or much less than they normally would. If you report symptoms of depression or distress that are determined to be at a level higher than is allowed for this study, you will be asked if you are interested in seeking treatment for these symptoms. If you are interested in seeking treatment for these symptoms, whether or not you qualify for the study, we will provide you a list of local places where you can get help.

Those individuals who meet criteria for some eating disorders (such as anorexia or bulimia) will also be excluded from participation. Some eating disorders may impact eating patterns and metabolism in a manner differently from what we are investigating in this study. If you meet criteria for an eating disorder or you find your eating pattern troublesome and you would like help, we will provide you a list of local places where you can get help.

Finally, those individual who respond in a manner on the Medical Information Form that suggests that they may have an untreated medical condition or a condition that may put them at higher risk during the exercise test may not be eligible to participate. If you respond in such a manner, we will inform you as to why we think you were not eligible to participate.

Brief Summary of the Second Part of the Study:

Subject Initials__________Date_______

The second part of this study will consist of three essential elements: a group orientation, an individual visit (body and health assessments), and daily food and exercise monitoring for one week. These three elements will be discussed further with eligible participants during the orientation session, but a summary is provided for you.

Summary of the Study

Event	Time
Visit 1: Group Orientation 1. Study Informed Consent Form 2. Measure stride length 3. Begin 1-week food and activity diaries 4. (Each participant will be called within 1 day to ask if they have any questions about the diaries). 5. Schedule appointments for remaining two visits. 6. (Return computers after 1 week.)	1- 1 _ hours
Visit 2: Individual Lab Meeting 1. Resting metabolic rate/body composition (60 min.) 2. Thermic effect of exercise (15 min.) 3. EDI-2 (20 min.) 4. Standardized meal (10 min.) 5. EI (20 min.) 6. Dietary Induced Thermogenesis assessment (20 min.)	2_ - 3 hrs
Receive payment through mail.	
Optional Lecture	(1_ HOURS)
Total Time:	4 hrs 20 min.- 5 hrs 40 min.

Eligible participants who complete all phases of the study will be paid $50 for their participation and be given individualized feedback on their metabolism, eating patterns, and physical activity. There is no payment for only completing this packet. All volunteers, including those who are not eligible for participation, will be invited to attend an optional and free seminar on metabolism and healthy eating patterns.

TO PERSONS WHO AGREE TO THE SCREENING FOR PARTICIPATION IN THIS STUDY:

It is important that you understand that your participation in this study is totally voluntary. **You may refuse to participate or choose to withdraw from this study at any time. However, you must complete this screening packet to be considered for participation in the second part of the study.**

Subject Initials___________Date________

If, during the course of the study you should have any questions about the study, your participation in it, or about your rights as a research volunteer, you may contact:

Teresa Hughes, M.S. at 301-295-1498
Department of Medical & Clinical Psychology, USUHS, Bethesda, MD 20814-4799
Or
Tracy Sbrocco, Ph.D., at 301-295-9674
Department of Medical & Clinical Psychology, USUHS, Bethesda, MD 20814-4799

Note: YOU ARE FREE TO WITHDRAW THE CONSENT AND TO STOP PARTICIPATING IN THIS STUDY OR ANY ACTIVITY AT ANY TIME FOR ANY REASON.

STATEMENT BY PERSON AGREEING TO PARTICIPATE IN THIS RESEARCH PROJECT:

I have read this consent form and I understand the procedures to be used in this screen procedure and the possible risks, inconveniences, and/or discomforts that may be involved. All of my questions have been answered. I freely and voluntarily choose to participate. I understand that I may withdraw at any time. My signature also indicates that I have received a copy of this consent form for my information.

SIGNATURES:

____
Signature of Witness

____
Witness Name (Printed)

Date ___________

I certify that I, or my research staff, have explained the research study to the above individual, and that the individual understands the nature and purpose, the possible risks and benefits associated in taking part in this research study. Any questions that have been raised have been answered.

_________________________________ _____________________________ ______
Investigator's or Designee's Signature **Printed Name** **Date**

UNIFORMED SERVICES UNIVERSITY OF THE HEALTH SCIENCES
F.EDWARD HEBERT SCHOOL OF MEDICINE
4301 JONES BRIDGE ROAD
BETHESDA, MARYLAND 20814-4799

Consent for Participation in a Research Study

Title of Project: **Understanding the Relationship between Eating Patterns and Caloric Needs**
Principle Investigator: Teresa Hughes, M.S.

TO PERSONS WHO AGREE TO PARTICIPATE IN THIS STUDY:

The following information is provided to inform you about the research project and your participation in it. Please read this form carefully and feel free to ask any questions you may have about this study and/or about the information given below.

It is important that you understand that your participation in this study is totally voluntary. **You may refuse to participate or choose to withdraw from this study at any time.**

If, during the course of the study you should have any questions about the study, your participation in it, or about your rights as a research volunteer, you may contact one of the following:

Teresa Hughes, M.S. at 301-295-1498
Department of Medical & Clinical Psychology, USUHS, Bethesda, MD 20814-4799

Tracy Sbrocco, Ph.D. at 301-295-9674
Department of Medical & Clinical Psychology, USUHS, Bethesda, MD 20814-4799

Office of Research at (301) 295-3303
USUHS, Bethesda, Maryland 20814

1. INDICATED BELOW ARE THE FOLLOWING:

- **a. THE PURPOSE OF THIS STUDY**
- **b. THE PROCEDURES TO BE FOLLOWED**
- **c. THE APPROXIMATE DURATION OF THE STUDY**

1a. THE PURPOSE OF THIS STUDY:
The American population is now more overweight than ever before. Since being overweight increases the risk for a number of health related problems including high blood pressure, heart disease, and diabetes mellitus, researchers are focusing on the ways in which we can change our behaviors to achieve and maintain a normal weight. Metabolic rate, the rate at which our bodies convert food into energy, is known to affect

individuals' weights and to be affected by our behaviors. There are some factors that affect metabolic rate that we cannot change, such as gender, age, and genetics. But, there are other factors that impact metabolic rate that we can change, such as our muscle mass, how much we exercise, and our eating patterns. Although our eating patterns have been shown to be important in influencing our metabolic rate, not enough is known about this. The purpose of this study is to compare how two different eating styles affect metabolic rate. You will be asked to monitor your eating for one week. The information from the food diaries will be used to assess your eating style. The metabolic rate, daily physical activity, body fat, and caloric intake will be measured and compared between the eating styles.

1b. THE PROCEDURES TO BE FOLLOWED:

Please see the summary of the study below. Each of the sections will be discussed further in the next sections.

Event	Time
Visit 1: Group Orientation (Tonight) 1. Study Informed Consent Form 2. Measure stride length 3. Begin 1-week food and activity diaries 4. You will be called within 1 day to ask if you have any questions about the diaries. 5. Schedule appointments for remaining two visits. 6. Return computers after 1 week	1- 1 _ hours
Visit 2: Individual Lab Visit 1. Resting metabolic rate/body composition (60 min.) 2. Thermic effect of exercise (15 min.) 3. EDI-2 (20 min.) 4. Standardized meal (5 min.) 5. EI (20 min.) 6. Dietary Induced Thermogenesis assessment (20 min.)	2_ - 3 hrs
Receive payment by mail	10 minutes
Optional Lecture (1_ HOURS)	
Total Time:	4 hrs 20 min.- 5 hrs 40 min.

Visit 1: Group Orientation – Initial Information Collection

At this first visit, you will be asked to fill out a questionnaire that will provide us information on your background, including your ethnicity, marital status, and income. This information is important so that we can further understand some factors that influence eating pattern and metabolic rate. You will also be instructed on keeping the eating diary, the activity diary, and using the pedometer. You will be asked to keep these diaries and wear the pedometer on your hip for one week. Each day, you will be asked to record the number of steps you have taken (both walking and running). Please use the form provided for your activity diary. In addition, we will ask you to schedule an individual laboratory appointment for the assessment of your metabolism and your body composition. To qualify for payment for participation in this study, you must return the computer with one week of accurate eating and exercise diary entries, complete the individual visit, and complete the questionnaires. When you have completed your 1-week eating and exercise diaries, we ask that you either mail in the computer and form or bring them into the school to Room B1022a. A self-addressed envelope will be provided.

Visit 2: Individual Visit: Assessment of Metabolism and Body Composition
The assessments of your metabolism and body composition will take place during one morning visit that will take approximately 3 – 3 _ hours. **You will need to schedule this appointment at least one week from today and so that it falls between the 5th and 9th day after the start of your next period.** To prepare for the lab visit, please read through and strictly follow the “Reminder Sheet for Individual Visit” that you received tonight. It is important that you fast the night before the individual lab visit by eating no later than 9:00 p.m. If you have been told that you need your physician’s consent, you must have the Physician’s Consent Form signed before you can participate in this portion of the study.

1. Resting Caloric Needs: In order to measure your caloric needs while at rest, we need you to be as close to “at rest” as you can be. You will be asked to lie still with a facemask (that covers your nose and mouth) in place for about 20 minutes to let your body get into a resting state and to let you adjust to the feel of the mask. After the 20 minutes has passed, the actual measurements will begin. This part will last for about another 30 minutes. The computer attached to the mask will calculate your resting metabolic rate telling us your caloric needs when you are at rest.

2. Body Fat Assessment: This test allows us to calculate how much body fat and muscle you have. While you are lying still during the first part of the resting metabolic rate assessment, an electrode (similar to the electrodes placed on the chest of someone having their heart monitored) will be attached to your foot and your hand. A quick, painless measurement is taken. You will not feel the measurement and it is in no way harmful to you.

3. Exercise Calorie Needs: This test involves riding a stationary bicycle for about 12 minutes with the facemask in place. The purpose of this test is to measure your caloric needs when you are moving around. The workload (how much tension is on the pedals) requires the same amount of energy as if you were walking at a pace of about 2 mph. You will pedal for 2 minutes to get used to the feel of the bicycle. Then, the testing will begin. This requires you to pedal for 10 minutes with a very light workload. You should not feel any more tired than if you walked on flat ground for 10 minutes walking at a pace of about 2 mph. The risks for this exercise test are minimal. As with any exercise, there is a very small chance that you could feel dizzy or have a heart attack. A physician will be on-call during the testing should there be any emergencies.

4. Questionnaires: After you have completed the bicycle test, you will be given 20 minutes to cool down. During this 20 minute cool down, you will be asked to fill out a questionnaire on your views of food and eating.

5. The Effect of Food on Calorie Needs: After 20 minutes, you will be asked to drink 8 ounces of Ensure Plus in 5 minutes. Ensure Plus is a nutritional supplement that comes in a variety of flavors (vanilla, chocolate, and cappuccino and is lactose and gluten-free. After you have finished drinking the Ensure Plus, you will be asked to complete another questionnaire that will take about 20 minutes. This questionnaire will ask you more questions on your views of food and eating. Then, you will be asked to lie still for about another 20 minutes with the facemask in place while the air you breathe in and out is measured. The purpose of this test is to measure how many calories you burn while digesting food. This measure will conclude the visit.

Payment

When you have completed the individual visit, completed the self-report questionnaires, and turned in a complete diary, you will be mailed $50 for your participation. You will also receive information on your caloric needs and your eating behaviors. Finally, you will be invited to attend an optional and free seminar on metabolism and healthy eating patterns.

1c. DURATION OF THE STUDY

The study will last approximately one to five weeks, depending on your menstrual cycle (period) and the scheduling of the individual visit.

2. THIS STUDY IS BEING DONE SOLELY FOR THE PURPOSES OF RESEARCH.

3. DISCOMFORTS, INCONVENIENCES AND/OR RISKS THAT CAN BE REASONABLY EXPECTED ARE:

a. The risks associated with this study are minimal. You may find the interviews and the questionnaires or the exercise uncomfortable. There is only minimal risk associated with the exercise test. As with any exercise, there is a very small chance that you could feel dizzy or have a heart attack. This test requires that you ride a stationary bike at a workload similar to walking about 2 mph. If, however, there is an emergency during the exercise test, a physician from the Department of Family Medicine will be on-call in case of emergency.

4. POSSIBLE BENEFITS TO YOU THAT MAY BE REASONABLY EXPECTED ARE:

You may gain a better understanding of your eating behavior, your energy needs, and your body composition. You may also find the exercise and body composition assessments help you to better understand and manage your weight. The testing is conducted at no charge. You will be paid $50 for your participation and be invited to attend a free seminar on metabolism and healthy eating patterns.

5. THE BENEFITS TO SCIENCE AND TO HUMANKIND THAT ARE SOUGHT IN THIS STUDY ARE:

You will be providing information that may be helpful in expanding scientific knowledge about eating behavior and metabolism. The results of this study may help us gain a better understanding of the impact of eating patterns on the energy needs of overweight and normal weight women.

6. ALTERNATIVE AVAILABLE PROCEDURES:

There are only a limited number of commercial alternatives for assessing your metabolic rate. Other commercial methods for assessing your eating patterns and your daily activity include visiting licensed nutritionists. The information collected in this program is a comprehensive assessment offered at no cost to you.

7. CONFIDENTIALITY: YOUR RIGHTS, WELFARE, AND PRIVACY WILL BE PROTECTED IN THE FOLLOWING MANNER:

Only properly authorized persons such as those directly concerned with the study such as the principal investigator and her assistants, Regulatory Authorities, and persons on the Institutional Review Board will be allowed access to your records. Any information will be treated as strictly confidential in accordance with applicable laws and regulations, and will not be made publicly available. By signing the consent form attached, you are authorizing such access to your records. All information collected during the study will be held in the strictest confidentiality. If information is published, your identity will not be revealed, you will be referred to only by a number. Personal information may be revealed during the group sessions. All group members will be informed that group members' names and any personal information discussed in the group session is confidential and should not be discussed outside of the group.

Note: YOU ARE FREE TO WITHDRAW THE CONSENT AND TO STOP PARTICIPATING IN THIS STUDY OR ANY ACTIVITY AT ANY TIME FOR ANY REASON.

Subject Initials__________Date_______

8. RECOURSE IN THE EVENT OF INJURY:

In the event of a medical emergency while participating in this study, you will receive emergency treatment in the facility you are in or a nearby Department of Defense (military) medical facility (hospital or clinic). Emergency treatment/care will be provided even if you are not eligible to receive such care at a military medical facility. Care will be continued until the medical doctor treating you decides that you are out of immediate danger. If you are not entitled to care in a military facility, you may be transferred to a private civilian hospital. The attending doctor or member of the hospital staff will go over the transfer decision with your before it happens. The military will bill your health insurance for health care you receive which is not part of this study. If you are uninsured, you will not be personally billed for such care, and you WILL NOT be expected to pay for medical care at military hospitals.

In case you need additional care following discharge from the military hospital or clinic, a military health care professional will decide whether your need for care is directly related to being in this study. If your need for care is related to the study, the military may offer you limited health care at its medical facilities.

If you believe the government or one of the government's employees (such as a military doctor) has injured you, a claim for damages (money) against the federal government (including the military) may be filed under the Federal Tort Claims Act. If you would like to file a claim, please contact the University's Office of General Counsel and request the filing forms.

If at any time you believe that you have suffered an injury or illness as a result of participating in this research project, you should contact the Office of Research at the Uniformed Services University of the Health Sciences, Bethesda, Maryland 20814 at (301) 295-3303. This office can review the matter with you, provide information about your rights as a subject, and may be able to identify resources available to you. Information about judicial avenues of compensation is available from the University's General Counsel at (301) 295-3028.

Should you have any questions at any time about the study or about your rights, you may contact the principal investigator, **Teresa Hughes, M.S., 1Lt., USAF, Department of Medical & Clinical Psychology, USUHS, Bethesda, MD 20814-4799, at 301-295-1498.**

Subject Initials__________Date_______

STATEMENT BY PERSON AGREEING TO PARTICIPATE IN THIS RESEARCH PROJECT:

I have read this consent form and I understand the procedures to be used in this study and the possible risks, inconveniences, and/or discomforts that may be involved. All of my questions have been answered. I freely and voluntarily choose to participate. I understand that I may withdraw at any time. My signature also indicates that I have received a copy of this consent form for my information.

SIGNATURES:

______________________________	______________________________
Signature of Volunteer	**Signature of Witness**
______________________________	______________________________
Volunteer Name (Printed)	**Witness Name (Printed)**
Date ___________	**Date____________**

I certify that I, or my research staff, have explained the research study to the above individual, and that the individual understands the nature and purpose, the possible risks and benefits associated in taking part in this research study. Any questions that have been raised have been answered.

______________________________	__________________________	______
Investigator's or Designee's Signature	**Printed Name**	**Date**

APPENDIX D: Participant Classification

Figure A. Flowchart for Step 1 of participant classification

Figure B. Flowchart for Step 2 of participant classification: EDE-Q.

Figure C. Flowchart for Step 3 of Participant Classification: Food diaries

Figure A. Flowchart for step 1 of participant classification

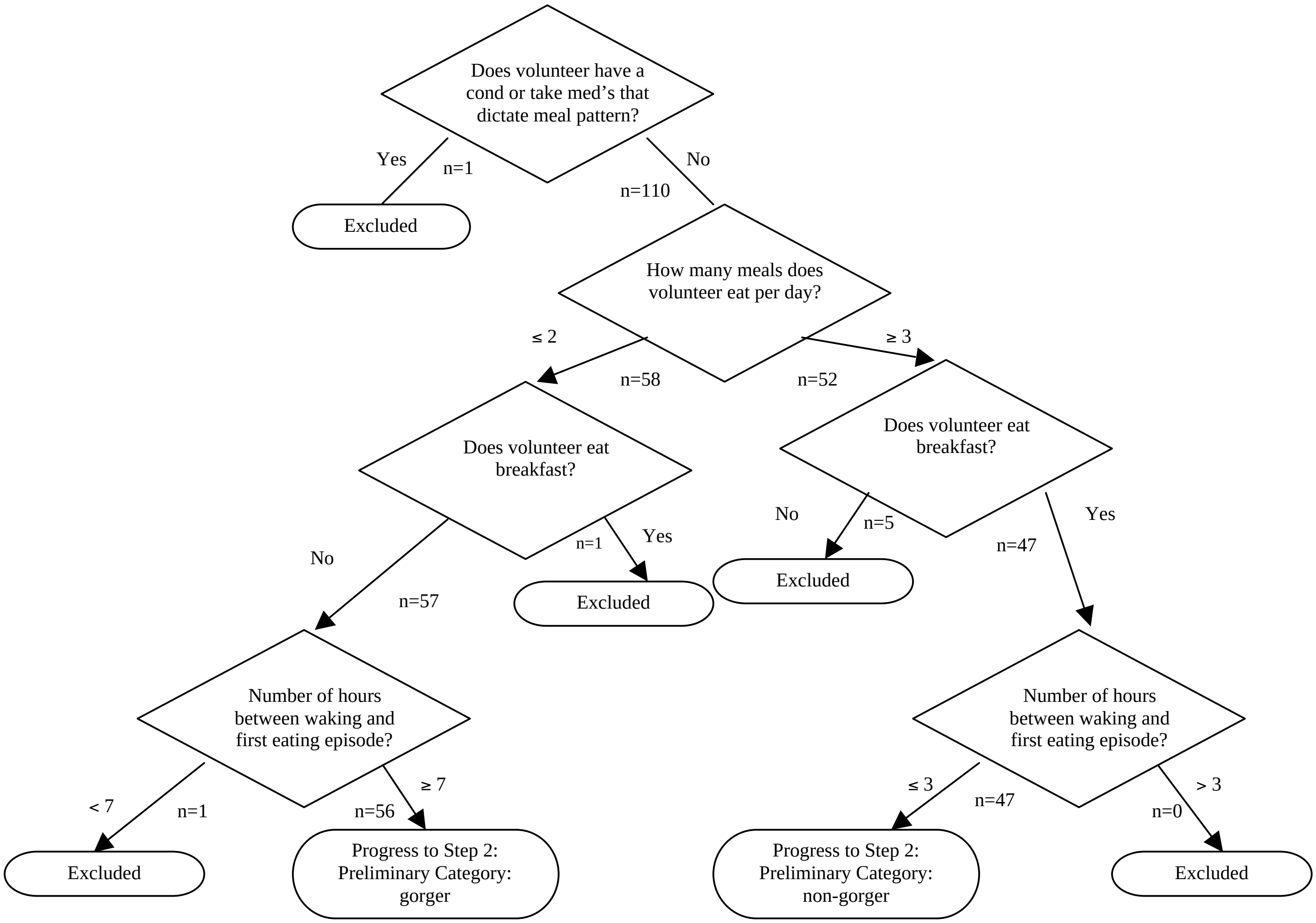


Figure B. Flowchart for Step 2 of Participant Classification: EDE-Q.

Preliminary Categories:

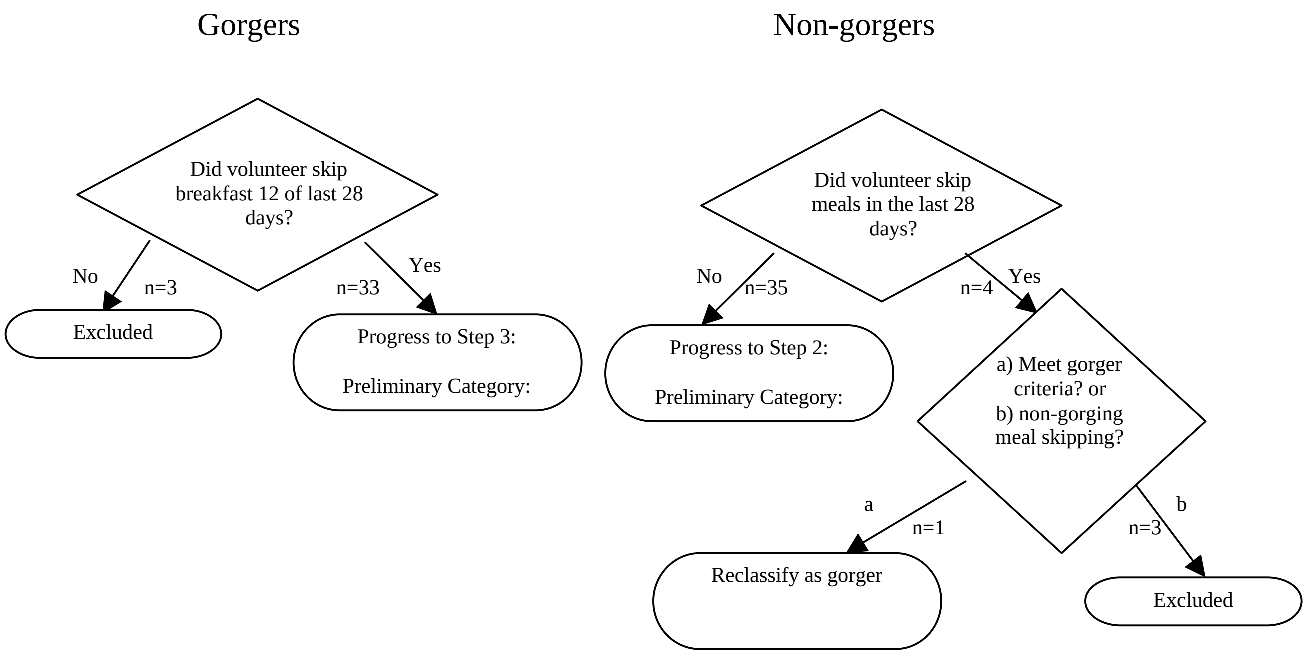
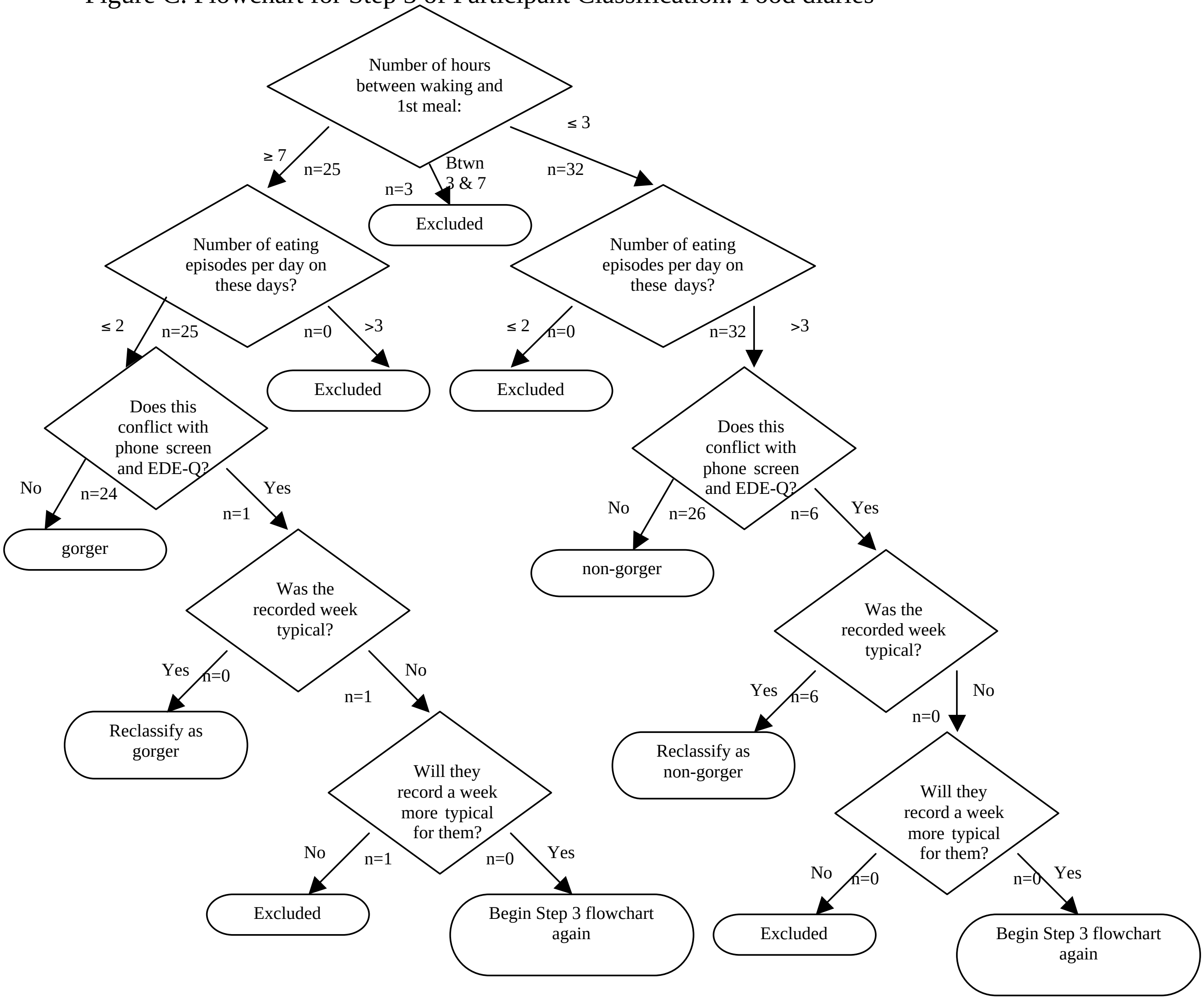


Figure C. Flowchart for Step 3 of Participant Classification: Food diaries



APPENDIX E: Demographics Form

Payment Information Form
Sample Demographics Form

PAYMENT INFORMATION FORM

Name ____

Address ____

City ____________________ State ________ Zip Code ________

Home phone ____________________ Work Phone ____________________

E-mail ____________________ Alt. Phone ____________________

Social Security Number (required for payment): __________-______-__________

DEMOGRAPHICS

SUBJECT CODE:____________ **DATE:___________**

Date of Birth ___________________________ Age ___________________________

Height ___________________________ Weight ___________________________

Ethnicity:
Please check one or more.

_______ Caucasian
_______ African
_______ Hispanic or Latino
_______ American Indian
_______ Other _________________
_______ Black or African American, Non-Hispanic
_______ West Indian or Caribbean
_______ Asian
_______ Native Hawaiian or other Pacific Islander
_______ Alaskan Native

Marital Status:
Please check one.

_______ Single, Never Married
_______ Married
_______ Divorced
______ Separated
______ Widowed
______ Living Together

Education:

Highest degree earned ______________

Please circle highest grade completed:

1 2 3 4 5 6 7 8 9 10 11 12 | 13 14 15 16 | 17 18 19 20 21 22

Please check one.

_______ Some high school
_______ Competed high school/GED
_______ Some College
______ Completed College
______ Partial Graduate/Professional school
______ Completed Graduate school/Professional school

Occupation: ______________________

Employment Status:
Please check one.

_______	Retired	______	Homemaker
_______	Full-time	______	Disabled
_______	Part-time	______	Unemployed

Annual Household Income:
Please check next to the amount that most closely indicates your total yearly household income.

_______	Below $20,000	______	$40,000-$50,000
_______	$20,000-$30,000	______	$50,000-$60,000
_______	$30,000-$40, 000	______	$60,000-$70,000
		______	Above $70,000

For Office Use Only:

Palm #: _________
Pattern Group: G NG **Weight Group: NW OB**

APPENDIX F: Medical Information Form

Cover Letter to Primary Care Physicians
Sample Medical Information Form

MEDICAL INFORMATION FORM

Subject ID: ____________

A. Medical History:

1. Do you receive regular medical care from a physician or clinic? ☐ No ☐ Yes

If yes, please provide the following information:

Name of physician or clinic _______________________ phone: _____________

2. Have you ever had to be hospitalized? ☐ No ☐ Yes

Year Reason

____

____

3. Have you ever had surgery, or been advised to have surgery? ☐ No ☐ Yes

Year Reason

____

____

4. Have you ever been told you have any of the following medical conditions?

	NO	YES	When/Explain	If yes, are you currently being treated or followed for these problems?
Heart Disease				
High Blood Pressure				
Diabetes or High Blood Sugar				
Cancer				
Thyroid Disease				
Other Hormone Problem				
Alcoholism				
High Cholesterol				
Gall Bladder Problems				
Digestive Disease				
Kidney Disease				
Peptic Ulcers (Stomach Ulcers)				
Colitis				
Meningitis or Encephalitis				
Tuberculosis				
Stroke				
Rheumatic Fever				
Asthma				

Birth Defects				
Gout				

5. Have you had any other disease? No Yes
If yes, explain:____
____

6. What is your current weight? ______________ lbs. __ estimate __ actual
7. What is the most you have ever weighed? ______________lbs. When? ______________
8. Have you recently lost or gained any weight? No Yes
Can you explain any recent weight loss or gain?_____________________________
____

Weight gained last month __________ Weight lost last month _________
Weight gained last 6 months __________ Weight lost last 6 months _________
Weight gained last year __________ Weight lost last year _________

9. Have you recently had any of the following tests?

	NO	YES	What were the diagnoses?
Physical Exam			
Blood Tests			
Chest X-ray			
Electrocardiogram (EKG)			
Brain Scan or EMI			
EEG			

10. Are you in the habit of using any of the following?

	Amount Currently Using	Most Ever Used	When Stopped Using
Coffee (cups/day)			
Cigarettes (Packs/day)			
Alcohol			
Vitamins			
Sleeping Pills			
Aspirin			
Laxatives			
Diet Pills			

11. Are you currently on any medication (including oral contraceptives)? ☐ No ☐ Yes
If yes, explain:____

B. Personal Psychiatric History

1. Have you ever received any previous psychiatric or psychological evaluation or treatment?
☐ No ☐ Yes If yes, complete the following:

Year	Reason	Medication Used

2. Have you ever attempted suicide in the past? ☐ No ☐ Yes If yes, complete the following:

Year	How did you attempt suicide?	What happened?

C. Review of Your Current Health:

1. Do you have any of the following?

	NO	Yes		NO	Yes
Fainting spells, blackout spells			Unusual excessive thirst		
Convulsion			Urine problems, blood in urine		
Paralysis			Indigestion, gas, heartburn		
Thyroid problem, goiter			Stomach pain or stomach ulcer		
Dizziness			Diarrhea		
Headaches			Constipation		
Cough or wheeze			Vomiting, vomiting blood		
Chest pain			Blood in stool		
Spitting up blood			Change in appetite or eating habits		
Shortness of breath at night or with exercise			Trouble sleeping		
Palpitation or heart fluttering			Weight loss or weight gain		
Problems with memory, thinking, concentration			Depression		
Suicidal thoughts			Dizziness		
Weakness or tiredness			Joint pain		

Please describe or explain any of the positive answers above
____
____
____

Date your last menstrual period began: ________
Do you use any contraceptive method? ☐ No ☐ Yes If yes, what?____________

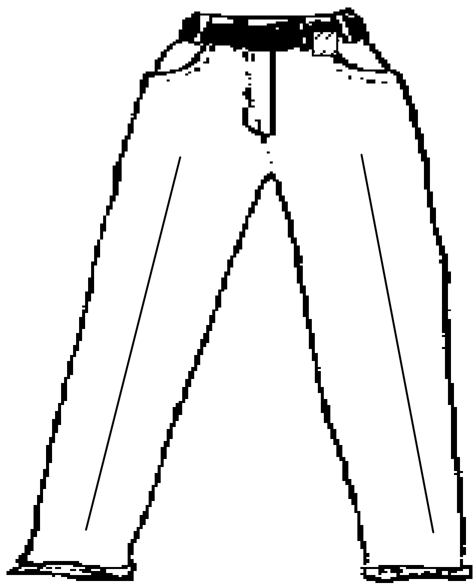
Patient's Signature ________________________________ **Date**: _______________

APPENDIX G: Exercise Monitoring Form

Directions for use of Pedometer and Monitoring Form
Sample Exercise Monitoring Form

Directions for Using Pedometer and Monitoring Form

Wearing your pedometer. Your pedometer must be worn so that it is in line with the "crease" of your pants. If you are wearing a skirt or a dress, estimate this point. If you draw an imaginary line from the midway point between your belly button and hipbone to the middle of the top of your foot, this is a good estimate of the crease line.



You should wear your pedometer from the time you wake up until the time you go to sleep. Do not wear your pedometer into the shower, bathtub, hot tub, spa, or pool or any place where it could get wet. Remember to start your pedometer each morning and stop it at night.

Operating your pedometer. Properly attach your pedometer to your clothing with the clip. Press the reset button to erase any steps from the previous day. Press the "start/stop" button. The cartoon person in the screen should start running. At the end of the day, press the "start/stop" to stop the pedometer. Record your daily activity.

Recording your daily activity. Each day, record the number of steps displayed on your pedometer. Press the mode button until the pedometer displays the miles you have walked. Record this number in the appropriate space on your recording sheet.

What to do if you jog or run… If you jog or run, you must record this separately. Before you start running or jogging, record the number of steps and the miles that you have walked up to that point in the day. When you are ready to start jogging or running reset the pedometer and change the mode to "run." When you finish jogging or running, record the number of steps and the miles jogged. Then reset the pedometer and change the mode back to "walk."

What if you participate in a different form of exercise? If you participate in an activity that prohibits the wear of the pedometer, such as swimming, please record how far and long you swam or participated in the activity in the column marked for jogging.

Code: ________

EXERCISE MONITORING FORM

			Daily Activity				OFFICE USE ONLY	
			Walking		Running			
Day	Date	Time	Steps	Miles	Steps	Miles	Calories	Fat
Mon								
Mon								
Tues								
Tues								
Wed								
Wed								
Thurs								
Thurs								
Fri								
Fri								
Sat								
Sat								
Sun								
Sun								

For Office Use Only:

Palm #: _________

Pattern Group: G NG **Weight Group: NW OB**

Sample Compliance Checklist for Body and Health Assessment Visit
Reminder Checklist for Participants

Checklist for Body and Health Assessments

Participant ID #: _____ Interviewer: ____________ Date: _______ Time: _______

1. On what day did you start your most recent period ______________.
2. Is today 5 to 7 days after this date? ☐ Yes ☐ No
3. Are you wearing comfortable exercise clothing? ☐ Yes ☐ No
4. Does your bra have underwire in it? ☐ Yes ☐ No
5. Are you wearing jewelry? ☐ Yes ☐ No
   If yes, ask to remove
6. Are you wearing nylons? ☐ Yes ☐ No
   If yes, ask to remove
7. Have you had 64 ounces of **water** in the last 24 hours? ☐ Yes ☐ No
8. When was the last time you exercised? ____________
   Is this at least 12 hours from right now? ☐ Yes ☐ No
9. When was the last time you ate? ____________
   Is this after 9:00 p.m. ☐ Yes ☐ No
10. When was the last time you had caffeine? ____________
    Is this at least 12 hours from right now? ☐ Yes ☐ No

Reminder Sheet for Individual Visit:
Body and Health Assessment

DO:

- ✓ Schedule your visit for 5 to 7 days after the start of your next period
  - o What day will you start your next period? _______________.
- ✓ Wear comfortable exercise clothing
- ✓ Wear jewelry that can be removed easily
- ✓ Try to avoid wearing nylons
- ✓ Drink at least 64 ounces of **water** the day before the assessment

DO NOT:

- ✓ Do not wear clothing with metal in it, such as an underwire bra
- ✓ Do not exercise 12 hours before you arrive for the assessment
- ✓ Do not eat after 9:00 p.m. the night before the lab visit
- ✓ Do not drink caffeine (coffee, tea, or soda) for 12 hours before you arrive for the assessment

*****Your appointment will probably be at 7:00 a.m., so 12 hours before is 7:00 p.m.*****

APPENDIX I: Phone Screen

Script for Phone Screen
Phone Screen

Script for Phone Screen

"Hello, my name is ________________. I am calling you back regarding the eating patterns study. Do you have a few minutes to talk right now?"

If no: "When can I call you back?"

If yes: *go on.*

"I'd like to tell you a few things about the study first and then I'll be glad to answer any questions that you might have, OK? This study is designed to compare three different eating patterns on caloric needs. Your caloric needs are determined by your metabolism, or metabolic rate. Your metabolic rate is the rate at which your body converts food into energy. We are interested in understanding how different eating patterns affect metabolic rate.

If you are eligible and agree to participate, you will be assigned to an eating pattern group based on your reported and recorded eating patterns. The members of both groups will be asked to complete the same questionnaires and body and health assessments. We will meet three times. The first meeting is a group meeting and you will need to be available on _____________ in order to be eligible to participate. During this meeting, you will schedule two additional visits. The first visit will take approximately 3 to 3 _ hours and begin at 7:00 a.m. During this visit, we will be calculating your caloric needs from the air that you breathe. In order to do this, we will have you wear a facemask that covers your nose and mouth and is connected to a computer with a tube. We will ask you to wear this mask for nearly 3 hours during which time you will spend most of it lying still. For 10 minutes, you will be asked to ride a stationary bicycle with a very light workload that is similar to walking. You will also be asked to drink 8 fluid ounces of Ensure Plus, which is lactose and gluten-free, low-cholesterol, and kosher. Finally, you will also be asked some questions about your eating habits and be asked to fill out some questionnaires. The second visit will be very short, just long enough to drop off your computer and set up payment.

We are located at the Uniformed Services University, which is near the National Naval Medical Center and across the street from NIH in Bethesda, Maryland. The study is being run by a senior graduate student who has a Master's Degree in Clinical Psychology and has had 3_ years of experience in working with individuals with a variety of eating patterns.

You may need to get your physician's permission to participate in the program if you indicate that you have a condition that could put you at higher risk for injury during the exercise assessment (such as dizziness). You will be asked to complete some questionnaires and monitor your food intake and exercise for one week. You will also be asked to complete all of the body and health assessments. If you complete all of this, you will be paid $50 and be eligible to attend a lecture on metabolism and healthy eating patterns. A pedometer is a device about the size and shape of a pager. It is worn on the clothing near your hip. It counts your steps and can tell you how far you've walked in a day. You may find this useful if you are interested in tracking your walking activity.

You do not have to attend the lecture and you may attend even if you do not qualify for the study. The lecture will be scheduled for the spring of 2002. Since we need all of the information requested in order to use your data, you will have to complete all parts of the study before you will be paid.

Does this sound like something you would be interested in?"

If no: "Thank you for your interest."

If yes: "Do you have any questions about the study?

Ok, now I will need to ask you some questions to see if you meet criteria for this study."

COMPLETE PHONE SCREEN.

If the caller does not meet requirements: "I am sorry, but you do not meet the requirements for this study. This doesn't mean that there is something wrong with you, it simply means that we are looking at very specific things. It is very important for research purposes that our groups look as similar to each other as possible.

Thank you for you interest."

If caller meets requirement: "Do you have any questions?"

"We will be sending you a packet including a consent form, the Medical Information Form, and two questionnaires. Would you prefer these to be e-mailed, faxed, or mailed to you?"
Circle answer on Phone Screen.

"When you receive this packet, please call this number again so that we may review the informed consent form with you. If you agree to continue the screening process, please initial and date the bottom of each page of the Informed Consent Form and sign and date the last page. Please also complete the two questionnaires labeled EDE-Q and BDI-II and the Medical Information Form. You must have your physician sign the last page of the Medical Information Form. You can return the questionnaires by e-mail, mail, or fax, but the Informed Consent Form and the Physician's Consent Form MUST be mailed in or brought in, they cannot be e-mailed in or faxed in. The questionnaires and medical information form will be reviewed and someone will call you to let you know if you are still eligible. If you are still eligible, you will be invited to the group orientation meeting."

Eligibility Contact:

If the caller does not meet requirements: "I am sorry, but you do not meet the requirements for this study. This doesn't mean that there is something wrong with you, it simply means that we are looking at very specific things. It is very important for research purposes that our groups look as similar to each other as possible. Would you be interested in attending a free seminar on metabolism and healthy eating patterns?"

If yes. "The seminar will be held in a lecture room on the first floor of the Building A at the USUHS at 5:30 – 7:00 pm. The room will be clearly marked. You can park in the school's underground parking garage for free."

If no. Again, thank you for you interest.

If the caller meet requirements: "I am pleased to inform you that you meet the requirements for this study. We will need you to come in for the group orientation meeting on _________. The orientation will be held on the first floor of the Building A at the USUHS from 5:30 to 7:00 pm. The room will be clearly marked. You can park in the school's underground parking garage for free. At this meeting you will schedule the remaining visit. Due to heightened security, you must bring a picture ID with you in order to get on base. Thank you in advance for your participation."

PHONE SCREEN

Interviewer: ____________________________ Date:____________

1. Are you in the military? YES NO
2. How did you hear about the study? ___________________________________
3. Age________ 4. Sex ____________
5. Height__________ inches 6. Weight_____________ pounds

7. Are you going through menopause (perimenopausal)?	YES	NO
If yes, do you still have regular periods?	YES	NO
8. Are you postmenopausal (stopped having periods)?	YES	NO
If yes, volunteer is not eligible.		
9. Have you lost more than 10 pounds in the past month?	YES	NO
10. Have you lost more than 25 pounds in the past 6 months?	YES	NO
11. Do you smoke?	YES	NO
12. Do you drink alcohol?	YES	NO
If yes, how much, how often? ____		
13. Do you drink caffeinated beverages (coffee, soda)?	YES	NO
14. Do you use any illegal drugs?	YES	NO

15. Have you been told by a physician that you had:

A. Hypertension	YES	NO
B. Heart Disease/Problems	YES	NO
C. High Blood Sugar/Diabetes	YES	NO
D. Thyroid Disease	YES	NO
E. Kidney Disease	YES	NO
F. Major Medical Problems	YES	NO

16. Have you been told by a psychiatrist or psychologist that you have or had:

A. Depression	YES	NO
B. Eating Disorder	YES	NO
C. Anxiety Disorder	YES	NO
D. Schizophrenia	YES	NO
E. Bipolar Disorder	YES	NO
F. Major Psychological/Psychiatric Problem	YES	NO
If yes, what was the diagnosis? ___________________________________		
G. Have you sought treatment for any of these problems?	YES	NO
If yes, when?		

____

If yes to D, E, or F, exclude from study

If yes to A, B, or C:

Have you been told that this condition is resolved? YES NO

17. Are you currently taking any medications? YES NO
If so, what are you taking? ____
Why and how much?____

18. Are you currently pregnant or nursing? YES NO

19. MENSTRUAL CYCLE
A. Do you have regular menstrual cycles? YES NO
B. How long is your menstrual cycle (i.e., 28 days)?: ________________
C. Date of Start of Last Period: ______________
D. (Dates for ind. visit: 7th day after start of period +/- 2 days)_________________

20. MEAL PATTERN:
A. Do you have a condition or take any medications that dictate how often or what you should eat? YES NO
B. In the last month, how many meals did you eat per day? ______________
C. Do you eat breakfast regularly (+3 times per week)? YES NO

21. FOOD ALLERGIES:
Do you have any food allergies? YES NO
If yes, what foods are you allergic to? _______________________________

21. STANDARDIZED MEAL:
Would you be willing/able to drink 8 fluid ounces of Ensure Plus? YES NO

If still eligible to participate:
Name: ___________________________
Address: ____
Home Phone: ____________ Work Phone: _______________ Fax: ___________________
E-mail: _______________________

Participant prefers (circle one): Fax Mail E-Mail

APPENDIX J: Palm Pilot Borrowing Contract

Sample Borrowing Contract

BORROWING CONTRACT

I have received a Palm Pilot handheld personal computer and a pedometer on loan from the United States Government to use for the purpose of logging my dietary intake and my physical activity. The computer and the pedometer are the property of the United States Government. I am expected to return the computer and the pedometer after the loan period in proper working order. I am responsible for both the computer and the pedometer in the event they are stolen, lost, or damaged. The replacement value of the computer is $200.00 and the pedometer is $50.00.

Please complete the following:

Print your full name: ______________________________
Home Address: ______________________________
____
Home Phone: ______________________________
Work Phone: ______________________________
Alternate Phone: ______________________________
Social Security #: ______________________________

Loan Period: _______________ to ______________

My signature below indicates that I am borrowing the computer and the pedometer for the time period indicated and that I understand my responsibilities in doing so.

___________________________________ _____________________
Participant's Signature Date

___________________________________ _____________________
Witness Signature Date

APPENDIX K: Sample Feedback Letter

*Please note, the information in this letter is completely fictional and does not reflect that of any of the participants.

1234
May 13, 2004

Dear Sample

The following information is based on your food diary, your exercise diary, and the metabolic testing. You may find this information helpful in talking to your doctor or your nutritionist. Whether you are trying to lose weight, gain weight, or maintain weight, you may find this information helpful in planning your exercise goals and your eating schedule. Currently, Giant Food Stores are offering similar tests. Their metabolic testing costs approximately $50 and their body fat measurement costs approximately $10-15. You may find this information helpful to measure your progress over time.

RESTING METABOLIC RATE

Your resting metabolic rate (RMR) is the energy that your body uses when you are at rest. Your body gets energy from the foods that you eat and the beverages that you drink. The energy from foods is called calories. Your body uses calories to keep your organs working (like your heart, lungs, and brain).

Several different factors determine your RMR, some you can control, others, you cannot. For example, your genes, your gender (whether you are a man or a woman), and your age help to determine your RMR (or how many calories your body needs while at rest). You cannot control these things. But, you can control how much muscle you have. Muscle burns more calories than fat does. Therefore, the more muscle you have, the more calories you will burn while at rest. You can increase the amount of muscle you have through exercise. The more you exercise, the more muscle you will have and the higher your RMR will be.

Your RMR is: 1300 calories per day.

This means that your body uses 1300 calories each day to keep you alive and your organs working.

ACTIVE METABOLIC RATE

When you move around each day, doing things like working or cleaning the house, you burn extra calories. The number of calories you burn through your daily activities is called your active metabolic rate (AMR). Your AMR depends on how much activity you do each day and how hard you work when you are doing these activities. For example, you will burn more calories walking up stairs than you will typing on a computer. But, you will burn calories doing BOTH activities.

Your AMR is: 1950 calories per day.

This means that your body needs at least 1950 calories each day to allow you to do your everyday activities.

DIETARY INDUCED THERMOGENESIS

Dietary induced thermogenesis (DIT) is just a fancy phrase to describe the amount of calories that your body uses to digest the food that you eat. When you eat food or drink beverages, your body uses up energy to make your food into useable energy. Your body uses extra energy for about 30-60 minutes after you eat trying to make your foods into useable energy.

Your DIT is: 1850

This means that for about 30 to 60 minutes after you eat, your body uses 1850 calories if you only sit after you eat. If you are active after you eat, then your body will use more than 1950 calories (or your AMR).

BODY COMPOSITION

Your body is made up of fat, muscle and other lean tissue (such as your organs), and water. Your "body composition" is used to tell you what percentage of your body is fat, how much is muscle and lean tissue, and how much is water.

Your body is composed of: 44% fat and 56% muscle and lean tissue

Since you weigh 169.00 pounds, 74.36 pounds of your body is fat and 94.64 pounds of your body is muscle and lean tissue.

The following chart may help you to figure out how fit you are.

Classification	**Women (% fat)**	**Men (% fat)**
Essential Fat	10-12%	2-4%
Athletes	14-20%	6-13%
Fitness	21-24%	14-17%
Acceptable	25-31%	18-25%
Obese	32% plus	25% plus

Remember, weight loss does not always mean fat loss. In order to increase the amount of fat lost and reduce the amount of lean muscle mass lost when you are trying to lose weight, you need incorporate exercise into your routine.

YOUR EATING HABITS

Calories

Too much
You reported eating 1941.71 calories per day. The number of calories that you reported eating is higher than what your body needs to maintain your current weight. In order to maintain your current weight, you would need to eat about 1950 calories per day. This means that you will likely gain weight unless you are burning extra calories through exercise.

Too few
You reported eating 1941.71 calories per day. The number of calories that you reported eating is lower than what your body needs to maintain your current weight. In order to maintain your current weight, you would need to eat about 1950 calories per day. This means that you will be more likely to lose weight.

Right on Target—this participant would receive this paragraph and not the 2 preceding paragraphs
You reported eating 1941.71 calories per day. The number of calories that you reported eating is right on track for what your body needs to maintain your current weight. In order to maintain your current weight, you would need to eat about 1950 calories per day. This means that you will likely be able to maintain your weight unless you are burning extra calories through exercise.

A Word on Dieting

Most people try to lose weight by dieting. Most diets, including many structured diet programs, have you eat TOO FEW calories. If you are eating fewer than 1,200 calories per day, then you will probably lose weight at first. However, your body will likely go into a "survival mode" that causes it to store the calories that you do eat. This SLOWS weight loss! Many dieters feel better about themselves when they skip meals or eat so little earlier in the day that they feel hungry. This also causes your body to go into a starvation mode. We have this starvation mode because our bodies are built for survival. In order to survive, we have to have stored up energy. We store energy in our fat. Our body fat is like a savings account. If you feed your body at regular intervals throughout the day, your body thinks it is in a safe environment and it will be willing to spend its "savings." In other words, if you eat just a little less than what you need to maintain your current weight and you eat frequently, you will lose fat.

If you skip meals or don't eat enough, your body will not be willing to spend its savings and will actually burn muscle for energy instead of fat! Remember that the more muscle you have the higher your metabolism is. So, if you're skipping meals, not only are you not burning fat, but you are decreasing your metabolism as well! When you go back to your old eating habits, as most people do after dieting, it will be easier to gain weight and harder to lose it! This process is why so many people have become "yo-yo" dieters.

Many of you have probably noticed that when you skip meals or cut way back on your calories, you lose a couple of pounds. These couple of pounds are actually muscle and water, not fat!

So how do you get rid of those extra pounds? This part takes some work, but you should NOT have to completely change your whole life in one fell swoop! You need to start with a little knowledge first.

1. 3,500 calories equals one pound. This means that if you eat 3,500 extra calories, you will gain one pound. If you burn an extra 3,500 calories, you will lose one pound. If you want to lose weight, you should make <u>small</u> changes in your diet so that you only cut out about 300-500 calories per day below your active metabolic rate. This will lead to _ to 1 pound weight loss per week. While this seem slow, losing weight at this speed will not make you feel as hungry or deprived as many diets. So, you will be more likely to keep your new eating habits. The best way to do this is to read labels and keep track of what you eat.

2. You need to eat frequently, at least 3 times per day. Remember that when you feed your body, it is willing to give up its savings. So, you have to fight the temptation to skip meals or starve yourself.

3. QUIT BEATING YOURSELF UP!! Every time you get down on yourself for "going off your diet," you make it harder to stick with your new patterns. Instead of making temporary changes "until you lose the weight," make changes that fit with your lifestyle and that you will be able to maintain *for the rest of your life.* When you slip back into your old habits, figure out what went wrong and try to fix it, don't beat yourself up.

4. *If it sounds too good to be true, it is!* If you're tempted to try the latest diet fad that promises "quick and easy weight loss," remember that there is NO *EASY* way to lose weight. If weight loss were quick and simple, wouldn't we all be a size 2? Weight loss is about planning, preparing, and learning. Plan ahead and you will be less likely to overeat. Prepare for times when you slip up. Learn from your mistakes and your habits.

Remember the three "t's" of eating: Timing, Type, and Total.

Timing: Plan your meals so that they are no more than 4 hours apart.

Type: Try to follow the food guide pyramid put out by the USDA.

Total: Keep track of the total number of calories that you eat. For weight loss, cut out about 300-500 calories per day. For weight gain, add about 300-500 calories per day. 300 calories equals 2 dinner rolls or 2 sodas!

Fat

Too much—this participant would receive this paragraph and not the other 2 following

You reported eating 71.00 grams of fat per day. This means that 32.9% of your calories come from fat. The USDA recommends that 20-30% of your diet come from fat. That means that you should try to cut down on your fat intake. Too much fat in your diet can put you at greater risk for some health problems, such as heart disease and some types of cancer. You can lower the amount of fat in your diet by cutting back on some high fat foods, such as fried foods or fast foods.

Too little
You reported eating 71.00 grams of fat per day. This means that 32.9% of your calories came from fat. The USDA recommends that 20-30% of your diet come from fat. That means that you should try to cut increase your fat intake. Nowadays, everyone seems to know that too much fat can be bad for you. But, too little fat in your diet can also be harmful to your health since your body needs fat. You can increase your fat intake in a healthy way by eating more lean meats, such as chicken and fish.

Right on Target
You reported eating 71.00 grams of fat per day. This means that 32.9% of your calories came from fat. The USDA recommends that 20-30% of your diet come from fat. This means that the amount of fat that you reported is right on track.

Protein

Too much
You reported eating 77.14 grams of protein per day. This means that 15.89% of your calories come from protein. The USDA recommends that 15-20% of your calories come from protein. That means that you should try to decrease your protein by eating fewer high protein foods. A lot of people are now trying to lose weight using high protein diets. While most people will lose weight quickly, these diets can be dangerous for several reasons. First, when you cut back on carbohydrates (foods like bread and potatoes), your body cannot hold water. Each gram of carbohydrate holds 3 grams of water. So, when you see that you have lost weight after cutting out carbohydrates and increasing protein, this is water weight, not fat. If your body loses too much water, this can be *very dangerous*. The second reason that these diets can be dangerous is that they encourage you to eat high fat foods, such as bacon and eggs. While these foods are fine in moderation, eating them too often can put you at greater risk for heart disease and other serious conditions. Remember, you can still have heart disease and be skinny! Third, these diets frequently encourage people to eat too few calories. When you don't eat enough, you may feel irritable, sluggish, and unmotivated.

Too little
You reported eating 77.14 grams of protein per day. This means that 15.89% of your calories come from protein. The USDA recommends that 15-20% of your calories come from protein. That means that you should try to increase your protein. Sometimes women have a difficult time getting enough protein because they do not eat a lot of meats. Meats carry essential minerals and vitamins, such as iron. Women need iron

since they lose it every month during their period. If you are not getting enough iron in your diet, you may feel sluggish or irritable. If you are a vegetarian and do not eat meats or you just don't like meats very much, you should consult a nutritionist to learn about foods that are higher in protein (such as yogurt).

Right on Target
You reported eating 77.14 grams of protein per day. This means that 15.89% of your calories came from protein. The USDA recommends that 15-20% of your calories come from protein. This means that the amount of protein in your diet is right on track.

DAILY ACTIVITY AND EXERCISE

You reported walking 12,766 steps per day or 5.47 miles per day. The recommendation is to walk 10,000 steps per day and to get in 3 hours of exercise each week. Exercise is an important part of weight loss and health. You do NOT have to exercise intensely 5 days a week to lose weight!! You also don't have to work out at a gym or run 10 miles!! You reported exercising 0.0 hour(s) per week. Your end goal should be to exercise at least 3 hours per week, but you should build up to this—especially if you do not exercise now. Remember that something (even 10 minutes of walking) is better than nothing. Set reasonable, achievable, concrete goals. For example, "I will walk for 10 minutes three times this week and increase by 5 minutes each week until I reach 3 hours per week."

> This goal is **reasonable** because even if you are a VERY busy person, you can spare 10 minutes to walk around the block.
>
> This goal is **achievable** because even if you are VERY out of shape, you can most likely walk for 10 minutes.
>
> This goal is **concrete** because you can know exactly when you have reached the short-term goal (10 minutes, three times this week) and the long-term goal (3 hours per week).

Thank you again for your participation.

Sincerely,

Teresa Hughes

APPENDIX L: Lecture Outline

Metabolism and Healthy Eating Pattern Lecture Outline

Metabolism and Healthy Eating Patterns

II. What is metabolic rate?

III. What factors influence metabolic rate?

   i. Age
   ii. Gender
   iii. Genetics
   iv. Physical Activity
   v. Food Intake

IV. The factors you can control: physical activity and food intake

V. Weight Regulation

   i. Maintain, Gain Weight, or Lose Weight
      1. Maintain = “energy in” = “energy out”
      2. Gain weight = “energy in” greater than “energy out”
      3. Weight loss = “energy out” greater than “energy in”
      4. Factors that influence “Energy Out”
         a. Daily physical activity
         b. Structured Exercise
         c. Metabolism
      5. Factors that influence “Energy In”
         a. What you eat: how much fat?
         b. How often you eat: the harm in skipping meals
         c. How much you eat: how many calories?
   ii. What is an eating pattern?
   iii. What are “healthy” eating patterns?
      1. Frequency
      2. Amount

VI. Questions

APPENDIX M: Detailed Data Analyses

Anthropomorphic and Demographic Variables

Anthropomorphic Data

There was not an eating pattern group by weight category group interaction effect for body mass [$F(1,46) = 2.85$, $p = 0.18$], height [$F(1,46) = 0.07$, $p = 0.79$], BMI [$F(1,46) = 1.67$, $p = 0.20$], or body fat percentage [$F(1,46) = 0.37$, $p = 0.85$]. There was not an eating pattern group main effect for body mass [$F(1,46) = 0.34$, $p = 0.57$], height [$F(1,46) = 0.07$, $p = 0.80$], BMI [$F(1,46) = 0.17$, $p = 0.32$], or body fat percentage [$F(1,46) = 1.02$, $p = 0.32$]. There was not a significant difference in the mean height of the obese vs. normal weight participants [$F(1,46) = 0.76$, $p = 0.39$].

Demographics Data

Age

A 2 (gorging, non-gorging) X 2 (obese, normal weight) ANOVA was used to examine the age differences between the groups. There was no eating pattern group by weight group interaction [$F(1,46) = 0.88$, $p = 0.35$]. There were no main effects for eating pattern group [$F(1,46) = 2.51$, $p = 0.12$] or weight category group [$F(1,46) = 2.1$, $p = 0.15$].

Marital Status

The initial marital status groups (“married,” “single, never married,” “divorced,” “widowed,” and “separated”) were collapsed in order to eliminate cells with frequencies of less than 5. The categories “married” and “non-married” were chosen to theoretically capture more similar demographic situations. The eating pattern [χ^2 (1) = 0.98, p = 0.32] and weight [χ^2 (1) = 0.01, p = 0.92] groups did not significantly differ in marital status. The eating pattern and weight groups were approximately equally split between married (52.9%) and non-married (47.1%) participants.

Education

The participants in this study were a highly educated group with 70.5% having completed at least a college degree. None of the participants had less than a high school degree. The education categories were collapsed into “some college or less,” “completed college,” and “partial or completed graduate/professional school” so that all of the cells would have a count of 5 or more. The categories were chosen to keep those individuals with similar education levels in similar strata. The frequency counts for the collapsed categories can be found in Table A. Chi-Square analysis was used to test frequency differences in education status. The eating pattern groups [gorger, non-gorger; $\chi^{2\,(}2)$ = 1.91, p = 0.39] and weight groups [obese, normal weight; $\chi^{2\,(}2)$ = 0.29, p = 0.86] did not differ significantly in level of education.

Table A

Frequency Counts for Collapsed Education Categories

	Gorger		Non-Gorger	
	Obese	Normal Weight	Obese	Normal Weight
(n; %N)	n (%N)	n (%N)	n (%N)	n (%N)
Some College or Less (15; 29.4%)	4 (7.8%)	5 (9.8%)	2 (3.9%)	4 (7.8%)
Completed College (14; 27.5%)	1 (2.0%)	4 (7.8%)	6 (11.8%)	3 (5.9%)
Partial or Completed Grad/Prof School (22; 43%)	7 (13.7%)	5 (9.8%)	3 (5.9%)	7 (13.7%)

Note. n = number of participants endorsing this status. %N = represents the percent of the total N falling in this category.

Employment Status

Nearly all of the participants were employed full-time (84.3% or 43/51). The employment categories were collapsed into two groups: "full-time" and "other" so that all of the cells would have a count of 5 or more. The "other" category included part-time, retired, and unemployed. The frequency counts for the collapsed categories can be found in Table B. Chi-Square analysis was used to test frequency differences in employment status. There were no significant differences between the eating pattern groups [gorger, non-gorger; χ^2 (1) = 0.50, p = 0.48] or weight groups [obese, normal weight; χ^2 (1) = 0.22, p = 0.64]

Table B

Frequency Counts for Collapsed Employment Categories

	Gorger		Non-Gorger	
	Obese	Normal Weight	Obese	Normal Weight
(N; %N)	n (%N)	n (%N)	n (%N)	n (%N)
Full-Time (43; 84.3%)	11 (21.6%)	10 (19.6%)	9 (17.6%)	13 (25.5%)
Other (8; 15.7%)	1 (2.0%)	4 (7.8%)	2 (3.9%)	1 (2.0%)

Note. n = number of participants endorsing this status. %N = represents the percent of the total N falling in this category.

Income

Because greater than 20% of the cells had an expected count less than 5, the income categories were collapsed into below $40,000 and above $40,000. An annual income of $40,000 was chosen as the cut-off for collapsing the data because this most closely matches the two lower tax brackets as defined by the IRS (2001; 15% and 27%, excluding the lowest tax bracket—10%) for married couples filing jointly. Since the question on the demographics questionnaire asked for total annual gross income and just over half of the participants were married, using the married couple filing jointly tax categories seemed most appropriate.

The frequency counts for the collapsed categories can be found in Table C. There were no significant differences between the eating pattern groups (gorger, non-gorger) reported income [χ^2 (1) = 0.94, p = 0.33]. When the groups were collapsed and compared by weight category (obese, normal weight), the obese group had significantly more participants with an annual income greater than $40,000 [$\chi^2$ (1) = 9.23, p = .002] than did the normal weight group. The obese group had 5 participants (9.8%) with an annual household income less than $40,000 whereas the normal weight group had 18 participants (35.3%) with an annual household income less than $40,000.

Table C

Frequency Counts for Collapsed Income Categories

	Gorger		Non-Gorger	
(n; %N)	Obese n (%N)	Normal Weight n (%N)	Obese n (%N)	Normal Weight n (%N)
< $40,000 (23; 45.1%)	1 (2.0%)	9 (17.6%)	4 (7.8%)	9 (17.6%)
≥ $40,000 (28; 54.9%)	11 (21.6%)	5 (9.8%)	7 (13.7%)	5 (9.8%)

Note. n = number of participants endorsing this status. %N = represents the percent of the total N falling in this category.

Ethnicity

The ethnicity categories were collapsed to allow for a valid Chi-Square analysis. The ethnicity categories were collapsed to compare the number of Caucasian participants to ethnic minority participants across the groups. Please see Table D for the frequency counts for the collapsed categories. There were significant differences between the ethnicities of the eating pattern groups [gorger, non-gorger; χ^2 (1) = 4.76, p = 0.03]. There were no significant differences between the ethnicities of the weight groups [obese, normal weight; χ^2 (1) = 0.32, p = 0.57].

Table D

Frequency Counts for Collapsed Ethnicity Categories

	Gorger		Non-Gorger	
(n; %N)	Obese n (%N)	Normal Weight n (%N)	Obese n (%N)	Normal Weight n (%N)
Caucasian (31; 60.7%)	5 (9.8%)	7 (13.7%)	8 (15.7%)	11 (21.6%)
Ethnic Minority (20; 39.3%)	7 (13.7%)	7 (13.7%)	3 (5.8%)	3 (5.8%)

Note. n = number of participants endorsing this status. %N = represents the percent of the total N falling in this category.

Oral Contraceptive Use

The frequency counts of oral contraceptive use by weight group and eating category group are presented in Table E. Using a Chi-square analysis, oral contraceptive use was examined by weight group and eating category. There were no significant differences in the use of oral contraceptives between the eating pattern groups [χ^2 (1, N = 51) = 1.09, p = 0.30]. This may be due to such variables as age, reproductive problems associated with obesity, alternative methods of contraception, contraindications for oral contraception use, or differences in sexual behavior. The remainder of the variables (such as alternative methods of contraception, etc.) was not assessed; therefore, the true cause for this trend is unknown.

Table E

Frequency Counts for Oral Contraceptive Use

	Gorger		Non-Gorger	
(n; %N)	Obese n (%N)	Normal Weight n (%N)	Obese n (%N)	Normal Weight n (%N)
Yes (13; 25.5%)	1 (2.0%)	4 (7.8%)	2 (3.9%)	6 (11.8%)
No (38; 74.5%)	11 (21.6%)	10 (19.6%)	9 (17.6 %)	8 (15.7%)

Note. n = number of participants endorsing this status. %N = represents the percent of the total N falling in this category.

Daily physical activity

There was not an eating pattern by weight group interaction effect for either steps [$F(1, 47) = 0.60$, $p = 0.44$] or miles walked per day [$F(1, 47) = 0.96$, $p = 0.32$]. The eating pattern and weight groups' reported daily activity, as measured by steps walked per day [eating pattern: $F(1, 47) = 0.34$, $p = 0.56$; weight: $F(1, 47) = 0.14$, $p = 0.71$] and miles walked per day [eating pattern: $F(1, 47) = 0.62$, $p = 0.44$; weight $F(1, 47) = 0.17$, $p = 0.68$], were not significantly different.

Exercise

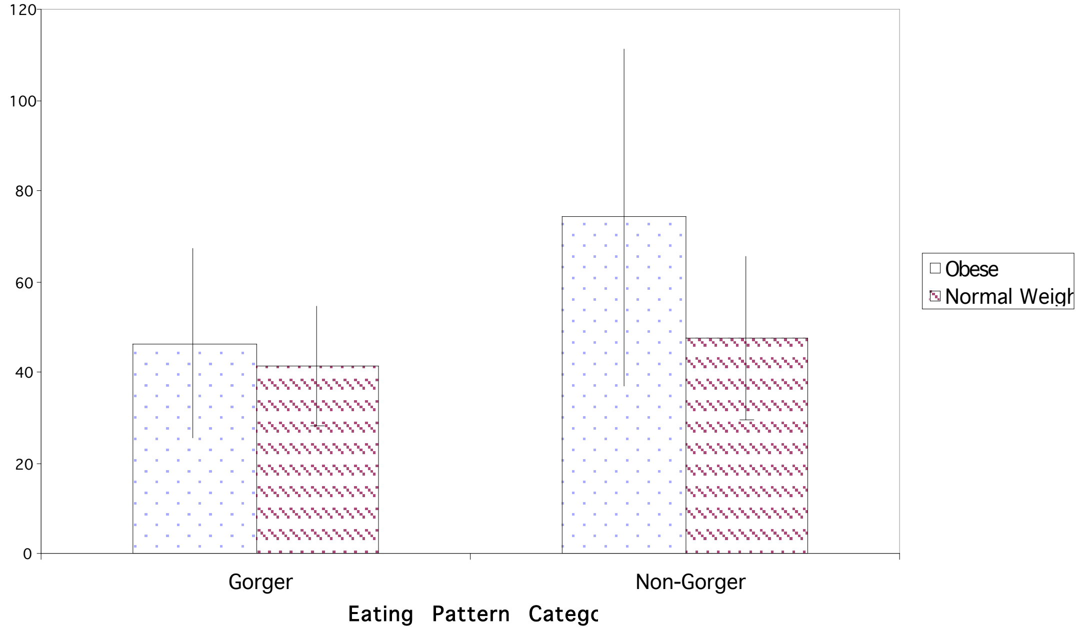
There was not an eating pattern by weight group interaction effect for amount of time exercised per week [$F(1, 24) = 0.09$, $p = 0.76$]. There were no main effects for weight group [$F(1, 24) = 1.11$, $p = 0.30$] or eating pattern group [$F(1, 24) = 0.33$, $p = 0.86$] exercisers for amount of time exercised per week. There was not an interaction effect for estimated energy expenditure through exercise [$F(1, 24) = 0.63$, $p = 0.44$]. There were no main effects for weight group [$F(1, 24) = 0.29$, $p = 0.60$] or eating pattern group [$F(1, 24) = 0.20$, $p = 0.66$] on estimated energy expenditure per day of exercise.

Since energy burned through exercise is largely affected by body mass, energy expenditure per day of exercise was analyzed using a 2 (gorging, non-gorging) X 2 (obese, normal weight) ANCOVA, covarying total body mass. There was not an interaction effect for estimated energy expenditure through exercise [$F(1, 23) = 0.49$, $p = 0.49$]. There were also no significant differences between the weight groups [$F(1, 23) = 0.03$, $p = 0.86$] or eating pattern groups [$F(1, 23) = 0.20$, $p = 0.66$] estimated energy expenditure through exercise.

Fat gram intake

Figure D displays the mean values of the fat intake (in grams) of the eating pattern group by weight group. There was a trend for an eating pattern group by weight group interaction for fat intake [$F(1,47) = 2.79$, $p = 0.10$]. As seen in Figure D, the obese non-gorging group had the highest fat intake, followed by the normal weight non-gorgers and obese gorgers, and finally the normal weight gorgers. Examination of the change terms revealed a significant difference between the two non-gorging groups [obese, normal weight; $t(23) = 2.36$, $p = 0.03$] not seen between the gorging groups [obese, normal weight; $t(24) = 0.72$, $p = 0.48$]. Also found was a significant difference between the two obese groups [non-gorging, gorging; $t(21) = 2.25$, $p = 0.04$] not seen between the normal weight groups [non-gorging, gorging; $t(26) = -1.02$, $p = 0.32$].

Figure D. Mean Daily Fat Intake in Grams



Eating Disorders Examination-Q

A 2 (gorging, non-gorging) X 2 (obese, normal weight) MANOVA was used to compare the subscales and the global score on the EDE. There were no weight group by eating pattern group interaction effects for restraint [$F(1, 47) = 1.47$, $p = 0.23$], eating concerns [$F(1, 47) = 2.07$, $p = 0.16$], shape concerns [$F(1, 47) = 2.10$, $p = 0.15$], weight concerns [$F(1, 47) = 0.13$, $p = 0.72$], or the global score [$F(1, 47) = 1.81$, $p = 0.19$]. Effect sizes of these analyses were calculated to be small and resultant calculated power was insufficient. There were no significant differences between the weight groups level of reported restraint [$F(1,47) = 0.60$, $p = 0.60$] or eating concerns [$F(1,47) = 1.33$, $p = 0.26$].