SELF-MONITORING IN THE LONG-TERM MANAGEMENT OF OBESITY

By

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To my parents, whose aspirations are my inspiration

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The prevalence of obesity in America has increased dramatically over the past few decades, with some of the highest rates of obesity being observed in rural populations. As research continues to identify the numerous negative health-related effects of obesity, the focus on developing and implementing effective weight loss interventions becomes important. Self-monitoring of dietary intake has been shown to be an important predictor of weight loss. However, less information exists describing the role of self-monitoring in the maintenance of lost weight. Thus, the purpose of this study was to assess the impact of self-monitoring during the year following initial treatment of obesity in context of the Treatment of Obesity in Underserved Rural Settings (TOURS) Project.

Food records of 220 women who completed a six-month lifestyle intervention for weight loss followed by a one-year extended-care period were examined. It was hypothesized that higher levels of frequency, consistency, and comprehensiveness of self-monitoring would be associated with less weight regain over the one-year extended-care period. Results of the present study revealed that during the year following lifestyle treatment, frequency of self-monitoring was significantly related to

lower percent weight regain. Participants who completed food records for at least 50% of the time were more likely to be successful in sustaining weight loss. Comprehensiveness self-monitoring was most effective when combined with frequent self-monitoring. These findings showed that self-monitoring facilitates the maintenance of lost weight by helping participants to adhere to daily caloric intake goals and, that women who successfully maintained body weight losses 10% or more self-monitored more frequently and more consistently than those women who were unable to sustain their initial weight losses. These findings can be utilized in future clinical and research endeavors that aim to improve the long-term management of obesity in adults seeking lifestyle intervention. Self-monitoring should be promoted not only for initial weight loss but also for successful long-term weight maintenance.

CHAPTER 1
INTRODUCTION

Overview

Obesity is a complicated and serious health condition that affects nearly one-third of Americans today (Ogden, Carroll, Curtin, et al., 2006). The causes of obesity include an interaction of biological, psychological, and environmental factors, and the medical complications of obesity are numerous; for example, obese persons are at higher risk for cardiovascular disease, diabetes mellitus- type 2, and several cancers (Haslam & James, 2005). Because even modest decreases in body weight can lead to improvements in health (Institute of Medicine, 1995), a variety of treatment options for weight loss exist. Lifestyle interventions targeting diet and physical activity are among the most popular and reliably successful treatment options available. The following paper will review the definitions, causes, consequences, treatment options of obesity, and the importance of self-monitoring in weight-loss treatment. The main objective of the proposed study is to examine the characteristics of self-monitoring in weight maintenance to identify recommendations that promote clinically significant weight reductions, feasibility, and efficiency for a person's lifestyle.

Definition and Measurement of Obesity

Obesity is defined as having an "excess amount of body fat" (World Health Organization [WHO], 1998). Excess body fat levels are associated with increased risk of high blood pressure, high blood cholesterol, type 2 diabetes, coronary heart disease, and other health problems (National Heart Lung Blood Institute [NHLBI], 1998). Commonly used methods for directly estimating body fat include hydrodensitometry (i.e., underwater weighing), dual-energy X-ray absorptiometry (DXA), magnetic resonance

imaging (MRI) scanning, computed tomography (CT) scanning, total-body electrical conductivity (i.e., bioimpedance) and total body potassium (Corsica & Perri, 2003; Pi-Sunyer, 2000; Presta, et al., 1983; Willett, Deitz, & Colditz, 1999). These methods, however, can be costly, impractical in large-scale studies, and are generally not available in routine clinical care settings (Willett, Dietz, & Colditz, 1999). Other methods used to assess body fat include waist circumference, ratio of waist circumference to hip circumference, and measures of skinfold thickness. The latter methods, while useful when researching body composition, can be affected by variation among observers and do not provide information on abdominal versus intramuscular fat (Willett, Dietz, & Colditz, 1999).

In most epidemiologic studies, obesity is described in terms of excess of body weight. This is calculated using Body Mass Index (BMI), also called the Quetlet index, which assesses body weight relative to height, (kg/m^2). The World Health Organization (1998) and the National Heart, Lung, and Blood Institute (1998) use six classifications for BMI as follows: BMI of <18.5 kg/m^2 is Underweight, BMI of 18.5- 24.9 kg/m^2 is Normal weight, BMI of 25-29.9 kg/m^2 is Overweight, BMI of 30-34.9 kg/m^2 is Obesity (Class I), BMI of 35-39.9 kg/m^2 is Obesity (Class II), and BMI of $\geq$ 40 kg/m^2 is Extreme Obesity (Class III). BMI has been found to correlate with the percent body fat mass in a curvilinear fashion (r = 0.68 to 0.89, ps < 0.001) in both men and women (Gallagher, Visser, Sepulveda, et al. 1996; Gallagher, Heymsfield, Heo, et al., 2000).

BMI is considered an acceptable but rough estimate of body fat, as it does not distinguish between lean mass from fat mass and does not take into account site-specific distribution of adipose tissue (NHLBI, 1998; Prentice & Jebb, 2001). For

example persons who have increased muscle mass can fall in the Obese category of BMI despite having a normal amount of body fat, while those with excess adiposity and reduced muscle mass may fall in the Normal category of BMI. Another criticism of BMI is that it is generally calculated using self-reported height and weight. While self-report is a simple way to collect data when sampling large numbers of individuals, it is subject to recall biases and social desirability (Gorber, Tremblay, Moher, & Gorber, 2007). Nonetheless, BMI is the most common method used, as it defines overweight and obesity according to cut-points, and BMI provides a systematic and consistent way to estimate worldwide obesity prevalence rates (WHO, 1998).

Prevalence of Overweight and Obesity in the United States

The prevalence of overweight and obesity in the United States has risen dramatically since the 1980s (Flegal, Carroll, Ogden, & Johnson, 2002; Ogden et al., 2006). According to the estimates published from the most current (2005-2006) National Health and Nutrition Examination Survey (NHANES), the prevalence of overweight has risen from 56.0% between 1988 and 1994 to 67.0% between 2005 and 2006. The prevalence of obesity has also risen from 22.9% between 1988 and 1994 to 34.3% between 2005 and 2006 (Flegal et al., 2002; Ogden, et al., 2006; Ogden, Caroll, McDowell, & Flegal, 2007). Thus, it should come as no surprise that this rise overweight and obesity has been described as an epidemic-like problem in the United States (Flegal, Carroll, Kuczmarski, Johnson, 1998; Allison et al., 2002).

Data from the NHANES 2003-2004 revealed that obesity is more prevalent among certain ethnic and racial subgroups. For all adults ages 20 and older, 45.0% of Non-Hispanic Blacks were found to be obese compared to 36.8% Mexican Americans and 30.6% of Non-Hispanic Whites (Ogden et al, 2006). A similar trend was also seen for the

prevalence of overweight in children and adolescents ages 2-19, such that 20.0% of Non-Hispanic black children and adolescents were found to be overweight compared their Mexican American and Non-Hispanic white counterparts (19.2% and 16.3%, respectively; Ogden et al, 2006).

Furthermore, sex and age may play a role in the odds of becoming obese. While the overall prevalence rates of obesity in men have increased from 1999-2006, no change was found in the prevalence rates of obesity in women during the same 8-year period. The 2005-2006 NHANES data showed that 33.3% of men compared to 35.3% of women ages 20 and older in the United States are obese (Ogden, Carroll, McDowell, & Flegal, 2007). The prevalence of obesity among men, however, did not differ significantly by ethnic or racial group; Non-Hispanic black men (34.0%), Mexican-American men (31.6%), and Non-Hispanic white men (31.1%). Among women, Non-Hispanic black women had higher rates of obesity (53.9%) compared to Mexican American women (42.3%) and Non-Hispanic white women (30.2%). When examining age, older adults were more likely to be obese compared to younger adults, with the exception of adults 80 years or older; the latter showed similar rates to adult men and women ages 20-39 (Ogden et al., 2006).

Consequences of Overweight and Obesity

Physical Impact

Obesity is linked to numerous health complications and is associated with five of the ten leading causes of death in the United States (Mokdad, Marks, Stroup, & Gerberding, 2004; Mokdad, Marks, Stroup, & Gerberding, 2005.) For example, obesity is related to the development and maintenance of stroke (Rimm, et al., 1995), cardiovascular disease (Poirier & Eckel, 2002), hypertension (American Heart Association, 2010), type-2 diabetes (NHLBI, 1998; Willett, Dietz, & Colditz, 1999),

osteoarthritis (Arthritis Foundation, 2007; Cooper, et al., 1998), sleep apnea (Vgontzas, et. al., 1994), and the development of certain cancers such as breast, gastric, and colon cancer (Peacock, White, Daling, Voigt, & Malone, 1999; Vaughn, Davis, Kristal, & Thomas, 1995; Ford, 1999).

Morbidity

Hypertension. According to the most recent but conservative estimates from the American Heart Association (2010), 33.6% of adults in the United States have high blood pressure (i.e., hypertension) which is defined as having a blood pressure greater than 140/90 mmHg. Hypertension is often called the “silent killer”, as it may not be accompanied by symptoms and uncontrolled high blood pressure. If left untreated, hypertension can lead to stroke, heart attack, heart failure or kidney failure (AHA, 2010). Hypertension was listed as a primary or contributing cause of death in approximately 326,000 U.S. deaths in 2006 (AHA, 2010). Blood pressure is very sensitive to weight gain and weight loss, with weight gain being positively associated with the development and progression of hypertension (Field, Byers, Hunter, Laird, Manson, Williamson, Willett, & Colditz, 1999). Central obesity, in particular, has been consistently associated with hypertension and increased cardiovascular risk (Krauss, Winston, Fletcher, & Grundy, 1998; Narkiewicz, 2006) by promoting insulin and leptin resistance, increasing sympathetic activity, and increasing renal sodium re-absorption (Wofford & Hall, 2004).

Stroke. The World Health Organization (1978) defined stroke, a type of cardiovascular disease, as a rapidly developing loss of brain function due to an interruption in the blood supply to all or part of the brain. Currently, stroke is the third leading cause of death in the United States, after heart disease and cancer (AHA, 2010). Results from prospective studies such as the Nurses' Health Study showed that

women who were overweight and obese (BMI $\geq$ 27 kg/m^2) had significantly increased risk of ischemic stroke compared to their normal weight counterparts. Researchers also demonstrated a positive relationship exists among BMI and risk of ischemic stroke in women. Ischemic stroke risk is 75% higher in women with BMI > 27, and 137% higher in women with a BMI > 32, compared to women with a BMI < 21 (Rexrode, et al., 1997). Another study completed in Finland also examined BMI as a risk factor for total and ischemic stroke in men and women. Results showed that abdominal adiposity was only a risk factor for total and ischemic stroke in men compared to women (Hu, et al., 2007).

Dyslipidemia. Dyslipidemia, or abnormal levels of lipids in the blood, is characterized by low levels of high-density lipoprotein cholesterol (HDL-C), high levels of triglycerides or high levels of low density lipoprotein cholesterol (LDL-C; AHA, 2010). The majority of dyslipidemia is hyperlipidemia (i.e., high cholesterol) which has been proposed as a mechanism related to increased risk of coronary heart disease (Field, Barnoya, & Colditz, 2002; Haslam & James, 2005). In 2006, 46.8% of U.S. adults had a of total cholesterol≥ 200 mg/dL according to 2003-2006 NHANES estimates (AHA, 2010). Low-density lipoprotein cholesterol levels in women and men can be reduced by a diet low in saturated fat and cholesterol (AHA, 2010). The latter result was supported by studies such as the Women's Healthy Lifestyle Project (WHLP), a randomized clinical trial that examined an intervention aimed at reducing dietary saturated fat and cholesterol, increasing physical activity, and preventing weight gain among "healthy" women. The trial was successful in preventing the rise in LDL cholesterol and weight gain from pre-menopause to peri-menopause to post-menopause (Kuller, Simkin-Silverman, Wing, Meilahn, & Ives, 2001).

Diabetes Mellitus. Diabetes mellitus is a group of diseases characterized by high levels of blood glucose resulting from defects in insulin production and/or insulin action (CDC, 2008). According to estimates from the American Diabetes Association (CDC, 2008), 20.8 million children and adults in the United States (7% of the population) have diabetes, with 14.6 million people diagnosed and 6.2 million people undiagnosed. People suffering from diabetes are at higher risk for complications of heart disease, stroke, hypertension, loss of vision, kidney disease, nervous system disease, dental disease, and amputation. According to the National Institute of Diabetes and Digestive and Kidney Diseases (NIDDK) type-2 diabetes, formerly known as non-insulin-dependent diabetes mellitus (NIDDM) or adult-onset diabetes, accounts for over 90% of all diagnosed cases (NIDDK, 2008) and is associated with obesity, physical inactivity, impaired glucose tolerance, older age, family history, and race/ethnicity (Haslam & James, 2005). A 2001 study demonstrated that both women and men who are obese were at a 20-fold increase in their risk of developing diabetes compared to people in the normal range of BMI (Field, et al., 2001). Additionally, abdominal obesity is specifically related to risk of developing type-2 diabetes (Chan, Rimm, Colditz, Stampfer, & Willett, 1994).

Cancer. Cancer is a disease characterized by the proliferation of abnormal cells that invade and destroy adjacent tissues and may spread to distant anatomic sites through a process called metastasis (Virshup & McCance, 2006). About 41,000 (3.2 %) new cases of cancer in the United States in 2002 were linked to obesity (Polednak, 2003). More specifically, one recent estimate suggested that 14% of cancer-related deaths were due to overweight and obesity in men compared to 20% in women (Calle,

Rodriguez, Walker-Thurmond, & Thun, 2003). The National Cancer Institute reported that obesity is related to risk of developing breast cancer in post-menopausal women and weight gain during adulthood has been found to be the most consistent and strongest predictor of breast cancer risk in women (Huang, Hankinson, Colditz, et al., 1997). Furthermore obesity is linked to the development of uterine (endometrial) cancer, colon cancer (in men), renal cell carcinoma (in women), esophageal and gastric cancer, and gallbladder cancer (Vainio & Bianchini, 2002).

Osteoarthritis. Osteoarthritis is a chronic disease characterized by the breakdown of the joint's cartilage, resulting in stiffness, pain and loss of movement in the joint (Arthritis Foundation, 2007). Obesity has been implicated as one of the many causes in the development of osteoarthritis, as increased body weight can increase the amount of stress placed on joints. Furthermore, increased body weight may increase the risk for bilateral knee-joint and hip-joint osteoarthritis. The Arthritis Foundation (2007) states that for every pound of body weight that a woman gains, she can add three pounds of pressure on her knees and six times the pressure on her hips. In a recent study (Marks, 2007), physical comorbidities, pain and function were compared among a sample of 82 women and 18 men with knee osteoarthritis. Those subjects with higher BMIs reported significantly higher pain levels than those with lower BMIs. The author concluded that being overweight may affect knee-joint impact rates and pain incrementally (Marks, 2007).

Decreased Pulmonary Function. Obese patients are at higher risk for breathing difficulty and experience higher rates of obstructive sleep apnea (OSA) and obesity hypoventilation (Koenig, 2001). OSA is caused by a blockage of the airway, usually

when the soft tissue in the rear of the throat collapses and closes during sleep (American Sleep Apnea Association, 2007). It has been shown that obesity is present in 60 to 90% of obstructive sleep apnea patients evaluated in sleep clinics (DeAlberto, Ferber, Garma, Lemoine, & Alperovitch, 1994; Rajala, et al., 1991). While several treatments exist for OSA, including use of a nasal Continuous Positive Airway Pressure (CPAP) machine, oral appliance, medications and surgery, many physicians recommend weight loss to improve the severity of sleep apnea symptoms (American Sleep Apnea Association, 2007; Rubinstein, Colapinto, Rotstein, Brown, & Hoffstein, 1988.) While weight loss can significantly decrease the number of apneas experienced, no information exists on the magnitude of weight loss needed to achieve improvements in pulmonary function (Koenig, 2001.)

Mortality

Assessing the overall health burden of obesity is difficult due to the complex interactions of obesity, poor health behaviors such as smoking, age, and disease risk. However, obesity has been consistently associated with increased mortality. This is especially true in adults with a BMI ≥30 kg/m^2. Some estimates of obesity-related mortality are as high as 365,000 deaths (15.2%) per year. However, the statistical calculations have been plagued by methodological errors that may have lead to an overestimation of the number of deaths caused by poor diet and physical inactivity (Mokdad, et al, 2005). Data based on nationally representative sample of U.S. adults conservatively estimate 111,000 -112,000 obesity-related deaths occur each year (Flegal, Graubard, Williamson, & Gail, 2005; Mokdad et al., 2004; Mokdad et al., 2005).

Several large epidemiological studies have reported that increased BMI is associated with increased risk of mortality. The Cancer Prevention Study II, a

prospective study begun by the American Cancer Society in 1982, examined mortality among men and women in the U.S. (Garfinkel, 1985). After excluding for missing information on race, smoking status, height, weight and for extreme values of height or weight, 457,785 men and 588,369 women were eligible to participate in the follow-up study on BMI and mortality; a total of 201,622 participants died during the 14-year follow-up period (Calle, Thun, Petrelli, Rodriguez, & Heath, 1999). Study results found an increased risk of cardiovascular death with increasing BMI in adults who had never smoked and who had no history of disease at enrollment. The lowest rates of death from all causes were found at BMI between 23.5 and 24.9 in men and 22.0 and 23.4 in women; the risk of death from all causes, cardiovascular disease, cancer, or other diseases increased as BMI increased for both men and women in all age groups (Calle, Thun, Petrelli, Rodriguez, & Heath, 1999).

The Framingham Heart Study, a longitudinal study with a follow-up from 1948 to 1990, provided data on age at death for people ages 30 to 49 at baseline in a study examining obesity and life expectancy (Peeters, et al., 2003). Smoking status was self-reported as current smoker or nonsmoker. Participants who had CVD at baseline or who died within 4 years of follow-up were excluded, as were participants who fell in the *Underweight* BMI category (BMI < 18.5 kg/m^2) bringing the final sample to 3457 participants (1550 men and 1907 women.) The authors concluded that obesity and overweight in adulthood were associated with large decreases in life expectancy. Forty-year old female nonsmokers lost 3.3 years of life due to overweight and 7.1 years of life due to obesity, while 40-year-old male nonsmokers lost 3.1 years of life to overweight and 5.8 years due to obesity (Peeters et al., 2003).

Psychological Impact

Obesity is also associated with many negative mental health consequences and with adverse psychological and social costs (Daniels, 2006; Corsica & Perri, 2003). Men and women who are obese experience greater levels of stigmatization in work settings because of their weight. For example, obese people are more likely to be treated poorly by their coworkers and employers and are more likely to be denied jobs and promotions (Paul & Townsend, 1995; Roehling, 1999). In a review of literature, Roehling (1999) reported that overweight employees were assumed to be less self-disciplined, less conscientious, less competent, lazier, sloppier, more disagreeable, and more emotionally unstable. Paul and Townsend (1995) similarly concluded that obese employees were stereotyped as also thinking slower, having poorer attendance records, and being poor role models. Furthermore in academic settings, obese students are more often teased by peers and perceived negatively by educators. BMI was found to be positively related to experiencing higher frequency of stigma and poorer psychological functioning; for example, obese people may experience higher levels of depression, psychiatric symptoms, body image distress, and lower levels of self-esteem (Myers & Rosen, 1999; Jasper & Klassen, 1990). It should be noted, however, that not all obese women are depressed but that they may be at a higher risk for depression (Carpenter, Hasin, Allison, & Faith, 2000; Onyike, Crum, Lee, Lykestsos, & Eaton, 2003).

Economic Impact

Finally, the direct costs of obesity have been estimated to be approximately $51.6 billion (5.7%) of health care expenditures in the United States (Finkelstein, Fiebelkorn, & Wang, 2003; Wolf & Colditz, 1998). Direct costs include costs of diagnosis and treatment related to a disease. Indirect costs, costs related to lost productivity due to morbidity and

mortality from obesity-related diseases, are estimated at an additional $47.6 billion (Wolf & Colditz, 1998). The most current estimates place the annual U.S. medical expenditures from obesity at $75 billion in 2003 dollars (Finkelstein, Fiebelkorn, & Wang, 2004).

Contributors to the Rise in Prevalence of Obesity

Obesity is caused by consuming more energy (calories) than what is expended over a long period of time. Excessive calorie intake leads to an accumulation of body fat. In general, ingesting 3500 kcal more (or less) than expended will lead to a gain (or loss) of approximately one pound of body weight [U.S. Department of Health and Human Services (USDHHS), 1996.] The contributors of obesity have been identified (Corsica & Perri, 2003) as a complex interaction among biological (i.e., genetics, metabolic abnormalities, energy expenditure), environmental (exposure to a “toxic” environment; Horgen & Brownell, 2002b), behavioral (intake of calories, sedentary lifestyle) and psychological factors (depression, binge-eating). Flegal and colleagues (1998) similarly point to increases in intake (calories), decreases in expenditure (sedentary lifestyle) interacting with an increasingly modernized society as contributing factors to weight gain.

Biological Factors

Differences in body composition (body mass and adipose tissue) may contribute to obesity. Adipose tissue in the body is stored in the form of fat cells. When people gain weight/fat, their fat cells increase in size. At a certain point, fat cells divide and grow to accommodate the increase in weight. When people lose weight, the fat cells shrink in size; however, the number of fat cells will never decrease. It has been proposed that obese people may have more of a likelihood of storing fat cells.

Studies have shown that obesity may have a heritable trait. For example twin studies show that monozygotic twins are more likely to weigh the same than dizygotic

twins. Genes have been shown to account for as much as two-thirds of individual differences in obesity in adults (Price, 2002). Adoption studies also have shown that children are more similar in weight to their biological parents than their adoptive parents (Stunkard, Harris, Pedersen, & McClearn, 1990). A person is at a 40% increased chance of becoming obese if he or she has one obese parent, and 80% more likely to become obese if both parents are obese (Ravuusin et al., 1999). Thus, a “genetic predisposition” may place a person at a higher risk for developing obesity, but their behaviors and interactions with the environment affect whether the genes are expressed or not expressed.

Metabolic abnormalities associated with obesity include deficits in insulin action and regulation (i.e., type-2 diabetes). Generally, people with these deficits tend to gain weight more easily. Lipoprotein lipase (LPR) is an enzyme receptor stored in adipose tissues that regulates the storage and uptake of fat. Obese people with deficiencies in LPR, are more likely to have an over-expression of obesity. Finally, leptin, a satiety-regulating hormone in adipose tissue has been studied via the ob-gene in mice (Zhang, et al., 1994). Leptin is responsible for body weight, insulin regulation, and energy intake.

Studies in animals and humans have shown that amounts of leptin in adipose tissue are positively related to dietary intake (i.e., as food intake increases, leptin levels increase and as people restrict food intake, leptin levels decrease). Obesity is associated with increased levels of leptin but with decreased leptin sensitivity. Moreover, leptin resistance is the key feature of diet-induced obesity (Scarpace & Zhang, 2007). This can be seen in studies with the Pima Indians, who are more likely to be obese but have

deceased amounts of leptin in blood plasma. More studies are being done to identify leptin as a cause or consequence of obesity (Scarpace & Zhang, 2007; Bray, 2002).

Finally differences in energy expenditure have been shown to affect rates of obesity. Energy expenditure is regulated by (1) resting metabolic rate (RMR), (2) the thermic effect of food (TEF), and (3) physical activity (PA) (Tataranni & Ravussin, 2002). RMR is the energy needed to keep the body's internal organs and temperature regulated and it accounts for 60-70% of energy expended. TEF is the energy needed to digest, absorb, and to take care of the slight increases in activity of sympathetic nervous system that occur after caloric consumption. TEF, however, only accounts for about 5-15% of energy expended and can be difficult to measure. Finally, physical activity (any movement of the body that is produced by skeletal muscles that produces energy expenditure), accounts for 15-30% of the energy expenditure and can most likely be altered (Tataranni & Ravussin, 2002). PA is quantified by metabolic equivalents (METS) where 1 MET equals 3.5mL of oxygen/ kg of weight. Intensity of PA can be quantified as light (< 3 METS), moderate (3-6 METS) and vigorous (7+ METS; Ainsworth, et al, 1993; Pate, et. al., 1995). While PA is the most variable component of energy expenditure, generally most obese individuals are sedentary or do not exercise at the level necessary to obtain benefits.

Environmental Factors

While biological contributions of obesity cannot be denied, most experts agree that environmental factors play a large role in the rise in prevalence rates of obesity (Hill & Peters, 1998; Hill, Wyatt, Reed, & Peters, 2003). Brownell and colleagues (2002b, 2004) have coined the term "toxic environment" to describe environmental factors that promote over consumption and sedentary lifestyles in the United States. Factors that may promote

increased consumption include availability and variety of highly-palatable, energy-dense, processed, inexpensive food that is often packaged or served in large portions (Hill & Peters, 1998; Hill et al., 2003; Horgen & Brownell, 2002a). Nielson and Popkin (2003) noted that portion sizes and energy intake of food have significantly increased from 1977-1998. For example, soft drinks have increased from12.2 oz and 130 kcal to 19.9 oz and 193 kcal over the course of a decade. Furthermore, Americans are currently are eating more fast food compared to home-cooked food (Nielson & Popkin, 2003; Putnam & Allshouse, 1996). "Eating out" has consistently been shown as a significant contributor to weight gain (Binkley, Eales, & Jekanowski, 2000; McCrory, Fuss, Hays, Vinken, Greenberg, Roberts, 1999).

Additionally, according to the Centers for Disease Control and Prevention (2008), about 75% of Americans do not meet the recommended guidelines set by governmental agencies for physical activity (i.e., accumulation of 30 minutes a day of moderate intensity activity on most, if not all days of the week; Pate, et al., 1995). Physical inactivity is also identified as a significant contributor to weight gain. Decreased energy expenditure results from reductions in requirements of occupational labor, school, and daily living along with increases in sedentary activity such as viewing television, using the internet, and playing videogames (Hill, Wyatt, & Menalson, 2000; Hill, Wyatt, Reed, & Peters, 2003). When examining the interaction of diet and physical activity, it was found that with increased mechanization and technologies, people still eat the high fat, high calorie diets of the past centuries but do not expend the same amounts of energy as they previously expended (Flegal, et al., 1998).

The literature examining obesity rates in “Westernized” societies compared to traditional societies (e.g., Polynesians, Pima Indians) further supports lifestyle factors over genetic contributions. Prevalence rates were found to be greater (35%) for Westernized region of Maori compared to the more traditional island of Pakupaku (15%; Prior, 1971). Pima Indians in Arizona (modernized) also have higher rates of obesity compared to their traditional rural-Mexico dwelling counterparts (Ravussin, Valencia, Esparza, Bennett, & Schulz, 1994).

Behavioral/Lifestyle Factors

Behavioral factors, also known as lifestyle factors, have received the most support as the mechanism for rise in obesity prevalence because people are more in control of their behavior than genetics (French et al., 2001; Hill & Peters, 1998; Poston & Foreyt, 1999). Overweight and obesity result from an energy imbalance that involves eating an excess amount of calories compared to the amount of calories that are expended. Researchers have also noted that the genetic composition of the population does not change rapidly. Thus, the large increases in the prevalence of obesity more accurately reflect major changes in non-genetic factors (Hill & Trowbridge, 1998.)

Available Treatments

With the prevalence of obesity increasing in the past two decades, a wide variety of pharmacological, surgical, and behavioral options have become available for the treatment of obesity. Perri and Corsica (2002) as well as Wadden, Brownell, and Foster (2002), have maintained that treatment must be matched for clients depending on BMI range, health risks, and diet history. For most individuals who fall in the BMI range of 21-29 kg/m^2, Wing (2004) concluded that a combination of low-calorie diet, regular physical

activity, and behavior modification were most effective for successful weight management.

Many options are available for overweight (BMI of 27-29.9 kg/m^2) persons. They can make changes to dietary intake and physical activity on their own, use a “popular” diet plan (e.g., Atkins, South Beach), join a self-help group (e.g., Overeaters Anonymous, TOPS), join a commercial weight loss program (e.g. Weight Watchers, Jenny Craig), or engage in behavioral (i.e., lifestyle) treatment according to recommendations published in the Clinical Guidelines for the Identification, Evaluation, and Treatment of Overweight (NHLBI, 1998).

Pharmacological treatments are recommended in addition to a portion-controlled, low-calorie diet for people with BMI of $\geq$ 30 kg/m^2. However, a person with a BMI $\geq$ 27 kg/m^2 who also has additional health risks such as hypertension and/or hyperlipidemia and a history of unsuccessful weight loss efforts may also benefit from pharmacotherapy (Wadden & Osei, 2002). Current pharmacological treatments that are approved by the U.S. Food and Drug Administration include sibutramine, a norepinephrine and noradrenaline reuptake inhibitor that produces early satiety and delays the next meal, and orlistat, a fat absorption blocker.

People in the Extreme Obesity (Class III) category (BMI $\geq$ 40 kg/m^2) or those in the Class III category (BMI $\geq$ 35 kg/m^2) with co-morbid conditions are generally recommended bariatric surgery (i.e. gastric bypass, gastric banding, gastroplasty, biliopancreatic diversion or biliopancreatic diversion with duodenal switch) in addition to undergoing major lifestyle changes. While surgical options produce an average loss of 25-30% of initial weight, significant risks of adverse consequences exist (Latifi, Kellum,

De Maria, & Sugerman, 2002). For example, persons who undergo surgical options for treatment must be informed of the operative mortality rates of 0.5 -1.0% and understand that they will undergo radical changes in their eating habits in terms of reductions in amounts and types of food consumed. Thus, the less intensive option for the latter population is available using portion-controlled, low-calorie diet and pharmacotherapy (Wadden & Osei, 2002).

Behavioral treatment is also referred to as a “lifestyle” approach for its focus on maintenance of long-term changes in eating and exercise habits across an individual’s life versus a focus on a short-term diet. Guided by the Learning Theory, researchers extended behavioral principles to the treatment of obesity in the late 1960s and the early 1970s. The main idea behind lifestyle treatment for weight management is that the behaviors used in the regulation of body weight can be learned and modified. Behaviorists noted the importance of modifying antecedents (i.e. cues) and consequences (i.e. reinforcers) in the management of weight (Wing, 2004). In general, researchers attempt to target the modifiable behaviors that result in overweight and obesity (Ravussin, Valencia, Esparza, Bennett, & Schulz, 1994.) General principles of behavioral treatment that have been successfully applied to weight loss include self-monitoring of behaviors, goal-setting, stimulus control, cognitive restructuring, problem-solving, relapse-prevention training, contingency management, stress management techniques, social support, and ongoing therapist contact (Perri, Nezu, and Viegener, 1992; Corsica & Perri, 2002; Wing, 2002).

Lifestyle interventions targeting decreases in dietary intake (decreases of average

of 500 kcal/ day) and increases in energy expenditure via physical activity have been proven to be effective in producing “moderate” weight reductions. “Successful” weight loss has been defined in lifestyle interventions ≥ 5% (IOM, 1995) or ≥ 10% (NHLBI, 1998) reductions in weight. Both percentages have been shown to produce significant changes in health risk factors such as improvements in glucose levels, blood pressure, triglycerides, total cholesterol, LDL, and HDL levels (Klein, et al., 2004; Vidal, 2002).

Maintenance of Lost Weight

Standard behavioral treatments for obesity of 15-26 weeks have reliably produced approximately 8-10% weight losses in adults (*M* = 8.5 kg or 18.7 lb). However, equally reliable is the fact that most people will regain lost weight when treatment ends; participants tend to regain all weight lost within 3-5 years (Perri & Corsica, 2002; Wadden, Stunkard, & Liebschutz, 1988). Length of treatment is positively associated with magnitude of initial loss (Perri, Nezu, Patti, & McCann, 1989), and larger initial weight losses are associated with larger amounts of weight maintained over the long run (Anderson, Konz, Frederich, & Wood, 2001). Thus, some researchers advocate for obesity to be treated using a continuous-care model, where obesity is viewed as a chronic disorder requiring long-term treatment (Lattner, Stunkard, Wilson, Zelitich, & Labouvie, 2000; Perri, 1998).

Numerous barriers in weight maintenance have been identified involving physiological, environmental, behavioral, and psychological factors (Perri & Corsica, 2002; Wing, 1998). These include reduced metabolic rate, constant exposure to low-cost, highly palatable, calorie-dense food choices, unrealistic expectations for weight loss, a lack of reinforcement for weight maintenance, and an unfavorable “cost/benefit” ratio (i.e., similar behavioral changes such as a reduction of caloric intake must still be

made but weight comes off slower if at all). Data obtained from the National Weight Control Registry (NWCR) have identified specific behaviors associated with successful long-term weight loss (Klem, Wing, McGuire, et al. 1997; McGuire, Wing, Klem et al., 1999; Wyatt, et al., 2002). While enrollment requirements for the registry include maintenance of a weight loss of ≥ 13.6 kg (≥ 30 lb) for at least 1 year, the average registry participant has maintained 32 kg (70 lb) weight loss for 6 years. The key behaviors related to successful maintenance reported by approximately 3000 NWCR participants were as follows: (1) self-monitoring of food intake and body weight, (2) consuming a low-calorie (1300–1400 kcal/d) and low-fat diet (20%–25% of daily energy intake from fat), (3) eating breakfast every day, and (4) performing regular physical activity that expends 2500 to 3000 kcal per week (e.g., walking 4 miles per day).

The Role of Self-Monitoring

Self-Regulation: The Conceptual Framework of Self-Monitoring

Because health is influenced by lifestyle habits, people are able to exercise some control over the state of their health by changing their behavior. Kanfer proposed that individuals achieve behavior change by using a feedback loop consisting of a sequence of three distinct stages: self-monitoring or self-observation, self-evaluation, and self-reinforcement (Kanfer, 1971, 1980; Kanfer & Karoly, 1972). The first stage of self-monitoring or self-observation is described as deliberate and careful attending to and recording of one's own behaviors (Bornstein, Hamilton, Bornstein, 1986). The second stage of self-evaluation involves making a discrimination response where actual behavior can be compared to what one should be doing based on a standard or performance criteria. Any discrepancies seen in the self-evaluation stage can lead a person towards two choices: continue the current behavior or correct the current

behavior in order to reduce the discrepancy. The third and final stage is a motivational stage of self-reinforcement that is dependent upon the degree to which the behavior deviates from the goal that was set.

Thus, Self-Regulation Theory (Kanfer, 1970) provides additional support for the benefits of self-monitoring in weight management. In fact, numerous researches have shown how principles associated with goal-setting and the feedback-loop apply to changing a variety of self-regulated behaviors. Self-monitoring has been used to evaluate a variety of health behaviors in research and clinical practice. For example, record keeping has been used to monitor pain levels (Flor & Birbaumer, 1993; James, Thorn, & Williams, 1993), sleep patterns (Coates, et al., 1983; Fichten, Creti, Amsel, Bailes, & Libman, 2005), nicotine cravings and intake (Foxx & Brown, 1979), food and fluid intake for hemodialysis patients (Dowell & Welch, 2006), medication adherence for asthma and HIV patients (Safren, et al., 2001; Sawyer, 2002), and blood-glucose monitoring in diabetic patients (CDC, 2008).

Behavioral treatment of obesity is characterized as goal-directed and specifies very clear goals that can easily be measured (Wadden & Foster, 2000). Of the behavioral modification techniques listed earlier, Wadden (1993) referred to self-monitoring as the “cornerstone” in the treatment of obesity as it promotes self-awareness, self-evaluation, and self-reinforcement in achieving a meaningful goal. (i.e., weight loss). When used in weight loss interventions, self-monitoring involves completion of a written diary documenting the quantity and content of foods eaten. The self-evaluation process fosters an individual approach to weight loss, by using the participants’ own behavioral data (Remmell, Gorder, Hall, & Tillotson, 1980).

Assessment Tool or Treatment Strategy?

In its inception, self-monitoring was intended to provide a record of baseline behavior (Kanfer, 1970). However, it was noted that the behavior being observed sometimes would change in a favorable direction. In the earliest literature, de Chardin (1959) noticed that as an individual gathers information about his own actions, the information may influence the very action being observed. Researchers have referred to this phenomenon as *self-monitoring reactivity* or *reciprocal reactivity* (Ciminero, Nelson, & Lipinski, 1977; Hay, Nelson, & Hay, 1980; Sperduto, Calhoun & Ciminero, 1978).

Thus, self-monitoring can serve as a behavioral tool as well as a mechanism for behavior change. Kanfer (1971) indicated that a participant can examine his or her own self-observations to self-evaluate behaviors to reach a goal. Meeting goals eventually leads to self-reinforcement. Literature on self-monitoring notes that the accuracy of self-monitoring compared to independent measures of the same behavior may vary widely in different situations (Kazdin, 1974). Thus self-monitoring may not be reliable enough on its own to show lasting effects as a behavior change mechanism. It can, however, serve as an important motivating tool when combined with other behavior change techniques such as goal-setting and self-reinforcement.

Methods of Self-Monitoring

Several different types of self-monitoring methods are available to record behavior change. When considering which method or device to choose, researchers agree that the device should be easy to use, cost-effective, able to record the behavior as soon as it occurs, and prominent enough to remind the user to monitor his behavior without drawing the attention of others (Ciminero, Nelson, & Lipinski, 1977; Foster, Laverty-Finch, Gizzo, & Osantowski, 1999). Common devices for self-monitoring behavior

comprise the following categories: 1) paper and pencil, 2) mechanical, and 3) electronic devices.

Paper and pencil methods include narratives (e.g., diaries, food records), rating scales (i.e., intensity of behavior such as cravings are rated on a 5-point scale), checklists (i.e., client makes a mark in an appropriate box when the target behavior occurs, such as servings of fruits and vegetables eaten in one day), and graphic scales (i.e., placing observational data on a graph, which can provide feedback as to progression of behavior change, such as weight change over the course of an intervention.) Mechanical devices are defined as “any means by which a client manipulates a physical object in order to count the occurrence of a specific behavior.” (Nay, 1979, p. 124). These devices include pedometers that count the number of steps taken. Pedometers are particularly useful as they are small, lightweight, inexpensive, easy to use, generate a minimal amount of disruption, and provide immediate feedback. Unidimensional and tri-axial accelerometers have also been used as objective measures of physical activity. Unidimensional accelerometers assess vertical movement of the body characteristic of walking and running, while tri-axial accelerometers detect vertical, horizontal, and lateral movements (Sallis & Owen, 1999). While these devices are generally small in size, relatively low cost, do not cause interference in ongoing activity, and have large memory capacity allowing for monitoring and storage of data, the reliability of accelerometers vary with different populations. Accelerometers have been used to study the validity of self-report and diary methods of physical activity (Jakicic, Polley, & Wing, 1998). Finally, electronic devices refer to audio and/or videotape recorders that are used to record behavior as it occurs. While these

devices can be convenient if behavior needs to be checked for reliability, they are usually expensive to employ.

Self-Monitoring Assessment Methods for Weight Management

Paper-and-Pen Food Records. Recording of dietary intake has usually been completed using paper-and-pen monitoring forms. These are also known as food logs/records/diaries or diet logs/records/diaries and provide an avenue to monitor food eaten. Often these food records have a place for recording physical activity that has been completed (Brownell, 2004).

While specific monitoring forms differ among studies, content often includes food choices, amounts eaten, calories eaten, times, total calories (Brownell, 2004). Instructions for completing monitoring records listed in the LEARN Manual are as follows: (1) Record everything, forget nothing, (2) Record the food, the amount, the calories, (3) Record immediately after eating, and (4) Carry your Monitoring Forms always (Brownell, 2004, p. 19-20).

Electronic Food Records. Personal Digital Assistants (PDAs), also known as hand-held computers, have also been used as tools for self-monitoring in an attempt to reduce underreporting, reduce the burden and inconvenience, and improve validity of self-reported calorie intake. Studies using electronic methods of self-monitoring have produced equivocal results. Results from a pilot study of 33 women in the Diet Modification arm of the Women's Health Initiative (WHI) showed that use of PDAs to monitor dietary intake for one month was related to increased self-monitoring and improved dietary adherence (i.e., met goals more often; Glanz, Murphy, Moylan, Evensen, & Curb, 2006). Yon and colleagues (2006) agreed that newer electronic

technologies may simplify the self-monitoring process and increase compliance but concluded that using PDAs to monitor dietary intake does not improve validity of the self-report.

Weight. While most behavioral therapists advocate focusing on self-monitoring of eating and exercise behaviors, evidence exists that long-term frequent monitoring of weight can also serve as an effective weight management strategy. For example when participants in the NWCR were asked about the frequency of weighing behavior, approximately 75% of the participants reported that they monitor their weight at least weekly and 38% indicated they weigh themselves at least daily (Klem et al., 1997; Wing & Hill, 2001; Wing & Phelan, 2005). In a study of 50 postmenopausal women in a 6-month weight loss program, results showed that self-monitoring of food intake was the best predictor of amount of weight lost, but that frequent weighing and keeping records of these results were the next best predictor (Qi & Dennis, 2000). Consistent self-weighing can also serve as an important strategy for weight maintenance (Butryn, Phelan, Hill, & Wing, 2007).

Key Components of Self-Monitoring in Weight Loss

In general, the literature examining self-monitoring and weight loss shows that the frequency of food record completion is positively related to weight loss during an initial 12-month period (Baker & Kirschenbaum, 1993; Streit, Stevens, Stevens, & Rossner, 1991). Based on previous research, Boutelle and Kirschenbaum (1998) suggest that a reasonable target for people to self-monitor all foods eaten is at least 75% of the days. In a recent randomized control trial of weight control in 12 to 16 year old adolescents, Saelens and McGrath (2003) reported that more frequent recording and summing of

calories during treatment were significantly related to positive changes in caloric consumption.

Consistency in self-monitoring of dietary intake has also been associated with weight loss during obesity treatment and weight control during the holidays (Baker & Kirschenbaum, 1993; Boutelle, Kirschenbaum, Baker, & Mitchell, 1999; Boutelle & Kirschenbaum, 1998). In a more recent study of people who consistently self-monitored exercise behavior (i.e., missed ≤ 1 week of self-monitoring) compared those who were inconsistent (i.e., missed > 1 week of self-monitoring) lost significantly more weight in 6-month behavioral program (Carels, et al., 2005). Consistency of dietary content was also found to be important in studies of weight maintenance; most participants in the NWCR reported that their diets remained the same on weekends and weekdays (59%) and on holidays/vacations and the rest of the year (45%; Wing & Phelan, 2005). When evaluated further, the NWCR participants who reported a consistent diet across the week were 1.5 times more likely to maintain their weight within 5 lbs over the following year compared to those participants who dieted more strictly on weekdays.

Ideally, self-monitoring of eating behavior is completed in a continuous and concurrent fashion (i.e., as a person eats, she records what she eats.) However, research shows that adherence to self-monitoring is not always this precise (Baker & Kirschenbaum, 1993; Burke, et al., 2006; Burke, et al., 2008) and may decline over time (Burke, et al., 2008). In a recent study, Burke and colleagues (2006; 2008) randomized participants to a standard paper-and-pencil diary or an instrumented paper diary (IPD) to evaluate adherence to self-monitoring. The IPDs were unobtrusively fitted with a circuit board embedded with photo-sensors that detected changes in light level when

the diary binder was opened or closed and provided a date and time stamp with a 1-minute resolution (Burke et al., 2008). Thus, the researchers were able to analyze the frequency, consistency, and timing of use for self-monitoring of food diaries. Results showed that self-monitoring adherence declined over time, that individuals commonly misrepresented the frequency of self-monitoring (i.e., they report recording more often than the electronically recorded data indicated), and that a significant relationship existed between the amount and time of self-monitoring and success at weight loss.

Research on completeness of recording is equivocal. Baker and Kirschenbaum (1993, 1998), along with Boutelle and colleagues (1999) report that completeness of recording is important for weight loss. However, results from a study by Helsel, Jakicic, and Otto (2007) revealed that frequency of recording was more important than the detail of recording in the facilitation of short-term weight loss in adults. Saelens & McGrath (2003) suggest that sufficiency of self-monitoring in adolescents, operationally defined as writing down at least five food items eaten on a particular day, was associated with improvements in post-treatment and three-month follow-up BMI. However, they noted that additional details of self-monitoring records (e.g., amounts, calories, and sum of calories) beyond sufficiency (i.e., five or more items) was not significantly related to weight loss outcomes immediately following treatment or at follow-up.

Previous research also suggests that that when self-reporting dietary intake, people tend to underestimate their calorie intake by 27- 46% (Johnson, Friedman, Harvey-Berino, Gold, & McKenzie, 2005; McKenzie, Johnson, Harvey-Berino, & Gold, 2002). Explanations for the underreporting of intake include self-presentation bias (McKenzie et al., 2002; Mertz, Tsui, Judd, Reiser, Hallfrisch, Morris, Steel, & Lashley,

1991) and forgetfulness due to the inconvenience of record keeping (Macdiarmid & Blundell, 1997; Price, Paul, Cole, & Wadsworth, 1997).

Food records can also provide researchers with estimate of adherence to recommendations and supply data for evaluating diet quality. In a recent study of the Framingham Offspring cohort (Quatromoni, Pencina, Cobain, Jacques, & D'Agostino, 2006), researchers assessed dietary quality of 2245 adult men and women. A five-point diet quality index (DQI) was calculated based on nutrient intake of Dietary Guidelines recommendations for total (< 30% kcal) and saturated fat (<10% kcal), cholesterol (< 300 mg/dl), sodium (< 2400 mg/dl) and carbohydrates (> 50 % kcal). Men and women who were most successful at minimizing age-related weight gain were those whose diet adhered closer to the U.S. Dietary Guidelines (Quatromoni, et al., 2006). Results from the Women's Health Initiative (WHI), a multicenter trial of dietary means for prevention of breast and colorectal cancer (i.e., not a weight loss intervention), showed that participants who followed a diet low in fat and high in fruits, vegetables, and grains, were more likely to maintain a lower weight than participants in the control condition during the 7.5-year follow-up (Howard et al., 2006).

Purpose

The current study describes and examines the individual components of self-monitoring of eating behaviors as related to the maintenance of treatment-induced weight loss during a one-year period. Although self-monitoring is an effective strategy in weight management, specific instructions have not been provided to answer questions such as "how much and what components of self monitoring are necessary to maintain beneficial amounts of weight loss?" This is important information from a practical standpoint because self-monitoring has been identified as a key mechanism for weigh

loss but has also been criticized for being too time consuming and too intrusive as a daily strategy for long-term weight management.

CHAPTER 2
METHOD

Treatment of Obesity in Underserved Rural Settings (TOURS)

The TOURS project was a three-arm randomized control trial evaluating the effects of three interventions designed to improve long-term weight management in obese women from six medically underserved rural counties in North Florida. Each participant was randomized to one of these group-based interventions delivered in Cooperative Extension Service offices over the course of 18 months.

Each intervention began with a 6-month lifestyle program for weight loss (Phase 1) and continued with randomization into one of three extended-care programs delivered over the next 12 months (Months 6 -18; Phase 2). The three extended-care programs compared two active conditions (i.e., bi-weekly office-based/ face-to-face session and bi-weekly telephone sessions) with one inactive or education control condition (i.e., health education via mailed newsletters). All assessments were conducted at baseline (Month 0), at the conclusion of Phase 1 (Month 6), and at the conclusion of Phase 2 (Month 18).

Participants

Participants in the current study were sedentary but healthy women, ages 50-75, from medically underserved rural areas who volunteered to take part in the TOURS trial. Three cohorts of participants were recruited and were randomized at 6-month intervals. Eligibility requirements included having a body mass index (BMI) of 30 kg/m^2 or higher and weight less than 350 pounds (to allow for measurement on a balance beam scale). Potential participants were excluded if their medical history, clinical examination, or laboratory results revealed underlying diseases likely to limit lifespan and/or increase

risk of intervention. This included cancer requiring treatment in the past five years, serious infectious diseases, myocardial infarction or cerebrovascular accident within the last six months, unstable angina within the past six months, congestive heart failure, chronic hepatitis, cirrhosis, chronic malabsorption syndrome, chronic pancreatitis, irritable bowel syndrome, previous bariatric surgery, history of solid organ transplantation, history of musculo-skeletal conditions that limit walking, chronic lung diseases limiting physical activity, serum creatinine > 1.5 mg/dl, anemia (hemoglobin < 10 g/dl), and any other condition likely to limit five-year life expectancy.

Participants were considered ineligible if they fell into any of the following categories: (1) metabolic values out of range (i.e., fasting blood glucose > 125 mg/dl at screening if not known to be diabetic (participants with medically-managed diabetes were enrolled with approval from a primary care provider), fasting serum triglycerides > 400 mg/dl at screening despite appropriate drug treatment, and resting blood pressure > 140/90 mmHg despite appropriate drug treatment); (2) use of certain medications (i.e., antipsychotic agents, monoamine oxidase inhibitors, systemic corticosteroids, antibiotics for HIV or TB, chemotherapeutic drugs, or current use of prescription weight-loss drugs); and (3) conditions or behaviors likely to affect the conduct of the trial (i.e., unwilling or unable to give informed consent, unable to read English at the 5th grade level, unwilling to accept random assignment, unable to travel to extension office for intervention sessions, participation in another randomized research project, weight loss > ten pounds in past six months, likely to move out of the county in next two years, major psychiatric disorder, excessive alcohol intake, body weight > 159 kg, and other conditions which in the opinion of the staff would adversely affect participation in the

intervention.) Finally, women who were pregnant or planning to become pregnant during the course of the study were also excluded.

Measures

Height and Weight

Height was measured without shoes for each participant to the nearest 0.1 centimeter using a Harpendon stadiometer ©. Weight was measured to the nearest 0.1 kilogram using a calibrated and certified balance beam scale. Actual height and weight, as measured by trained study staff, was used to calculate body mass index.

Body Mass Index

BMI was computed based on height (centimeters) and weight (kilograms) of the participants that was measured during medical assessments. BMI is calculated by dividing weight in kilograms by height in meters squared (kg/m^2). Widely used in research and clinical settings, BMI is a reliable estimate of obesity; however, there is a 5% standard error when using BMI to estimate body fat percentage (American College of Sports Medicine [ACSM], 2000; Garrow & Webster, 1985).

Daily Food Records

Food records were used primarily as an intervention tool to assess the total number of calories consumed each day and to allow for goal setting (See Appendix). Participants were instructed to keep a daily record of the specific food eaten, associated amount eaten, associated calories consumed, time of day of eating episode, activity while eating (e.g., watching television), feelings while eating (e.g., bored, sad), and place of eating episode (i.e., kitchen, family room). A column was also available for the participant to track the associated fat grams that were consumed.

Research shows that daily food records have limitations, most commonly an under-estimation of caloric intake (Thompson & Subar, 2001; Hill & Davies, 2001). However, food records provided a rough estimate of participants' average caloric consumption at various points during the intervention and showed whether or not participants were adhering to daily calorie intake goals that were set at the previous session. Completion of self-monitoring records was also used to assess treatment adherence during Phase 2 of the study. Self-monitoring records were either given to the interventionist by the face-to-face group participants at their session or mailed in by the telephone and education control group participants.

Procedure

Recruitment

Participants were recruited through a variety of methods including direct mailings, newspaper announcements, media articles, and presentations to community groups. Following a preliminary telephone screening assessing demographic information and exclusionary criteria listed previously, potential participants were asked to attend an assessment in their local county extension office. During this assessment the study staff explained the purposes and procedures of the study and obtained informed consent for study participation.

Initial Assessment

After providing consent, each individual completed a 12-lead electrocardiogram (ECG); a blood-draw; a 6-minute walk test; measurement of height, weight, and girth; measurement of resting heart rate and blood pressure; medical history forms that included questions concerning current and past illnesses, past surgeries, and current medication use; and various questionnaires assessing dietary intake, physical activity,

health-related quality of life, depressive symptoms, and problem-solving. Following the initial assessment, potential participants' results were reviewed to determine if participation criteria had been met. Participants were then contacted via the telephone to inform them of their eligibility.

Intervention

Phase 1. In Phase 1, all participants attended 24-weekly session during months 0-6. Participants met for approximately 90 minutes in groups of 10-15 at their local County Extension Offices. Interventionists were Family and Consumer Science Agents, registered dieticians, or graduate-level psychology students. All the interventionists completed extensive training, were monitored, and met for weekly supervision with a licensed psychologist throughout the 18-month intervention.

The general goals of Phase 1 were fourfold: (1) improve the quality of nutritional intake, (2) increase physical activity, (3) manage weight, and (4) improve quality of life. During the 90-minute group sessions, educational material was presented using a manual designed for the TOURS study and participants were encouraged to talk about ways to change their eating and exercise behavior to reach these program goals. All participants received behavioral self-management training including instruction on self-monitoring of behavior, goal setting, stimulus control, self-reinforcement and cognitive reframing. Session topics included information about nutrition, physical activity, stress management, assertiveness training, and body image. During the session each participant was given a chance to discuss any particular challenges she faced in the previous week. Participants were also weighed at each session and were asked to turn in food and physical activity records that were completed during the previous week. At

the end of each session, participants identified specific behavioral goals for the week (e.g., calorie goal, step goal, exercise goal).

Phase 2. Phase 2, the extended-care period occurred during months 7-18, consisted of participants being randomly assigned to one of three follow-up maintenance conditions: Office-based /face-to-face program, telephone-based program, or mail-based/education control condition. Each group of women was randomized together and was informed of their assignments at the conclusion of Phase 1. All women were strongly encouraged to maintain healthy lifestyle changes in diet and physical activity that were accomplished during Phase 1.

Participants assigned to the office-based/ face-to-face program continued to meet at the County Extension Office for bi-monthly on-site group sessions. During Phase 2 sessions, participants were weighed and then meet as a group for each participant to discuss what went well during the past two weeks, what challenges (if any) were encountered and what problem or issue (if any) would she desire group assistance with. The interventionist, who had been trained in Problem-Solving Therapy, led the group through the problem-solving process. Problem Solving has been described as a self-directed cognitive-behavioral process by which a person attempts to identify or discover effective or adaptive solutions for specific problems encountered in everyday living (D'Zurilla & Nezu, 1999). The 5-step process involves (1) having a positive mindset, (2) defining the problem, (3) generating solutions, (4) making a decision, and (5) carrying out and evaluating the solution. During the Phase 2 sessions, interventionists along with the group members chose one or two group member's problem and generated a solution plan for that participant to implement. Finally, specific behavioral goals for the

upcoming two weeks were identified by each participant. All participants were encouraged to continue monitoring their dietary intake and physical activity and were encouraged to turn in at least three food records per week during Phase 2 (the one-year extended-care period).

Participants in the telephone-based program also had two contacts per month with their interventionist via individual telephone calls. The telephone-contact session had similar goals and procedure as the office-based/ face-to-face condition. First, the participant reviewed her week with the interventionist, provided her weight as measured that week, and reported how often she met her behavioral goals within the past two weeks. The interventionist then asked what went well in the participant's eating and activity and also what problems or challenges the participant encountered within the past two weeks. In response to problems encountered by the participant, the interventionist guided the participant through the same 5-step problem-solving process as implemented in the office-based/ face-to-face program. Again, the ultimate goal was for the interventionist to assist the participant in generating a solution plan to implement within the subsequent 2-week period between phone contacts.

Finally, the participant set her goals for the next two weeks and set up the time and date for the next phone contact. All participants had a specified time for their "phone appointment" with their interventionist and phone sessions were set at approximately 10-15 minutes in length. To maximize the likelihood of reaching participants by phone, up to five callbacks are made to individuals who could not be reached at their phone appointment. All telephone contacts were logged and a the following information was recorded by the interventionist: the length of the phone

session, the progress reported by the participant, a description of the problem-solving process implemented, and the solution that was to be implemented by the participant before the next phone contact. All participants in the telephone-based program were encouraged to continue monitoring their dietary intake and physical activity and were encouraged to mail in at least three food records per week during Phase 2 (the one-year extended-care period).

Participants in the mail-based/education control condition received biweekly newsletters providing psycho-educational information about nutrition and exercise and the same written materials on problem solving that were given to the office-based/ face-to-face and telephone-based groups. The newsletters also included low-fat, low-calorie recipes and offered tips about healthy lifestyle behaviors that promote maintenance of lost weight. This mail-based condition served as a control or comparison group to the effects of interventionist contact in the office-based/ face-to-face and telephone-based programs. All participants in the mail-based/education control condition were also encouraged to mail in at least three food records per week during Phase 2 (the one-year extended-care period).

Aims and Proposed Analyses

The purposes of this study were as follows: (1) to describe the specific characteristics of self-monitoring (i.e., frequency, consistency, and comprehensiveness) of participants during a 12-month extended-care period following the completion of 6-month lifestyle intervention for weight loss, (2) to examine the relation between self-monitoring and percent weight regain during a 12-month post-treatment extended-care period, (3) to evaluate whether the association between self-monitoring and percent weight regain is mediated by meeting daily caloric intake goals, and (4) to identify

characteristics of self-monitoring that differentiate between women who were successful vs. unsuccessful in maintaining their weight losses over one year.

Aim 1

The first aim of this study was to describe the characteristics of self-monitoring (i.e., frequency, comprehensiveness, and consistency) associated with weight change during a 12-month extended-care period following the completion of 6-month lifestyle intervention for weight loss. The following definitions were used to code and analyze the data:

Frequency. A food record was defined as a record that specified food amounts, associated caloric values, and total daily caloric intake. Thus, frequency of food records was defined as the number of food records that a participant submitted to the interventionist or by mail during months 7 to 18 of the study.

Consistency. As noted earlier, during Phase 2, participants were encouraged to submit at least three dietary self-monitoring records per week. This cut-off of three records per week was used to delineate between people who were adherent to the weekly self-monitoring recommendations. Weekly adherence was plotted (*M* and *SD* of records) by month across the extended-care year can to distinguish participants who were consistent.

Comprehensiveness. First, the variables that participants tracked in their food records were described. Each food record was coded using the following point system: participants received 1 point for each breakfast variable (time, food name, amount, and calories; 0 - 4 points for breakfast), 1 point for each lunch variable (time, food name, amount, and calories; 0 - 4 points for lunch), 1 point for each dinner variable (time, food name, amount, and calories; 0 - 4 points for dinner), and 1 point for total calories. Thus,

a participant could have accumulated 13 possible points per day if she tracked all variables of a daily food record. A final comprehensiveness score was calculated by dividing actual number of points received by the possible points a participant could have received and multiplying by 100.

Because participants often provide incomplete information for amount of food eaten and calories for food eaten, participants were given full credit (i.e., 1 point) if they wrote down all the amounts for the respective foods that were recorded, partial credit (i.e., 0.5 points) if they wrote down amounts for some of the respective foods that were recorded, and no credit (i.e., 0 points) if they did not write down amounts for the respective food that was recorded. The same coding applied to the calorie variable.

If a column was left blank (i.e., no written note indicating that a meal was skipped), it was assumed that the participant had a meal but did not record data (actual/possible = 0/7). On the other hand, if a participant skipped a meal and indicated this, she would not be penalized (actual/possible = 0/0). Calculating a percentage comprehensiveness score accounted for participants who may have skipped a meal and thus could not accumulate all the points.

Aim 2

The second aim of this study is to examine the association between various characteristics of self-monitoring (i.e., frequency, consistency, and comprehensiveness) and percent weight regain during a 12-month extended-care period following the completion of 6-month lifestyle intervention for weight loss

Hypothesis 1. A higher frequency of self-monitoring would be associated with a smaller amount of weight regain.

Hypothesis 2. Higher levels of consistency of self-monitoring would be associated with a smaller amount of weight regain.

Hypothesis 3. Higher levels of comprehensiveness of self-monitoring would be associated with a smaller amount of weight regain.

Analyses

First, simple linear regressions were used to examine the relationship between self-monitoring variables and percent weight regain during months 7 to 18. Because consistency, as defined by three or more records submitted per week, is likely to be highly correlated with frequency, a hierarchical regression was used to examine the added benefit of consistency after controlling for frequency of self-monitoring.

Aim 3

Self-monitoring plays a critical role in the process of behavior change, according to Self-Regulation Theory (Kanfer, 1970) because it provides an individual with feedback about his or her behavior and subsequently allows the individual to evaluate his or her progress in achieving a stated goal. The feedback from self-monitoring thus allows the individual either to reinforce or to modify his or her target behavior. In this study, participants aimed to lose weight by decreasing caloric intake. Each participant had a daily calorie goal, she had to meet. Thus, the third aim of this study was to evaluate the relationship between self-monitoring behaviors, percent weight regain, and meeting goals.

Hypothesis 4: Meeting daily calorie goals would mediate the relationship between self-monitoring and percent weight regain.

Analysis

Bootstrapping analysis was conducted using methods described by Preacher and Hayes (2008) for estimating direct and indirect effects of mediators. Bootstrapping is a nonparametric re-sampling procedure that is advocated for testing mediation; it involves repeatedly sampling from the data set and estimates the indirect effect in each re-

sampled data set. The estimation process is repeated thousands of times to build an empirical approximation of the sampling distribution of *ab* (indirect effect), which is subsequently used to construct a confidence interval for the indirect effect (Preacher & Hayes, 2008). Three main advantages of the bootstrapping procedure are that (a) multiple mediators can be tested simultaneously, (b) the assumption of a normal sampling distribution is not imposed, and (c) the likelihood of Type 1 error is reduced by minimizing the number of inferential tests (Preacher & Hayes, 2004, 2008).

Aim 4

Successful weight maintenance has been defined as "achieving an intentional weight loss of at least 10% of initial body weight and maintaining this weight loss for at least one year" (Wing & Hill, 2001; NHLBI, 1998). For the final aim, a sub-set of participants who lost 10% of their initial body weight at the end of Phase 1 of the study (i.e., month 6) were analyzed. From this sub-set, the participants were further classified into three degrees of successful maintenance (High, Moderate, or Low) based on their body weight at the end of the study (month 18), and differences in the study variables of self-monitoring (frequency, consistency, and comprehensiveness) were examined between the three maintenance groups. Based on the a criteria from the NHLBI (1998, High-Success Maintainers were defined as participants who maintained ≥10% of initial body weight at month 18, Moderate-Success Maintainers were those who maintained between 5 - 9.99 % of their initial body weight at month 18, and Low-Success Maintainers were those participants who maintained < 5% of their initial body weight at month 18.

Hypothesis 5: The highest levels of frequency, consistency, and comprehensiveness of self-monitoring would be observed in the High Success Maintainers followed by the Moderate- and Low-Success groups.

Analyses

Using post-hoc defined groups, a MANOVA was run to examine differences for High-Success, Moderate-Success, and Low-Success Maintainers on self-monitoring variables. The independent variable was the *success category* (i.e., high, moderate, and low success) and the dependent variables were the self-monitoring variables.

CHAPTER 3
RESULTS

Sample Characteristics

A total of 298 women initiated treatment in the standard 6-month lifestyle modification program (Phase 1). Two hundred and thirty four women completed the initial treatment and were randomized into one of three extended-care programs delivered over the following 12 months (Phase 2). Of the latter group, 220 women (i.e. completers) completed both phases of the intervention and had recorded weights at all assessment time-points: baseline (Month 0), at the conclusion of Phase 1 (Month 6), and at the conclusion of Phase 2 (Month 18). There were 14 women (i.e., non-completers) who did not have recorded weights at Month 18. Baseline demographic characteristics for age, height, weight, BMI, and percentages for ethnicity, employment, marital status, education level, and income are presented in Table 3-1.

Weight and weight change characteristics are presented in Table 3-2. No statistically significant differences were found between completers and non-completers with respect to body weight at Month 0, t (232) = -0.93, p = .35, change in body weight from Month 0 to 6, t (232) = 0.10, p = .92, or percent body weight changes from Month 0 to 6, t (232) = -0.29, p = .77.

Mean and standard deviations for frequency, consistency, and comprehensiveness of self-monitoring for food records that were submitted from Month 7 to 18 (Phase II or the extended-care year) are presented in Table 3-3. An ANOVA revealed group differences between the completers and non-completers for frequency of self-monitoring, F (1, 233) = 8.88, p = .003, such that women who did not complete the study, submitted significantly fewer food records than women who completed the

study. A significant difference was also found for consistency of self-monitoring, F (1, 233) = 9.60, p = .002; women who did not complete the study, submitted food records less consistently than women who completed the study. Finally, a marginally significant difference was found for completers and non-completers for comprehensiveness of self-monitoring, F (1, 233) = 3.48, p = .06.

Preliminary Analyses

To verify that the assumptions for normality were met, the data were examined for skewness and kurtosis. Although, a value of zero indicates a normal distribution, values between 2.0 and -2.0 are acceptable criterion for meeting the assumptions of normality. Skewness and kurtosis values were also converted to z-statistics; because the study sample was large, values between 2.58 and -2.58 were used to verify normal data. The sample in this study (n = 220) met the criterion for normality for percent weight change from Months 7 to 18. See Table 3-4 for means, standard error, and z-statistics of skewness and kurtosis for the study participants.

The self-monitoring variables were non-normal and were transformed as needed for subsequent analyses. Frequency data were positively skewed and was transformed using a square root transformation ($\sqrt{(X_i + 1)}$). Consistency data were bimodal in nature, which made transformation by log, square root or reciprocal ineffective; this variable was re-coded into two categories that represented participants who consistently self-monitored for 50% or more of the follow-up year and those who did not. Comprehensiveness data were negatively skewed and was bimodal in nature; these data were transformed to improve normality by first reflecting the data (subtracting each score from the highest score obtained; 100- Xi) and then taking the logarithm of the reflected numbers ($\log_{10}(100-X_i)$). Transformed and recoded data were used in

subsequent analyses, as noted. See Table 3-5 for Skewness and Kurtosis statistics for the transformed variables.

Primary Analyses

Aim 1

Frequency. The first aim of the study was to describe the characteristics of self-monitoring (i.e., frequency, consistency, and comprehensiveness) of dietary intake using written food records. During Months 7 to 18 of the study, the mean number of complete records that were submitted was M = 113.53 ± 98.24 (range = 0 to 336). As reported in the TOURS main outcome paper (Perri et al., 2008), participants in the telephone-based and office-based/ face-to-face follow-up conditions submitted significantly more food records than participants in the mail-based/educational control extended-care condition (see Table 3-6).

During Months 7 to 18 of the study, 23 women (10.5%) did not submit complete food records, 89 women (40.5%) submitted complete records for 1-25% of the days, 61 women (27.7%) submitted complete records for 26-50% of the days, 20 women (9.1%) of the sample submitted complete records for 51-75% of the days, and 27 women (12.3%) submitted complete records for 76-100% of the days (See Figure 3.1). Frequency of self-monitoring decreased from month 7 to month 18, as seen in Figure 3.2. The mean number of records submitted per week decreased from 3.62 ± 0.15 at month 7 to 1.46 ± 0.15 records per week at month 18.

Consistency. During Months 7 to 18 of the study, participants were asked to submit at least three records per week. The cut-off of three records per week was used to delineate between participants who were consistent vs. not consistent in their self-monitoring over the extended-care year. The average weeks per month in which

participants submitted three or more records per month was 1.84 ± 0.54 (range = 0 to 4 weeks/month); Consistency decreased from month 7 to month 18, as seen in Figure 3.3. On average, during months 7 to 18, 101 ± 29.6 participants (43.3% of the sample) had at least one week per month, in which they were adherent with record keeping; this decreased from month 7 to month 18, as seen in Figure 3.4.

Comprehensiveness. As noted earlier, comprehensiveness was determined using a point system, where each participant could accumulate a maximum of 13 points per day for a complete food record. The following equation was used to calculate a comprehensiveness score for each record: (actual number of points/ possible number of points) x 100. Due to the large volume of records, the extended-care year was divided into quartiles and individual records from the middle month (i.e., months 8, 11, 14, and 17) of each quartile were coded for comprehensiveness by the author. Finally, comprehensiveness scores from this 16-week subset of data were averaged and used to calculate a total comprehensiveness score for each participant.

Of the subset of records that were coded that contained self-monitoring information, the Time variable was recorded 68.3% of the time, the Food variable was recorded 100% of the time, the Amount variable was recorded 81.8% of the time, the Calorie variable was recorded 98.4% of the time, and the Total Calories variable was recorded 97.6% of the time. The average total comprehensiveness scores of records that contained self-monitoring information was 84.0 ± 15.03 (range = 29.4% to 100%); for participants who did not turn in records, it was assumed that they did not fill out information (i.e., comprehensiveness of 0%). Comprehensiveness scores decreased from Month 8 to 17, as seen in Figure 3.5.

Aim 2

The second aim of this study was to examine the relationship between characteristics of self-monitoring (i.e., frequency, comprehensiveness, and consistency) and percent weight regain during a 12-month period following the completion of a 6-monthlifestyle treatment for weight loss. The results of these analyses are separated by self-monitoring characteristics and described in detail below.

Frequency. As noted earlier, frequency data were transformed using the square root transformation ($\sqrt{(X_i + 1)}$). A simple linear regression was undertaken to determine the strength of the relationship between frequency of self-monitoring (number of complete food records; independent variable) and percent weight regain (% weight change from Month 7 to 18; dependent variable.) Results showed that higher frequency of self-monitoring, $b = -.57$, $p < .01$, resulted in significantly lower percent weight regain during the extended-care year, $R^2 = .157$, F (1, 219) = 40.46, $p < .01$; frequency of self-monitoring records explained 15.7 % of the variance in percent weight regain during the extended-care year.

Consistency. As noted earlier, consistency was re-coded into two categories: participants who consistently self-monitored for 50% or more of the follow-up year and those who did not; a t-test was used to examine differences in percent weight regain. The Levene's test for equality of variances was not significant, $F = .431$, $p = .512$, therefore the equal variances assumed statistic was used to interpret the t-test. Results showed that the mean percent weight change of participants who consistently self-monitored for 50% or more of the follow-up year, $M = -0.98\% \pm 6.67\%$, was significantly different than that of the participants who self-monitored for less than 50% of the follow-up year, $M = 5.1\% \pm 6.59\%$, t (218) = 6.08, $p < .001$.

Comprehensiveness. As noted earlier, comprehensiveness was transformed by taking the logarithm of the reflected data ($\log_{10}(100\text{-}X_i)$). A simple linear regression was undertaken to determine the strength of the relationship between comprehensiveness of self-monitoring (independent variable) and percent weight regain (% weight change from Month 7 to 18; dependent variable.) Results showed more comprehensive self-monitoring, $b = 2.92$, $p < .001$, resulted in significantly lower percent weight regain during the extended-care year, $R^2 = .068$, F (1, 215) = 15.64, $p < .001$; comprehensiveness of self-monitoring explained 6.8% of the variance in percent weight regain during the extended-care year. Because a person could have turned in fewer but more complete records, the data were further analyzed to examine an interaction among frequency and comprehensiveness of self-monitoring on percent weight regain.

A significant correlation was found between comprehensiveness and frequency, $r = -.51$, $p < .001$. Therefore for the next analysis, all main effects were centered before running the regression. Using a hierarchical regression analysis (HRA), percent weight change during months 7 to 18 (dependent variable) was regressed on frequency of self-monitoring (Block 1), comprehensiveness of self-monitoring (Block 2), and frequency X comprehensiveness interaction term (Block 3). Examination of the variance inflation factor (VIF) for the percent weight regain HRA revealed that mulitcollinearity among the independent variables was not significant. The VIF values ranged from 1.1 to 1.4, which are well below the recommended cut-off of ≤ 10 (Bowerman & O'Connell, 1990; Myers, 1990).

Results showed that frequency explained 15.4% of the variance in percent weight change, $R^2 = .154$, F (1, 215) = 38.82, $p < .001$). Comprehensiveness explained

an additional 0.6% of the variance in percent weight change; however, the variance explained was not significant above and beyond the variance explained by frequency. The Frequency X Consistency interaction term explained an additional 4.9 % of the variance in percent weight regain, $R^2 = .208$, F (2, 215) = 18.59, $p < .001$. The three predictor model was the best in predicting percent weight regain, however, only two of the variables (frequency and the interaction term) contributed significantly to the variance explained by the model. See Table 3-7 for predictors of percent weight regain during Months 7 to 18.

Aim 3

The third aim of this study was to evaluate the relationship between self-monitoring behaviors, percent weight regain, and meeting daily caloric intake goals. Because univariate and multivariate assumptions of normality were violated, consistency was removed as an indicator. Percent adherence to daily caloric intake goals was considered a potential mediator as it correlated significantly ($p < .001$) with self-monitoring variables of frequency and comprehensiveness and with percent weight regain. During months 7 to 18, participants met their weekly calorie goal an average of 19.0% ± 19.1% of the days that they completed food records (range = 0 to 87%).

To determine whether percent adherence to daily caloric intake goals fully mediated the relationship between self-monitoring and percent weight-regain, bootstrapping analyses were conducted using methods described by Preacher and Hayes (2008) for estimating direct and indirect effects of mediators. In the current analysis, 2000 bootstrapping estimations were requested to build an empirical approximation of the sampling distribution of *ab* (indirect effect). This sampling

distribution was subsequently used to construct a confidence interval for the indirect effect (Preacher & Hayes, 2008).

Percent weight regain was entered as the dependent variable, frequency of self-monitoring controlling for comprehensiveness of self-monitoring was entered as the predictor variable, and percent adherence to daily caloric intake goals was entered as a proposed mediator in the SPSS macro created by Preacher and Hayes for bootstrap analyses. The bootstrap results indicated that the total effect of frequency of self-monitoring on percent weight regain, while controlling for comprehensiveness of self-monitoring (total effect = -.49, $p < .001$) became non-significant when the percent adherence to daily caloric intake goals was included in the model as a mediator (direct effect self-monitoring = -.08, $p = .63$). Furthermore, the analyses revealed, with 95% confidence, that the total indirect effect (i.e., the difference between the total and direct effects) of frequency of self-monitoring on the outcome variable through the mediator was significant, with a point estimate of -0.42 and a 95% BCa (bias-corrected and accelerated; Efron, 1987) bootstrap confidence interval of -.7242 to -.0308. Thus, percent adherence of daily caloric intake goals fully mediated the association between frequency of self-monitoring and percent weight regain, F (3, 212) = 17.37, $p < .001$.

The analysis was re-run entering percent weight regain as the dependent variable, comprehensiveness of self-monitoring controlling for frequency of self-monitoring as the predictor variable, and percent adherence to daily caloric intake goals as the proposed mediator in the SPSS macro for bootstrap analysis (Preacher & Hayes, 2008). The bootstrap results indicated that the total effect of comprehensiveness of self-monitoring on percent weight regain (total effect = .98, $p = .23$) remained non-significant when the

percent adherence to daily caloric intake goals was included in the model as a mediator (direct effect self-monitoring = .96, p = .23).

While Barron and Kenny (1986) require the total effect (path between X and Y) to be significant in order to proceed with mediation, several authors have argued that a significant total effect of *X* on *Y* is not necessary for mediation to occur (Preacher & Hayes, 2008). The second analyses revealed, with 95% confidence, that the total indirect effect (i.e., the difference between the total and direct effects) of comprehensiveness of self-monitoring on the outcome variable through the mediator was not significant, with a point estimate of .017 and a 95% BCa (bias-corrected and accelerated; Efron, 1987) bootstrap confidence interval of -.3304 to .4799. Percent adherence of daily caloric intake goals, however, was still found to be a full mediator of self-monitoring and percent weight regain, F (3, 212) = 17.37, p < .001.

Aim 4

For the fourth aim, the use of self-monitoring among women who lost ≥ 10% of their baseline body weight after the 6-month lifestyle intervention was examined. Overall, 113 women (54.1% of the sample) were successful in losing ≥10% of their initial body weight from months 0 to 6, M = -14.60% ± 3.20%. These women were classified as High-Success Maintainers (women who maintained ≥ 10% of initial body weight at month 18), Moderate-Success Maintainers (women who maintained between 5 - 9.99 % of their initial body weight at month 18), and Low-Success Maintainers (women who maintained < 5% of their initial body weight at month 18).

During Months 7 to 18, High-Success Maintainers (n = 70) continued to lose an average of -2.52 % ± 6.73% of their initial body weight, Moderate-Success Maintainers (n = 22) gained an average of 6.68% ± 4.03% of their initial body weight, and Low-

Success Maintainers (n = 21) gained an average of 12.92% ± 5.06% of their initial body weight. Thus, at Month 18, High-Success Maintainers lost a total of 17.92% ± 5.94% of their initial body weight, Moderate-Success Maintainers lost a total of 7.34% ± 1.56% of their initial body weight, and Low-Success Maintainers lost a total of 1.06% ± 2.72% of their initial body weight.

Frequency and Comprehensiveness. A Multivariate Analysis of Variance (MANOVA) was conducted to examine the mean differences between women who maintained > 10% of their initial body weight at Month 18 (High-Success Maintainers), women who maintained 5 - 9.9% of their initial body weight at Month 18 (Moderate-Success Maintainers) and women who maintained < 5% of their initial body weight at Month 18 on frequency and comprehensiveness of self-monitoring. Transformed frequency and comprehensiveness variables were used in this analysis. The independent variable was degree of success (high, moderate, or low) in maintaining weight at Month 18 and the dependent variables were the self-monitoring variables (frequency and comprehensiveness).

The Box's Test was not significant, thus, homogeneity of variance-covariance was met, Box's M = 5.86, F (6, 27441) = .937, p = .467, and a Wilks' Lambda test statistic was used to interpret the MANOVA results. A significant difference was found for degree of success in maintaining and self-monitoring variables, Wilks' Lambda = .78, F (4, 212) = 6.93, p < .001, η^2 = .12. Analysis of the independent variables showed that group differences in the comprehensiveness of food records did not reach Bonferroni-corrected significance, F (2, 107) = 3.52, p = .03, η^2 = .06. The three groups differed,

however, in terms of the frequency of self-monitoring submitted, F (2, 107) = 14.71, p < .001, η^2 = .22. Follow-up univariate ANOVAs were conducted to provide further details.

Levene's Test of Equality of Error Variance was not significant, F (2, 107) = .182, p = .83; therefore, a Bonferroni-corrected post hoc comparison were interpreted. Examination of mean frequency revealed that High-Success Maintainers submitted significantly more self-monitoring records than the Moderate-Success Maintainers, p = .005, and Low-Success Maintainers, p < .001. However, no significant difference was found between Moderate-Success Maintainers and Low-Success Maintainers for frequency of self-monitoring, p = .32. See Table 3-8 for mean and standard deviation for weight, frequency, and comprehensiveness of records submitted by success category during Months 7 to 18.

Consistency. A multi-dimensional chi-square test was performed to test the differences in consistency of self-monitoring (consistency≥ 50% vs. < 50% during Months 7 to 18) between success categories (high, moderate, and low-success) during the extended-care year. Results showed a significant relationship between consistency of self-monitoring and success in weight maintenance, χ^2 (2, N = 113) = 29.35, p < .001. The association was of moderate strength, Cramer's V = .510, p < .001, and consistency of self-monitoring accounted for 26% of the variance in the success of maintaining lost weight. See Table 3-9 for crosstabulation results of for consistency of self-monitoring and success in maintenance of weight loss during Months 7 to 18. See Figure 3.6 for consistency of self-monitoring by extended-care group.

Because the *Frequency, Consistency,* and *Comprehensiveness* data were non-normal, the analyses were re-run as using three Kruskal-Wallis tests (the non-

parametric equivalent of the one-way between subjects ANOVA) on the untransformed self-monitoring data. Results of the first Kruskal-Wallis test revealed a significant effect of frequency of self-monitoring on maintenance success, χ^2 (2, N = 113) = 25.72, p < .001. Follow-up Mann-Whitney U tests were run on all pairs of groups to determine if there were significant differences between them.

Results revealed a significant difference between High-Success Maintainers (n = 70) and Low-Success Maintainers (n = 21) on the frequency of self-monitoring, U = 246.00, p < .001, such that High-Success Maintainers (median = 147, range = 311) self-monitored more frequently than Low-Success Maintainers (median = 51, range = 194). A significant difference was also revealed between High-Success Maintainers (n = 70) and Moderate-Success Maintainers (n = 22) on the frequency of self-monitoring, U = 440.50, p = .003, such that High-Success Maintainers (median = 147, range = 311) self-monitored more frequently than Moderate-Success Maintainers (median = 101.00, range = 258). There was no statistically significant difference between Moderate-Success Maintainers (n = 22) and Low-Success Maintainers (n = 21) on the frequency of self-monitoring, U = 158.00, p = .076.

Results of the second Kruskal-Wallis test revealed a significant effect of consistency of self-monitoring on maintenance success, χ^2 (2, N = 113) = 32.01, p < .001. Follow-up Mann-Whitney U tests were run on all pairs of groups to determine if there were significant differences between them. Results revealed a significant difference between High-Success Maintainers (n = 70) and Low-Success Maintainers (n = 21) on the consistency of self-monitoring, U = 222.00, p < .001, such that High-Success Maintainers (median = 40.50, range = 50) self-monitored more consistently

than Low-Success Maintainers (median = 9, range = 49). A significant difference was revealed between High-Success Maintainers (n = 70) and Moderate-Success Maintainers (n = 22) on the consistency of self-monitoring, U = 354.50, p < .001, such that High-Success Maintainers (median = 40.50, range = 50) self-monitored more consistently than Moderate-Success Maintainers (median = 20.50, range = 47). Finally, a significant difference was also revealed between Moderate-Success Maintainers (n = 22) and Low-Success Maintainers (n = 21) on the consistency of self-monitoring, U = 147.00, p = .041, such that Moderate-Success Maintainers (median = 20.5, range = 47) self-monitored more consistently than Low-Success Maintainers (median = 9.0, range = 49).

Results of the third Kruskal-Wallis test revealed that there was a non-significant effect of comprehensiveness of self-monitoring on maintenance success, χ^2 (2, N = 113) = 5.42, p = .067. Thus, the overall results of the non-parametric testing also support the previous findings.

Table 3-1. Baseline Descriptive Statistics of Women who Participated, Completed, and Did Not Complete Assessments at Months 0, 6 and 18.

Variable	All Participants (*N* = 234) *M* (*SD*)	Completers (*n* = 220) *M* (*SD*)	Non-Completers (*n*=14) *M* (*SD*)
Age	59.14 (6.05)	59.29 (6.06)	57.88 (6.02)
Height (cm)	161.82 (5.75)	161.85 (5.83)	161.33 (4.43)
Weight (kg)	96.38 (14.80)	96.61 (15.08)	92.81 (9.02)
BMI (kg/m^2)	36.76 (4.85)	36.82 (4.89)	35.75 (4.21)
Ethnicity (%)			
African-American	18.4	18.2	21.4
Caucasian	77.4	77.7	71.4
Hispanic/Latina	2.1	2.3	7.1
Other	2.1	1.8	0.0
Employment (%)			
Not working	8.1	8.2	7.1
Retired	26.1	25.9	28.6
Homemaker	4.3	4.1	7.1
Employed (FT or PT)	45.7	45.9	42.9
Disabled	2.1	2.3	0.0
Other	1.7	1.8	1.0
More than one category	12.0	11.8	14.3
Marital Status (%)			
Never Married	1.7	1.4	7.1
Divorced or separated	10.7	10.9	7.1
Widowed	9.0	9.5	0.0
Presently married	76.1	75.5	85.7
Living in marriage-like relationship	2.6	2.7	0.0
Education Level (%)			
Less than 12 years	37.2	38.6	14.3
Trade, voc., assoc. degree	41.0	40.9	42.9
Bac degree	11.5	10.5	28.6
Post-bac study/ degree	10.3	10.0	14.3
Annual Household Income (%)			
Less than $10,000	5.1	5.0	7.1
$10,000-19,999	15.5	15.9	7.1
$20,000-34,999	23.2	22.7	28.6
$35,000-49,999	21.9	21.8	21.4
$50,000-74,999	19.7	20.5	7.1
$75,000-99,999	9.9	9.5	14.3
$100,000-149,000	3.0	2.7	7.1
$150,000 or more	0.4	0.5	0.0
Don’t know/ no answer	1.3	1.4	0.0

Table 3-2. Weight and Weight Change Statistics.

Variable	Randomized Participants (*N* = 234) *M* (*SD*)	Completers (*n* = 220) *M* (*SD*)	Non-Completers (*n* = 14) *M* (*SD*)
Weight (kg)			
Month 0	96.38 (14.80)	96.61 (15.08)	92.81 (9.02)
Weight Change (kg)			
Month 0 to Month 6	-9.99 (5.17)	-10.00 (5.30)	-9.86 (2.67)
Weight Change (%)			
Month 0 to Month 6	-10.42 (5.18)	-10.39 (5.28)	-10.80 (3.36)

Table 3-3. Mean and Standard Deviation Scores for Number of Food Records Submitted From Month 7 to Month 18 for Women Who Were Randomized, Completed, and Did Not Complete Assessments at Months 0, 6 and 18.

Variables	Randomized Participants (*N* = 234) *M* (*SD*)	Completers (*n* = 220) *M* (*SD*)	Non-Completers (*n* = 14) *M* (*SD*)
Frequency	108.82 (97.39)	113.53 (98.24)[a]	34.86 (33.79) [a]
Consistency	22.59 (17.60)	23.47 (17.67) [b]	8.71 (8.42) [b]
Comprehensiveness	70.79 (33.66)	71.37 (33.10)	54.61 (43.61)

[a] $p = .033$, [b] $p = .002$ between Completers and Non-Completers

Table 3-4. Mean, Standard Error, and Z-Statistics of Skewness and Kurtosis for the 220 Women Who Completed the Study.

Variables	Skewness *M* (*SE*)	*z-stat*	Kurtosis *M* (*SE*)	*z-stat*
% weight change (Months 7 – 18)	-.236 (.16)	-1.47	.762 (.33)	2.31
Frequency of Self-Monitoring	.821 (.16)	5.13	-.316 (.33)	-0.96
Consistency of Self-Monitoring	.170 (.16)	1.06	-1.47 (.33)	-4.45
Comprehensiveness of Self-Monitoring	-1.37 (.16)	-8.56	.487 (.33)	-1.48

Table 3-5. Mean, Standard Error, and Z-Statistics of Skewness and Kurtosis of Transformed Self-Monitoring Variables for the 220 Women Who Completed the Study.

Transformed Variables	Skewness *M* (*SE*)	*z-stat*	Kurtosis *M* (*SE*)	*z-stat*
Frequency of Self-Monitoring	-.020 (.16)	-0.13	-.862 (.33)	-2.61
Comprehensiveness of Self-Monitoring	-.634 (.17)	-3.73	.403 (.33)	1.22

Table 3-6. Number of Food Records Submitted by Group Randomization.

Randomization	*n*	Complete Food Records *M* (*SE*)
Office/ Face-to-face	83	109 (10.6)[a]
Telephone	72	131 (11.3)[b]
Mail/ Education Control	79	80 10.8)

[a] p = .006, [b] p = .03 versus mail/ education control group

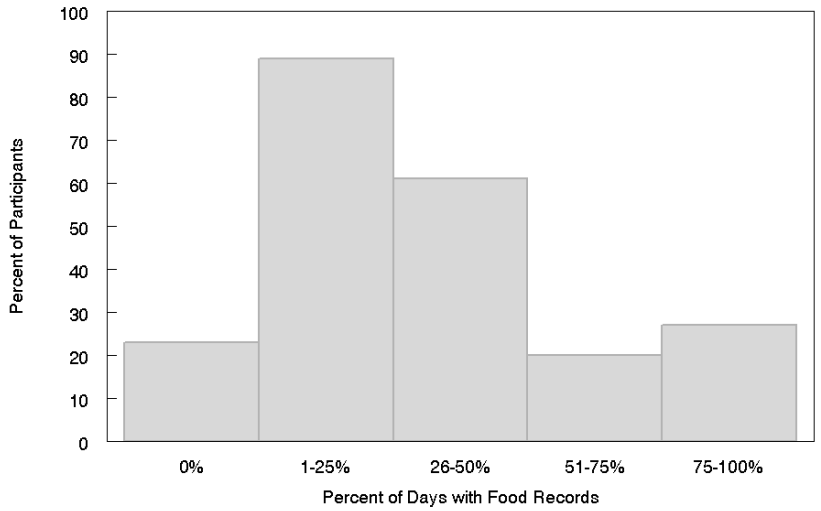

Figure 3-1. Number of Participants in the Different Categories Based On Percent of Days with Food Records Submitted During Months 7 to 18.

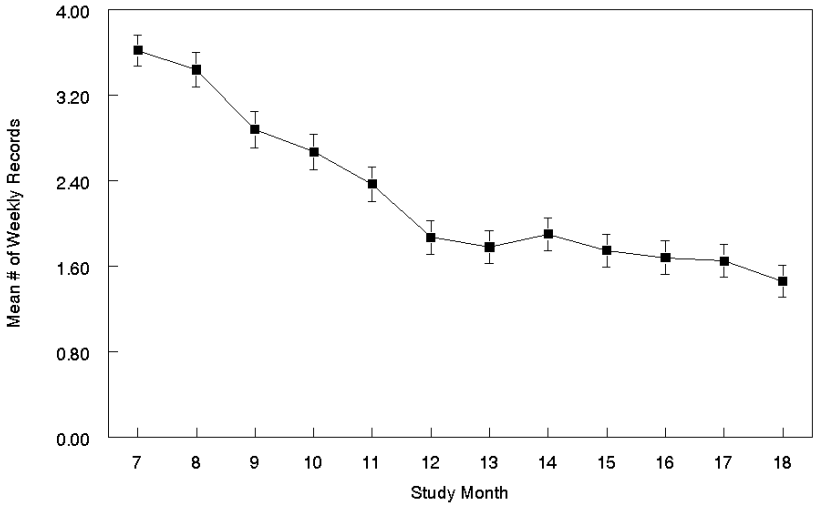

Figure 3-2. Mean (± SE) Number of Weekly Food Records Submitted During Months 7 to 18.

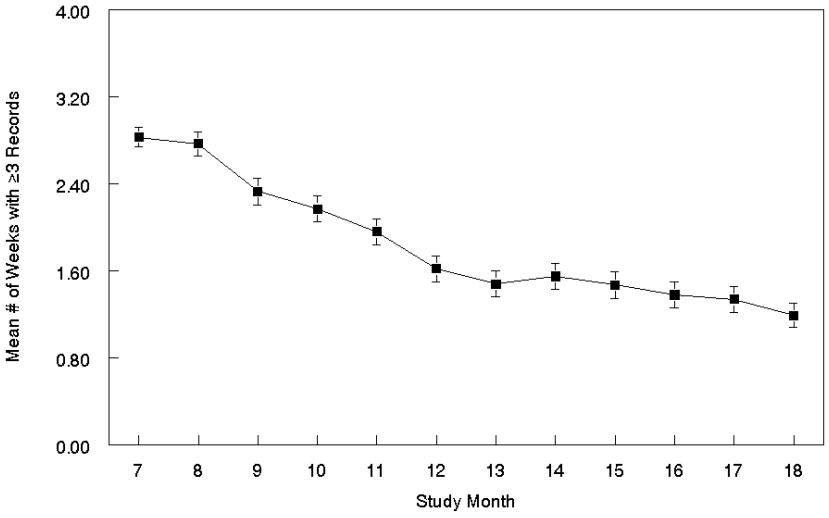

Figure 3-3. Mean (± SE) Number of Weeks With Three or More Records Submitted During Months 7 to 18.

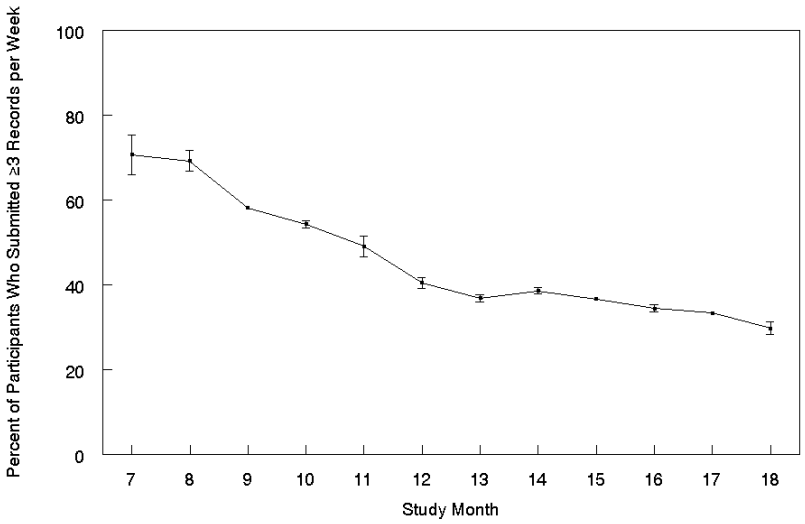

Figure 3-4. Mean Percent (± SE) of Participants Who Submitted Three or More Records Per Week During Months 7 to 18.

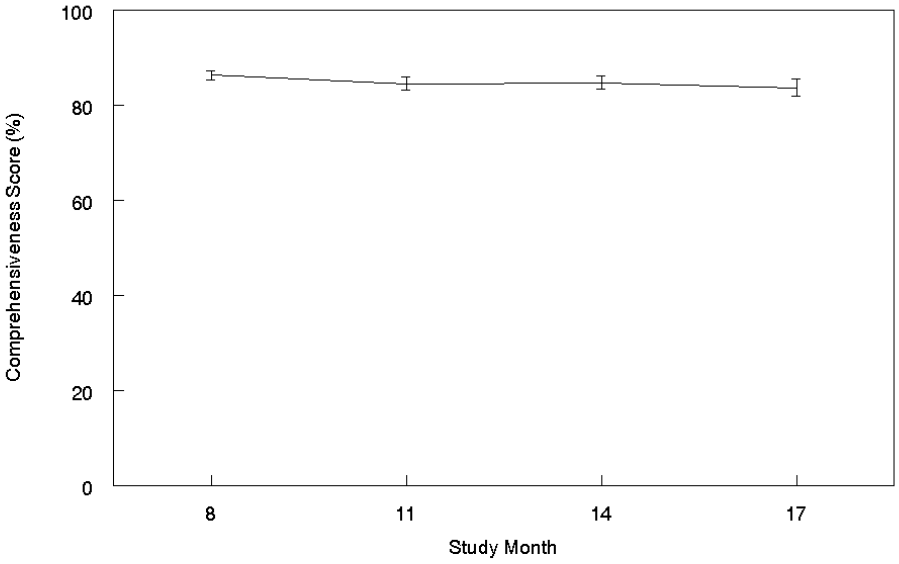

Figure 3-5. Mean (± SE) Comprehensiveness Scores Across Time from Months 7 to 18.

Table 3-7. Hierarchical Regression Predicting Weight Change during Months 7 to 18 by Self-Monitoring Variables.

% Weight Change	R^2	*F*	*df*	β	*t*	*p*
Block 1	.154	38.82	1, 215			
Frequency				-.392	-6.23	< .001
Block 2	.159	20.20	1, 215			
Frequency				-.348	-4.81	< .001
Comprehensiveness				.088	1.22	.23
Block 3	.208	18.59	1, 215			
Frequency				-.420	-5.74	< .001
Comprehensiveness				.108	1.53	.13
Freq X Comp Interaction				.236	3.62	< .001

Table 3-8. Mean and Standard Deviation for Weight, Frequency, and Comprehensiveness of Records Submitted By Success Category during Months 7 to 18.

Variables	High Success ≥10% (*n* = 70) *M* (*SD*)	Moderate Success 5 - 9.99% (*n* = 22) *M* (*SD*)	Low Success < 5% (*n* = 21) *M* (*SD*)
% Wt loss at Month 18	17.92 (5.94)	7.34 (1.56)	1.06 (2.72)
Frequency	156.63(18.20)[ab]	85.53 (15.20)[b]	50.92 (16.36) [a]
Comprehensiveness	91.80 (3.48)	87.44 (4.60)	80.50 (3.70)

[a] $p < .001$, [b] $p < .01$ between Success Category with Bonferroni-corrected significance of p < .025

Table 3-9. Crosstabulation for Observed Count of Consistency of Self-Monitoring and Success in Maintenance of Weight Loss during Months 7 to 18.

Success Category	Yes Monitored ≥ 50%	No Monitored < 50%	Totals
High Success ≥10%	52	18	70
Moderate Success 5 - 9.99%	7	15	22
Low Success < 5%	3	18	21

$p < .001$

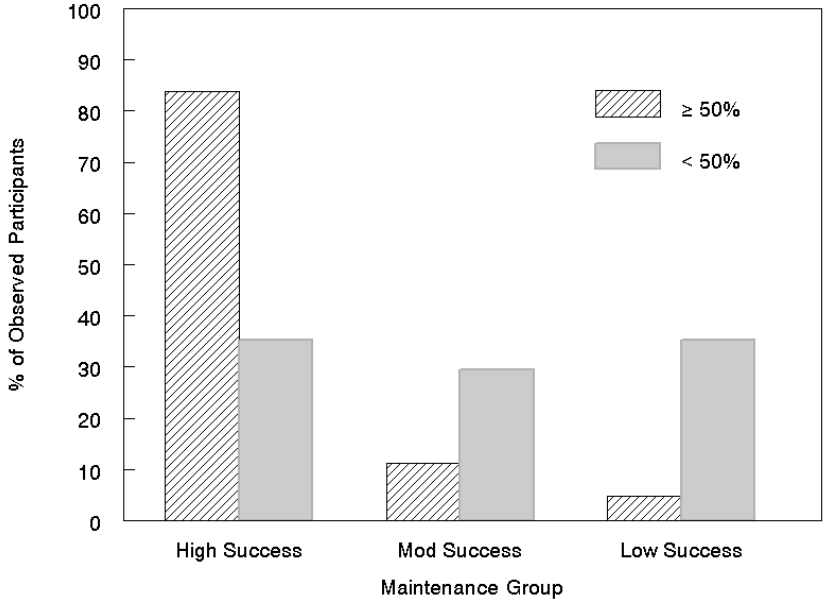

Figure 3-6. Consistency of Self-Monitoring by Success Category

CHAPTER 4
DISCUSSION

According to Self-Regulation Theory, self-monitoring plays a critical role in the process of behavior change (Kanfer, 1970). Self-monitoring of behavior provides an individual with feedback that allows the individual to evaluate his or her progress in achieving a stated goal. The feedback from self-monitoring thus allows the individual either to reinforce or to modify his or her target behavior.

Self-monitoring has consistently been found to be a key behavioral component in the treatment of obesity and is associated with successful weight loss (Baker & Kirschenbaum, 1993; Streit, Stevens, Stevens, & Rossner, 1991; Wadden, 1993). Thus, participants in weight management programs are taught to complete daily written logs of their food intake (Brownell, 2004). While numerous studies have demonstrated the beneficial effects of dietary self-monitoring in promoting initial weight loss, less is known about the contribution of self-monitoring to the *maintenance* of lost weight. To our knowledge, the current study is the first investigation to examine the characteristics of self-monitoring associated with successful maintenance of lost weight.

Main Findings

The first aim of the present study was to describe the patterns of self-monitoring (i.e., frequency, consistency, and comprehensiveness) during a 12-month extended-care period following the completion of 6-month lifestyle intervention. Frequency was defined as number of food records that were submitted, consistency was defined as the number of weeks that a participant completed three or more food records, and comprehensiveness was defined as the amount of information that was tracked on each individual food record. During study month 7 (the first month of extended care), the

women in the study submitted an average of 3.62 ± 0.15 food records per week. This number declined each month until study month 18 (the end of the study) when 1.46 ± 0.15 records per week were submitted. This finding may reflect the fact that although participants were encouraged to continue self-monitoring their intake on a daily basis during months 7 to 18, they were only required to submit at least three food records per week during the extended-care period.

Next, consistency of self-monitoring over the extended-care year was examined. Results revealed that the mean number of weeks in which a participant submitted three or more records decreased from 2.83 ± 1.36 at month 7 to 1.19 ± 1.69 at month 18. Furthermore, the percent of participants who were adherent to the requirement of self-monitoring at least 3 days per week also decreased from 70.7% ± 4.7 at month 7 to 29.8% ± 1.5 at month 18. The pattern of decline seen in both the frequency and consistency of self-monitoring is in line with previous findings that self-monitoring of eating and exercise behaviors and other adherence factors (e.g., attendance, adherence to fat gram goals and exercise goals) decline as the intervention intensity is reduced (Acharya, et al., 2009; Burke, et al, 2006; Burke, et al., 2008).

Comprehensiveness of self-monitoring was also examined for a subset of 16 weeks of the extended-care year that fell during study months 8, 11, 14, and 17. Interestingly, while the number of participants who submitted food records decreased over time from 186 ± 13.4 at month 8 to 100 ± 18.2 at month 17, the mean scores for comprehensiveness of food records submitted remained fairly stable from 86.3% ± 13.4% month 8 to 83.7% ± 18.2% at month 17. That is, the women who continued to submit food records remained fairly comprehensive with their self-monitoring. It is likely

that as comprehensiveness declined, that the participants in this study also stopped submitting records.

For the next aim of this study, the components of self-monitoring and their relation to percent weight regain during a one-year extended-care period following lifestyle treatment of obesity were investigated. It was hypothesized that higher levels of frequency, consistency, and comprehensiveness would be related to lower percent weight regain during the extended-care year.

Results showed that frequency of self-monitoring resulted in significantly lower percent weight regain during the extended-care year. For the consistency variable, the participants were categorized into two groups; those who self-monitored≥ 50% of the extended-care year and those who self-monitored < 50% of the extended-care year. Results showed that the women who self-monitored 50% or more of the follow-up year lost weight (-1.0%), while the women self-monitored less than 50% of the extended-care year gained weight (5.1%) during the follow-up year.

Finally, comprehensiveness was examined in two ways. First comprehensiveness and its relationship to percent weight regain was analyzed. Results showed more comprehensive self-monitoring was related to significantly lower percent weight regain during the extended-care year. Again, because it was highly probably that participants submitted fewer but more complete records, the data were further analyzed to examine an interaction among frequency and comprehensiveness of self-monitoring on percent weight regain. Results of the hierarchical regression analysis revealed that comprehensiveness did not provide any added benefit above and beyond the variance explained by frequency. This finding supports previous literature that states that

frequency of recording was more important than the detail of recording in the facilitation of short-term weight loss in adults (Helsel, Jakicic, & Otto, 2007). On the other hand, the interaction of frequency and comprehensiveness of self-monitoring explained an additional 4.9 % of the variance in percent weight regain above and beyond frequency of self-monitoring; the latter result suggests that higher comprehensiveness along with high frequency helps facilitation weight maintenance and further weight loss, but that high comprehensiveness with low frequency of self-monitoring may not have as much impact on weight management.

Next the relationship between self-monitoring, meeting daily calorie goals, and percent weight regain was examined. Based on the Self-regulation Theory, it was hypothesized that self-monitoring would have a direct effect on percent weight regain and that meeting goals would mediate this relationship. Results revealed that meeting weekly calorie goals fully mediates the relationship between self-monitoring and weight regain. Thus, self-monitoring appears to facilitate the maintenance of lost weight by helping participants to adhere to daily caloric intake goals. These findings directly support the Self-Regulation Theory proposed by Kanfer (1970) and suggest that self-monitoring serves as a key mechanism to promote behavior change.

Finally, a subset of women who initially lost 10% or more of their initial weight during the treatment period were examined. These participants were categorized as follows: *High-Success Maintainers* (i.e., participants who maintained a loss of 10% or more of their initial body weight at month 18), *Moderate-Success Maintainers* (i.e., participants who maintained a loss between 5 - 9.99% of their initial body weight at month 18), and *Low-Success Maintainers* (i.e., participants who maintained a loss of

less than 5% of their initial body weight at month 18.) It was hypothesized that High-Success Maintainers would self-monitor more frequently, more consistently, and more comprehensively than Moderate-Success Maintainers, who in turn would show higher levels than Low-Success Maintainers. Results revealed that women who were highly successful in maintaining their initial weight losses of ≥ 10% of their initial body weight at the end of the study, self-monitored at high levels of frequency and consistency compared to those women who were not able to sustain their initial weight losses of 10% or more. Again, comprehensiveness of self-monitoring did not affect success in weight maintenance.

Limitations and Strengths

In considering the implications of these findings, a few potential limitations should be noted. First, this study did not utilize a prospective, randomized design to assign participants to the different *frequencies* of self-monitoring per week. Additionally, paper-and-pencil self-monitoring was the method that was introduced. While the paper records were provided to each participant, some participants kept records via internet and computer programs. The paper-and-pen method may have become too time consuming and impractical for long-term use.

Second, a full intent-to-treat analysis was not possible because of missing weight data on 14 women at Month 18 of the study. The preliminary analyses revealed that these 14 women significantly differed in the frequency and thus, the consistency of their self-monitoring. It is most likely that these women stopped keeping food records and experienced increases in their weight during the one-year follow-up period. Because these women were excluded from the analyses, these findings should be interpreted with caution.

Third, because data for participants were collected within the parameters of the parent study, only measured weight at three time points (Months 0, 6, and 18) was available. Weekly weights during the extended-care period were for the most part based on participants' self report. If directly measured weekly weight data were available, more sophisticated trajectory analyses could have been conducted to examine patterns of self-monitoring across the weeks and months of the study.

Fourth, the prediction of weight change in this study was based solely on self-monitoring-related variables. Other variables that affect weight loss and weight maintenance that were not addressed in the analyses include attendance, changes in caloric intake, changes in physical activity, meal patterns, and mastery of other self-regulatory skills commonly taught in lifestyle programs (e.g., stimulus control, self-reinforcement, and cognitive restructuring). The inclusion of additional variables may increase our ability to predict long-term weight change.

Finally, the study is limited by the population; specifically, the study population consisted of only women between the ages of 50 and 75, who lived in rural counties. Generalizability, therefore, is limited by the exclusion of men and individuals of younger age groups.

Despite these limitations, the current study has a number of important strengths. While the benefits of self-monitoring as an essential component in the treatment of obesity have been demonstrated (Baker & Kirschenbaum, 1993; Streit, Stevens, Stevens, & Rossner, 1991), there is less research examining the relationship between self-monitoring and maintenance of lost weight (Acharya, et al., 2009.) This study

extends previous research by examining self-monitoring and weight regain over a one-year period following lifestyle treatment of obesity.

Second, these results revealed bi-modal distributions such that most participants self-monitored at high levels of frequency and consistency or at low levels of frequency and consistency. Non-normal data lead to a variety of potential statistical confounds (e.g., violations of homogeneity of variance and normality); however, these were considered and corrected for in the analyses (e.g., using transformations and non-parametric testing when appropriate). While the self-monitoring data were non-normal, they reflect the reality of self-monitoring in the population from which the sample is drawn.

Third, the richness of data that was provided and analyzed in this study along with the sample size of the study population serves as a strength. In general, previous studies focus on number of completed verses non-completed records. These data also provided results that support previous research on weight loss but also highlight significant outcomes related to long-term weight maintenance.

Clinical Significance and Future Directions

Our findings suggest that self-monitoring is important to long-term success in weight management. Specifically, high frequency and consistency are related to lower percent weight regain. This finding suggests that self-monitoring of dietary intake on a regular basis should be encouraged beyond the initial treatment period. According to the results of the current study, food records should be kept for minimum of three days per week to sustain treatment-induced weight losses.

The results of the current study also highlight the mechanism behind self-monitoring and long-term success in weight management. It is clear that frequent self-

monitoring of dietary intake leads to awareness of behaviors. The information provided by food records subsequently helps people adhere to their daily calorie goals on a regular basis.

As researchers advocate for obesity to be treated in a continuous-care model, where obesity is viewed as a chronic disorder requiring long-term treatment (Lattner, Stunkard, Wilson, Zelitich, & Labouvie, 2000; Perri, 1998), it is necessary to identify the components of behavioral treatment that have the most impact on weight maintenance and to try to reduce the burden of these components. Streamlining the components of self-monitoring is important because participants in weight-loss programs often laud the importance of self-monitoring but also complain that it is time-consuming. Our findings suggest that the comprehensiveness or detail of self-monitoring provided by a participant is less important than the frequency of self-monitoring.

The latter finding is important as it provides further support for designing treatment programs that tailor methods of self-monitoring to the individual person. More convenient self-monitoring tools that provide instant feedback are likely to improve adherence to this important behavior. While results of self-monitoring using personal electronic devices vs. traditional paper and pen methods have shown use of a personal electronic device did not improve the relationship between self-monitoring and weight loss (Yon, Johnson, Harvey-Berino, Gold, & Howard, 2007), most researchers encourage matching participants with a self-monitoring method that is appropriate to their lifestyle and skill level (Burke, Swigart, Turk, Derro, & Ewing, 2009; Yon, Johnson, Harvey-Berino, Gold, & Howard, 2007).

Burke and colleagues (2009) completed a study in which they interviewed fifteen individuals who completed a behavioral weight loss treatment and explored their feelings and attitudes about paper-and-pen food records. They reported that positive personal feelings, committed and determined attitudes, aptitudes that favored organization and computation, and support from significant others helped promote and sustain self-monitoring. Their study results provided strong support for individuation of self-monitoring strategies to improve adherence and subsequent weight control (Burke, et al., 2009). Furthermore, use of abbreviated food records may decrease burden of self-monitoring and subsequently promote increased frequency of recording (Helsel, Jakicic, & Otto, 2007).

Summary and Conclusions

Results of the present study revealed that during the year following lifestyle treatment, frequency of self-monitoring was significantly related to lower percent weight regain. Participants who completed food records for at least 50% of the time were more likely to be successful in sustaining weight loss. Comprehensiveness self-monitoring was most effective when combined with frequent self-monitoring. Our findings showed that self-monitoring facilitates the maintenance of lost weight by helping participants to adhere to daily caloric intake goals and, that women who successfully maintained body weight losses 10% or more self-monitored more frequently and more consistently than those women who were unable to sustain their initial weight losses. These findings can be utilized in future clinical and research endeavors that aim to improve the long-term management of obesity in adults seeking lifestyle intervention. Self-monitoring should be promoted not only for initial weight loss but also for successful long-term weight maintenance.

APPENDIX
SELF-MONITORING RECORD

Keeping Track Log

Today's Date: _____

Time	Food Name	Amount	Activity	Feelings/ Place	Calories	Fat Grams
Breakfast						
Lunch				**Breakfast Total**		
Dinner				**Lunch Total:**		
Planned Snacks				**Dinner Total:**		
Unplanned Eating		**Planned Snack Total:**				
		Unplanned Eating Total:				
		Total meals and snack calories today:				

Did you meet your goals today?	**Yes/No**	**Planned Exercise Today**	
Stay within calorie goal.		**Type of Exercise**	**Time**
Meet step count goal.			
Follow my eating Plan: 3 meals & 1 snack			
Stay within fat gram goal?			
Total Steps Today:			

Notes

REFERENCES

Acharya, S.D., Elci, O.U., Sereika, S.M., Music, E., Sytn, M.A., Turk, M.W., & Burke, L.E. (2009). Adherence to a behavioral weight loss treatment program enhances weight loss and improvements in biomarkers, *Patient Preference and Adherence, 3*, 151-160.

Ainsworth B.E., Haskell W.L., Leon A.S., Jacobs R., Jr., Montoye H.J., Sallis J F., & Paffenbarger R.S. (1993). Compendium of physical activities: Classification of energy costs of human physical activities. *Medicine & Science in Sports & Exercise, 25*, 71-80. doi:10.1249/00005768-199301000-00011

American Heart Association. (2010). Heart Disease and Stroke Statistics – 2010 Update. Dallas, Texas: American Heart Association.

American College of Sports Medicine (ACSM). (2000). *Guidelines for exercise testing and prescription* (6th ed.) Philadelphia: Lippincott Williams & Wilkins.

Anderson, J.W., Konz, E.C., Frederich, R.C., & Wood, C.L. (2001). Long-term weight-loss maintenance: A meta-analysis of US studies. *American Journal of Clinical Nutrition, 74*, 579-584.

Baker, R.C. & Kirschenbaum, D. S. (1993). Self-monitoring may be necessary for successful weight control*. Behavior Therapy, 24*, 377-394. doi:10.1016/S0005-7894(05)80212-6

Binkley , J., Eales, J., & Jekanowski, M. (2000). The relation between dietary change and rising US obesity, *International Journal of Obesity, 24*, 1032-1039. doi:10.1038/sj.ijo.0801356

Boutelle K.N. & Kirschenbaum, D.S. (1998). Further support for consistent self-monitoring as a vital component of successful weight control. Obesity Research, 6, 219-224.

Boutelle, K. N., Kirschenbaum, D. S., Baker, R. C., & Mitchell, M. E. (1999). How can obese weight controllers minimize weight gain during the high risk holiday season? By self-monitoring very consistently. *Health Psychology, 18*, 364–368. doi:10.1037/0278-6133.18.4.364

Bornstein, P. H., Hamilton, S. B., & Bornstein, M. T. (1986). Self- monitoring procedures. In A. R. Ciminero, K. S. Calhoun, & H. E. Adams (Eds.), Handbook of behavioral assessment (2nd edition, NY: Wiley, pp. 176-222).

Bowerman, B. L., & O'Connell, R. T. (1990). Linear statistical models: An applied approach. (2nd ed.). Belmont, CA: Duxbury.

Bray, G. A. (2002). Drug treatment of obesity. In T. A. Wadden & A. J. Stunkard (Eds.), *Handbook of obesity treatment* (pp. 317-338). New York: Guilford Press.

Brownell, K.D., The LEARN program for weight management (10th edition). Dallas, TX: American Health Publishing Company; 2004.

Brownell, K.D., & Battle Horgen, K. (2004). Food fight, The inside story of the food industry, America's obesity crisis, and what we can do about it. New York, NY: McGraw-Hill.

Burke, L.E., Choo, J., Music, J., Warziski, M.T., Styn, M.A., Novak, J. & Sereika, S.M. (2006). Patterns of self-monitoring behavior affect weight change among weight loss study participants, *Annals of Behavioral Medicine, 31*, S017.

Burke, L. E., Sereika, S. M., Music, E., Warziski, M., Styn, M. A., & Stone, A. A. (2008). Using instrumented paper diaries to document self-monitoring patterns in weight loss. Contemporary Clinical Trials, 29(2), 182-193. doi:10.1016/j.cct.2007.07.004

Burke, L.E., Sigwart, V., Turk, M.W, Derro, N., & Ewing, L.J. (2009). Experiences of self-monitoring successes and struggles during treatment for weight loss. *Qualitative Health Research, 19*, 815-828. doi:10.1177/1049732309335395

Butryn, M.L., Phelan, S, Hill, J.O., & Wing, R.R. (2007). Consistent Self-Monitoring of weight: A key component of successful weight loss maintenance. *Obesity, 15*, 3091-3096. doi:10.1038/oby.2007.368

Calle E.E., Rodriguez, C., Walker-Thurmond, K., & Thun, M.J. (2003). Overweight, obesity, and mortality from cancer in a prospectively studied cohort of U.S. adults. *New England Journal of Medicine,*348, 1625–1638. doi:10.1056/NEJMoa021423

Calle, E.E., Thun, M.J., Petrelli, J.M., Rodriguez, C., & Heath, C.W. (1999). Body-mass index and mortality in a prospective cohort of U.S. adults. *New England Journal of Medicine, 341*, 1097-1105. doi:10.1056/NEJM199910073411501

Carels, R.A., Darby, L.A., Rydin, S., Douglass, O.M., Cacciapaglia, H.M., & O'Brien, W.H. (2005). The relationship between self-monitoring, outcome expectancies difficulties with eating and exercise, and physical activity and weight loss treatment outcomes. *Annals of Behavioral Medicine, 30*, 182-190. doi:10.1207/s15324796abm3003_2

Carpenter, K.M., Hasin, D.S., Allison, D.B., & Faith, M.S. (2000). Relationships between obesity and DSM-IV Major Depressive Disorder, suicide ideation, and suicide attempts: Results from a general population study. *American Journal of Public Health, 90*, 251-257. doi:10.2105/AJPH.90.2.251

Centers for Disease Control and Prevention. (2008). National diabetes fact sheet: General information and national estimates on diabetes in the United States, 2007. Atlanta, GA: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention.

Chan, J.M., Rimm, E.B., Colditz, G.A., Stampfer, M.J., & Willet, W.C. (1994). Obesity, fat distribution, and weight gain as risk factors for clinical diabetes in men. *Diabetes Care, 17,* 961-969. doi:10.2337/diacare.17.9.961

Ciminero, A.R., Nelson, R.O., & Lipinski, D.P. (1977). Self-monitoring procedures. In A.R. Ciminero, K.S. Calhoun, and H.E. Adams (Eds.) Handbook of behavioral assessment, New York; Wiley.

Clinical Guidelines on the Identification, Evaluation, and Treatment of Overweight and Obesity in Adults. (1998). NIH publication no. 98-4083. Bethesda, MD: National Institutes of Health.

Coates, T.J., Killen, J.D., Silverman, S., George, J., Marchini, E., Hamilton, S., & Thoresen, C.E. (1983). Cognitive activity, sleep disturbance, and stage specific differences between recorded and reported sleep. *Psychophysiology, 20*, 243–250. doi:10.1111/j.1469-8986.1983.tb02151.x

Cooper, C., Inskip, H., Croft, P., Campbell, L., Smith, G., McLaren, M., & Coggon, D. (1998). Individual risk factors for hip osteoarthritis: Obesity, hip injury, and physical activity. *American Journal of Epidemiology, 147*, 516-522.

Corsica, J.A., & Perri, M.G. (2003). Understanding and managing obesity. In A.M. Nezu, C.M. Nezu, & P. Geller (Eds.), *Comprehensive handbook of psychology, Volume 9: Health psychology* (pp. 121-146). New York: John Wiley & Sons.

Daniels, J. (2006). Obesity: America's epidemic: What goes up does not always come down. Is there a solution? *American Journal of Nursing, 106*, 40-49.

de Chardin, P.T. (1959). The phenomenon of man. New York: Harper.

DeAlberto, M.J., Ferber, C., Garma, L., Lemoine, P., & Alperovitch, A. (1994). Factors related to sleep apnea syndrome in sleep clinic patients. *Chest, 105*, 1753-1758. doi:10.1378/chest.105.6.1753

Dowell, S.A. & Welch, J.L. (2006). Use of electronic self-monitoring for food and fluid intake: A pilot study. *Nephrology Nursing Journal, 33,* 271-277.

D'Zurilla T. J., & Nezu, A. M. (1999). *Problem-solving therapy: A social competence approach to clinical intervention* (2nd ed.). New York: Springer.

Efron, B. (1987). Better bootstrap confidence intervals. Journal of the American Statistical Association, 82, 171-185. doi:10.2307/2289144

Fichten, C.S., Creti, L., Amsel, R., Bailes, S., Libman, E. (2005). Time estimation in good and poor sleepers. *Journal of Behavioral Medicine, 28,* 537-553. doi:10.1007/s10865-005-9021-8

Field, A.E., Barnoya, J., & Colditz, G.A. (2002). Epidemiology and health and economic consequences of obesity. In T.A. Wadden & A. J. Stunkard (Eds.), *Handbook of Obesity Treatment* (pp. 3-18). New York: Guilford Press.

Field, A.E., Byers, T., Hunter, D.J., Laird, N.M., Manson, J.E., Williamson, D.F., Willett, W.C., & Colditz, G.A. (1999). Weight cycling, weight gain, and risk of hypertension in women. *American Journal of Epidemiology, 150*, 573-539.

Field, A.E., Coakley, E.H., Must, A., Spadano, J.L., Laird, N., Dietz, W.H., Rimm, E., & Colditz, G.A. (2001). Impact of overweight on the risk of developing common chronic diseases during a 10-year period. *Archives of Internal Medicine*, 161, 1581 -1586. doi:10.1001/archinte.161.13.1581

Finkelstein, E.A., Fiebelkorn, I.C., & Wang, G. (2003).National medical spending attributable to overweight and obesity: How much, and who's paying? *Health Affairs* ,W3, 219-26.

Finkelstein, E.A., Fiebelkorn, I.C., & Wang, G. (2004). State-level estimates of annual medical expenditures attributable to obesity. *Obesity Research, 12*, 18-24. doi:10.1038/oby.2004.4

Flegal, K. M., Carroll, M.D., Kuczmarski, R.J., Johnson, C.L. (1998). Overweight and obesity in the United States: Prevalence and trends, 1960-1994. International Journal of Obesity, 22, 39-47. doi:10.1038/sj.ijo.0800541

Flegal, K. M., Carroll, M. D., Ogden, C. L., & Johnson, C. L. (2002). Prevalence and trends in obesity among US adults, 1999-2000. *Journal of the American Medical Association, 288*, 1723-1727. doi:10.1001/jama.288.14.1723

Flegal, K.M., Graubard, B.I., Williamson, D.F., & Gail, M.H. (2005). Excess deaths associated with underweight, overweight, and obesity. *Journal of the American Medical Association, 293,* 1861-1867. doi:10.1001/jama.293.15.1861

Flor, H. & Birbaumer, N. (1993). Comparison of the efficacy of electromyographic biofeedback, cognitive-behavioral therapy, and conservative medical interventions in the treatment of chronic musculoskeletal pain. *Journal of Consulting and Clinical Psychology, 61*, 653-8. doi:10.1037/0022-006X.61.4.653

Ford, E.S. (1999). Body mass index and colon cancer in a national sample of adult US men and women. *American Journal of Epidemiology, 150*, 390-398.

Foster, S.L., Laverty-Finch, C., Gizzo, D.P, & Osantowski, J. (1999). Practical issues in self-observation. Psychological Assessment, 11, 426-438. doi:10.1037/1040-3590.11.4.426

Foxx, R.M. & Brown, R.A. (1979). Nicotine fading and self-monitoring for cigarette abstinence or controlled smoking. Journal of Applied Behavior Analysis, 12, 111-125. doi:10.1901/jaba.1979.12-111

Gallagher, D., Heymsfield, S.B., Heo, M., Jebb, S.A., Murgatroyd, P.R., & Sakamoto, Y. (2000). Healthy percentage body fat ranges: an approach for developing guidelines based on body mass index. *American Journal of Clinical Nutrition, 72,* 694-701.

Gallagher. D., Visser, M., Sepulveda, D., Pierson, R.N., Harris, T., & Heymsfield, S.B. (1996). How useful is body mass index for comparison of body fatness across age, sex, and ethnic groups? *American Journal of Epidemiology, 143*, 228-39.

Garfinkel, L. (1985). Overweight and cancer. *Annals of Internal Medicine, 103*, 1034-36.

Garrow, J. S., & Webster, J. (1985). Quetelet's Index (W/H^2) as a measure of fatness. *International Journal of Obesity, 9,* 147-153.

Glanz, K., Murphy, S., Moylan, J., Evensen, D., & Curb, J.D. (2006). Improving dietary self-monitoring and adherence with hand-held computers: A pilot study. *American Journal of Health Promotion, 20*, 165-170.

Gorber, S.C., Tremblay, M., Moher, D. & Gorber, B. (2007). A comparison of direct vs. self-report measures for assessing height, weight and body mass index: A systematic review. *Obesity Reviews, 8*, 307-326. doi:10.1111/j.1467-789X.2007.00347.x

Haslam, D.W. & James, W.P. (2005). Obesity. *Lancet, 366***,** 1197–1209. doi:10.1016/S0140-6736(05)67483-1

Hay, L.R., Nelson, R.O., & Hay, W.M. (1980). Methodological problems in the use of participant observers. *Journal of Applied Behavior Analysis, 13*, 501-504. doi:10.1901/jaba.1980.13-501

Helsel, D.L., Jakicic, J.M, & Otto, A.D. (2007). Comparison techniques for self-monitoring eating and exercise behaviors of weight loss in a correspondence-based intervention, *Journal of the American Dietetic Association, 107,* 1807-1810. doi:10.1016/j.jada.2007.07.014

Hill, J.O., & Peters, J.C. (1998). Environmental contributions to the obesity epidemic. *Science, 280,* 1371-1374. doi:10.1126/science.280.5368.1371

Hill, J.O. & Trowbridge, F.L. (1998). Childhood obesity: future directions and research priorities. *Pediatrics, 101*, 570-574. doi:10.1542/peds.101.3.570

Hill, J.O., Wyatt, H.R., & Melanson, E.L. (2000). Genetic and environmental contributions to obesity. *Medical Clinics of North America, 84,* 333-346. doi:10.1016/S0025-7125(05)70224-8

Hill, J.O., Wyatt, H.R., Reed, G.W., Peters, J.C. (2003). Obesity and the environment: where do we go from here? *Science, 299*, 853-855. doi:10.1126/science.1079857

Hill, R.J., & Davies, P.S.W. (2001). The validity of self-reported energy intake as determined using the doubly labelled water technique. *British Journal of Nutrition, 85*, 415-430. doi:10.1079/BJN2000281

Holmbeck, G. M. (1997). Toward terminological, conceptual, and statistical clarity in the study of mediators and moderators: Examples from the child-clinical and pediatric psychology literatures. *Journal of Consulting and Clinical Psychology*, *65*, 699–710. doi:10.1037/0022-006X.65.4.599

Horgen, K.B., & Brownell, K.D. (2002a). Comparison of price change and health message interventions in promoting healthy food choices. *Health Psychology*, 21, 505-512. doi:10.1037/0278-6133.21.5.505

Horgen, K.B. & Brownell, K.D. (2002b). Confronting the toxic environment: Environmental and public health actions in a world crisis. In T.A. Wadden & A. J. Stunkard (Eds.), *Handbook of Obesity Treatment* (pp. 95-106). New York: Guilford Press.

Howard, B.V., Manson, J.E., Stefanick, M.L., Beresford, S.A., Frank, G., Jones, B., Rodabough, R.J., Snetselaar, L., Thompson, C., Tinker, L., Vitolins, M., & Prentice, R. (2006). Low-Fat dietary pattern and weight change over 7 years. *The Journal of the American Medical Association, 295*, 39-49. doi:10.1001/jama.295.1.39

Hu, G., Tuomilehto, J., Silventoinen, K., Sarti, C., Männistö, S., & Jousilahti, P. (2007). Body Mass Index, waist circumference, and waist-hop ratio on the risk of total and type-specific stroke. *Archives of Internal Medicine, 167*, 1420-1427. doi:10.1001/archinte.167.13.1420

Huang, Z., Hankinson, S.E., Colditz, G.A., Stampfer, M.J., Hunter, D.J., Manson, J.E.., Hennekens, C.H., Rosner, B., Speizer, F.E., Willett, W.C. (1997). Dual effects of weight and weight gain on breast cancer risk. Journal of the American Medical Association, 278, 1407-1411. doi:10.1001/jama.278.17.1407

Institute of Medicine. (1995). *Weighing the options: Criteria for evaluating weight management programs*. Washington, D. C.: National Academy Press.

Jakicic, J.M., Polley, B.A., & Wing, R.R. (1998). Accuracy of self-reported exercise and the relationship with weight loss in overweight women. *Medicine and Science in Sport and Exercise, 30*, 634-638. doi:10.1097/00005768-199804000-00024

James, L.D., Thorn, B.E., & Williams, D.A. (1993). Goal specification in cognitive-behavioral therapy for chronic headache pain. *Behavior Therapy, 24*, 305- 320. doi:10.1016/S0005-7894(05)80271-0

Jasper, C.R. & Klassen, M.L. (1990). Perceptions of salespersons' appearance and evaluation of job performance *Perceptual Motor Skills, 71*, 563-566. doi:10.2466/PMS.71.5.563-566

Johnson, R., Friedman, A., Harvey-Berino, J., Gold, B., & McKenzie, D. (2005). Participation in a behavioral weight loss program worsens the prevalence and severity of underreporting among obese and overweight women. *Journal of American Dietetic Association, 105,* 1948–1951. doi:10.1016/j.jada.2005.09.006

Kanfer, F. H. (1970). Self-monitoring: Methodological limitations and clinical applications. *Journal of Consulting & Clinical Psychology, 35*, 148-152. doi:10.1037/h0029874

Kanfer, F.H. (1971). The maintenance of behavior by self-generated stimuli and reinforcement. In A. Jacobs & L.B. Sachs (Eds.), *The psychology of private events: Perspectives on covert response systems*. New York: Academic Press.

Kanfer, F. H., & Karoly, P. (1972). Self-control: a behavioristic excursion into the lion's den. *Behavior Therapy, 3,* 398–416. doi:10.1016/S0005-7894(72)80140-0

Kanfer, F. H. (1980). Self-management methods. In F.H. Kanfer & A. P. Goldstein (Eds.), *Helping people change: A textbook of methods* (2nd ed.). Elmsford, NY: Pergamon Press.

Kazdin, A.E. (1974). Reactive self-monitoring: The effects of response desirability, goal setting and feedback. *Journal of Consulting and Clinical Psychology, 42*, 704-716. doi:10.1037/h0037050

Klein, S., Burke, L.E., Bray, G.A., Blair, S., Allison, D.B., Pi-Sunyer, X., Hong, Y., & Eckel, R.H. (2004). Clinical implications of obesity with specific focus on cardiovascular disease: A statement for professionals from the American Heart Association Council on Nutrition, Physical Activity and Metabolism. *American Heart Association Council on Nutrition, Physical Activity, and Metabolism, 110,* 2952-2967.

Klem, M.L., Wing, R.R., McGuire, M.T., Seagle, H.M., & Hill, J.O. (1997). A descriptive study of individuals successful at long-term maintenance of substantial weight loss. *American Journal of Clinical Nutrition, 66*, 239–46.

Koenig, S.M. (2001). Pulmonary complications of obesity. *The American Journal of Medical Sciences, 321*, 249-279. doi:10.1097/00000441-200104000-00006

Krauss, R.M., Winston, M., Fletcher, B.J., & Grundy, S.M. (1998). Obesity: Impact of cardiovascular disease. *Circulation, 98*, 1472-1476.

Kuller, L.H., Simkin-Silverman, L.R., Wing, R.R., Meilahn, E.N., & Ives, D.G. (2001). Women's Healthy Lifestyle Project: A randomized clinical trial; Results at 54 months. *Circulation, 103*, 32-37.

Latifi, R., Kellum, J.M., De Maria E.J., & Sugerman HJ. (2002). Surgical treatment of obesity. In: Wadden TA, Stunkard AJ, eds. *Handbook of Obesity Treatment.* New York: Guilford Press. pp. 339–56.

Latner, J. D., Stunkard, A. J., Wilson, G. T., Zelitch, D. S., & Labouvie, E. (2000). Effective long-term treatment of obesity: A continuing care model. *International Journal of Obesity, 24*, 893-898. doi:10.1038/sj.ijo.0801249

Macdiarmid, J. & Blundell, J. (1997). Dietary under-reporting: What people say about recording their food intake, 51, 199-200.

Marks, R. (2007). Obesity profiles with knee osteoarthritis: Correlation with pain, disability, disease progression. Obesity, 15, 1867–1874. doi:10.1038/oby.2007.221

McCrory M.A., Fuss, P.J., Hays, N.P, Vinken, A.G., Greenberg, A.S., Roberts, S.B. (1999). Overeating in America: association between restaurant food consumption and body fatness in healthy adult men and women ages 19 to 80. *Obesity Research, 7*, 564-571. doi:10.1038/oby.2002.65

McKenzie, D.C., Johnson, R.K., Harvey-Berino, J., & Gold, B.C. (2002). Impact of interviewer's body mass index on underreporting energy intake in overweight and obese women. *Obesity Research, 10,* 471–477. doi:10.1038/oby.2002.65

McGuire, M.T., Wing, R.R., Klem, M.L., & Hill, J.O. (1999).What predicts weight regain among a group of successful weight losers? *Journal of Counsulting and Clinical Psychology, 67,* 177– 85. doi:10.1037/0022-006X.67.2.177

Mertz, W., Tsui, J.C., Judd, J.R., Reiser, S., Hallfrisch, J., Morris, E.R., Steel P.D., & Lashley, E. (1991). What are people really eating? The relation between energy intake derived from estimated diet records and intake determined to maintain body weight. *American Journal of Clinical Nutrition, 54,* 291–295.

Mokdad, A.H., Marks, J.S., Stroup, D.F., Gerberding, J.L. (2004). Actual causes of death in the United States, 2000. *Journal of the American Medical Association, 291*(10), 1238-1245. doi:10.1001/jama.291.10.1238

Mokdad, A.H, Marks, J.S., Stroup, D.F., & Gerberding, J.L. (2005). Correction: actual causes of death in the United States, 2000. Journal of the American Medical Association, 293, 293-294. doi:10.1001/jama.293.3.293

Myers, A., & Rosen, J. C. (1999). Obesity stigmatization and coping: relation to mental health symptoms, body image, and self-esteem. *International Journal of Obesity, 23*, 221–230. doi:10.1038/sj.ijo.0800765

Myers, R. (1990). *Classical and modern regression with applications (*2nd ed.). Boston, MA: Duxbury.

Narkiewicz, K. (2006). Diagnosis and management of hypertension in obesity. *Obesity Reviews, 7*, 155-162. doi:10.1111/j.1467-789X.2006.00226.x

National Institute of Diabetes and Digestive and Kidney Diseases. (2008). National Diabetes Statistics, 2007 fact sheet. Bethesda, MD: U.S. Department of Health and Human Services, National Institutes of Health.

National Heart, Lung, and Blood Institute. Obesity Education Initiative Expert Panel on the Identification, Evaluation, and Treatment of Overweight and Obesity in Adults. (1998). Clinical guidelines on the identification, evaluation, and treatment of overweight and obesity in adults: The evidence report. *Obesity Research*, *6,* 51S-210S.

Nay, W.R. (1979). Multimethod clinical assessment, New York; Gardner.

Nielson, S.J. & Popkin, B.M. (2003). Patterns and trends in food portion sizes, 1977-1998. *Journal of the American Medical Association, 289*, 450-453. doi:10.1001/jama.289.4.450

Ogden, C.L., Caroll, M.D., Curtin, L.R., McDowell, M.A., Tabak, C.J., Flegal, K.M. (2006). Prevalence of overweight and obesity in the United States, 1999-2004. *Journal of the American Medical Association, 295*(13), 1549-1555. doi:10.1001/jama.295.13.1549

Ogden, C.L, Caroll, M.D., McDowell, M.A., & Flegal, K.M. (2007). Obesity among adults in the United States--no statistically significant chance since 2003-2004. NCHS Data Brief, 1, 1-8.

Onyike C.U., Crum, R.M., Lee, H.B., Lykestsos, C.G., & Eaton, W.W. (2003). Is obesity associated with major depression? Results from the Third National Health and Nutrition Examination Survey. *American Journal of Epidemiology, 158*, 1139–1147. doi:10.1093/aje/kwg275

Pate, R.R., Pratt, M., Blair, S.N., Haskell, W.L., Macera, C.A., Bouchard, C., Buchner, D., Ettinger, W., Heath, G.W., King, A.C., Kriska, A., Leon, A.S., Marcus, B.H., Morris, J., Paffenbarger, R.S., Jr., Patrick, K., Pollock, M.L., Rippe, J.M., Sallis, J., & Wilmore, J.H. (1995). Physical activity and public health: A recommendation from the Centers for Disease Control and Prevention and the American College of Sports Medicine. *Journal of the American Medical Association,* 273, 402-07. doi:10.1001/jama.273.5.402

Paul, R.J. & Townsend, J.B. (1995). Shape up or ship out? Employment discrimination against the overweight. *Employee Responsibilities and Rights Journal, 8*,133-145. doi:10.1007/BF02621279

Peacock, S.L., White, E., Daling, J.R., Voigt, L.F., & Malone, K.E. (1999). Relation between obesity and breast cancer in young women. *American Journal of Epidemiology, 149*, 339-346.

Peeters, A., Barendregt, J.J., Willekens, F., Mackenbach, J.P., Al Mamun A., & Bonneux L. (2003). Obesity in adulthood and its consequences for life expectancy: a life-table analysis. *Annals of Internal Medicine, 138*, 24-32.

Perri, M.G. (1998). The maintenance of treatment effects in the long-term management of obesity. *Clinical Psychology: Science and Practice, 5*, 526-543.

Perri, M.G., & Corsica, J.A. (2002). Improving the maintenance of weight lost in behavioral treatment of obesity. In T.A. Wadden & A.J. Stunkard (Eds.), *Handbook of Obesity Treatment* (pp. 357-379). New York: Guilford Press.

Perri, M.G, Limacher, M.C., Durning, P.E., Janicke, D.M., Lutes, L.D., Bobroff, L.B., Dale, M.S., Daniels, M.J., Radcliff, T.A., and Martin, A.D, (2008). Extended-Care programs for weight management in rural communities. *Archives of Internal Medicine, 168*, 2347-2354. doi:10.1001/archinte.168.21.2347

Perri, M.G., Nezu, Patti, E.T., & McCann, K.L.(1989). Effect of length of treatment on weight loss. *Journal of Consulting and Clinical Psychology, 57*,450-452. doi:10.1037/0022-006X.57.3.450

Perri, M. G., Nezu, A. M., & Viegener, B. J. (1992). Improving the long-term management of obesity: Theory, research, and clinical guidelines. New York: John Wiley & Sons.

Pi-Sunyer, F.X. (2000) Obesity: criteria and classification. *Nutrition Society, 59*, 505-509.

Polednak, A.P. (2003). Trends in incidence rates for obesity-associated cancers in the U.S. *Cancer Detection and Prevention, 27,* 415–421. doi:10.1016/j.cdp.2003.09.002

Poirier, P. & Eckel, R.H. (2002). Obesity and cardiovascular disease. *Current Atherosclerosis Report,* 4, 448–453. doi:10.1007/s11883-002-0049-8

Poston, W.S. & Foreyt, J.P. (1999). Obesity is an environmental issue. Atherosclerosis, 146, 201-209. doi:10.1016/S0021-9150(99)00258-0

Preacher, K. J., & Hayes, A. F. (2004). SPSS and SAS procedures for estimating Indirect effects in simple mediation models. *Behavior Research Methods, Instruments, and Computers, 36*, 717-731.

Preacher, K.J., & Hayes, A.F. (2008). Asymptotic and resampling strategies for assessing and comparing indirect effects in multiple mediator models. *Behavior Research Methods, 40*, 879-891. doi:10.3758/BRM.40.3.879

Presta, E., Wang, J., Harrison, G.G., Bjorntorp, P., Harker, W.H., & Van Itallie, T.B. (1983). Measurement of total body electrical conductivity: a new method for estimation of body composition. American Journal of Clinical Nutrition, 37, 735-739.

Prentice, A.M. & Jebb, S.A. (2001). Beyond body mass index. *Obesity Reviews, 2*, 141-147. doi:10.1046/j.1467-789x.2001.00031.x

Price, R.A. (2002). Genetics and common obesities: Background, current status, strategies and future prospects. In T.A. Wadden & A.J. Stunkard (Eds.), *Handbook of Obesity Treatment* (pp. 73-94). New York: Guilford Press.

Price, G.M., Paul, A.A., Cole, T.J., & Wadsworth, M.E.J. (1997). Characteristics of the low-energy reporters in a longitudinal national dietary survey, 77, 833-851.

Prior, I.A. (1971). The price of civilization, *Nutrition Today, 6*, 2-11. doi:10.1097/00017285-197107000-00001

Putnam J.J. & Allshouse J.E. (1996). Food consumption, prices, and expenditures, 1996: Annual data, 1970–94. Food and Consumer Economics Division, Economic Research Service, U.S. Department of Agriculture, statistical bulletin no. 928 Washington, D.C.

Quatromoni, P.A., Pencina, M., Cobain,M.R., Jacques, P.F. & D'Agostino, R.B. (2006). Dietary quality predicts adult weight gain: Findings from the Framingham Offspring Study. *Obesity Research, 14*, 1383-1391. doi:10.1038/oby.2006.157

Qi, B.B., & Dennis, K.E. (2000). The adoption of eating behaviors conducive to weight loss. Eating Behaviors, 1, 23-31. doi:10.1016/S1471-0153(00)00003-9

Rajala, R., Partinen, M., Sane, T., Pelkonen, R., Huikuri, K., & Seppalainen, A.M. (1991). Obstructive sleep apnoea syndrome in morbidly obese patients. Journal of Internal Medicine, 230, 125-129. doi:10.1111/j.1365-2796.1991.tb00419.x

Ravussin, E., Valencia, M.E., Esparza, J., Bennett, P.H., & Schulz, L.O. (1994). Effects of traditional lifestyle on obesity in Pima Indians. *Diabetes Care, 9*, 1067-1074. doi:10.2337/diacare.17.9.1067

Remmell, P.S., Gorder, D.D., Hall, Y., & Tillotson, J.L. (1980). Assessing dietary adherence in the Multiple Risk Factor Intervention Trial (MRFIT). I. Use of a dietary monitoring tool. *Journal of the American Dietetic Association, 76*, 351-356.

Rimm, E.B., Stampfer, M.J., Giovannucci, E., Ascherio, A., Spiegelman, D., Colditz, G.A., & Willett, W.C. (1995). Body size and fat distribution as predictors of coronary heart disease among middle-aged and older U.S. men. *American Journal of Epidemiology, 141*, 1117-1127.

Rexrode, K.M., Hennekens, C.H., Willett, W.C., Colditz, G.A., Stampfer, M.J., Rich-Edwards, J.W., Speizer, F.E., & Manson, J.E. (1997). A prospective study of body mass index, weight change, and risk of stroke in women. *Journal of the American Medical Association, 277*, 1539–1545. doi:10.1001/jama.277.19.1539

Roehling, M. V. (1999). Weight-based discrimination in employment: Psychological and legal aspects. *Personnel Psychology, 52,* 969-1016. doi:10.1111/j.1744-6570.1999.tb00186.x

Rubinstein, I. Colapinto, N., Rotstein, L.E., Brown, I.G., & Hoffstein, V. (1988). Improvement in upper airway function after weight loss in patients with obstructive sleep apnea. *The American Review of Respiratory Disease, 138*, 1192-1195.

Saelens, B.E., & McGrath, A.M. (2003). Self-Monitoring adherence and adolescent weight control efficacy. Children's Health Care, 32, 137-152. doi:10.1207/S15326888CHC3202_5

Safren, S.A., Otto, M.W., Worth, J., Salomon, E., Johnson, W., Mayer, K., & Boswell, S. (2001). Two strategies to increase adherence to HIV antiretroviral medication: LifeSteps and medication monitoring. *Behavioural Research and Therapy, 39,* 1151-1162. doi:10.1016/S0005-7967(00)00091-7

Sallis, J.F. & Owen, N. (1999). Physical activity and behavioral medicine. Thousand Oaks, CA: Sage.

Sawyer, S.M. (2002). Action plans, self-monitoring and adherence: Changing behaviour to promote better self-management. Medical Journal of Australia, 177, S72-74.

Scarpace, P.J. & Zhang, Y. (2007). Elevated leptin: Consequences or cause of obesity? *Frontiers in Bioscience,12*, 3531-3544. doi:10.2741/2332

Sperduto, G.R., Calhoun, K.S., & Ciminero, A.R. (1978). The effects of reciprocal reactivity on positively and negatively self-rated behaviors. Behaviour Research and Therapy, 16, 429-434. doi:10.1016/0005-7967(78)90014-1

Streit, K.J., Stevens, N.H., Stevens, V.J., & Rossner, J. (1991). Food records: A predictor and modifier of weight change in a long-term weight loss program. *Journal of the American Dietetic Association, 91*, 213-216.

Stunkard, A.J., Harris, J.R., Pedersen,N.L. & McClearn, G.E. (1990). The body-mass index of twins who have been reared apart. *New England Journal of Medicine, 322*, 1483-1487.

Tataranni & Ravussin, 2002). Energy Metabolism and Obesity. In T.A. Wadden & A.J. Stunkard (Eds.), *Handbook of Obesity Treatment* (pp. 42-72). New York: Guilford Press.

Thompson, F.E., & Subar, A.F. (2001). Dietary assessment methods. In A. M. Coulston, C. L. Rock & E. R. Monsen (Eds.), *Nutrition on the Prevention and Treatment of Disease* (pp.3-30). San Diego: Academic Press. doi:10.1016/B978-012193155-1/50003-9

U.S. Department of Health and Human Services. (1996). *Physical activity and health: a report of the Surgeon General*. Atlanta: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention National Center for Chronic Disease Prevention and Health Promotion.

Vainio, H., & Bianchini, F. (2002). *IARC handbooks of cancer prevention. Volume 6: Weight control and physical activity.* Lyon, France: IARC Press.

Vaughn, T.L., Davis, S., Kristal, A., & Thomas, D.B. (1995). Obesity, alcohol, and tobacco as risk factors for cancers of the esophagus and gastric carida: Adenocarcinoma versus squamous cell carcinoma. *Cancer Epidemiology Biomarkers & Prevention, 4*, 85-92.

Vgontzas, A.N., Tan, T.L., Bixler, E.O., Martin, L.F., Shubert, D., & Kales, A. (1994). Sleep apnea and sleep disruption in obese patients. *Archives of Internal Medicine, 154*, 1705–1711. doi:10.1001/archinte.154.15.1705

Vidal, J. (2002). Updated review on the benefits of weight Loss. *International Journal of Obesity*, *26,* S25-S28. doi:10.1038/sj.ijo.0802215

Virshup, D.M. & McCance, K.L. (2006). Biology of cancer. In K.L. McCance and S.E. Huether (Eds.) Pathophysiology. *The Biological Basis for Disease in Adults and Children. Fifth Edition* (pp. 333-374). St. Louis, MO: Mosby.

Wadden, T. A. (1993). The treatment of obesity: An overview. In A. J. Stunkard, & T. A. Wadden (Eds.) *Obesity: Theory and therapy* (2nd ed., pp. 197–218). New York: Raven Press.

Wadden, T. A., Brownell, K. D., & Foster, G. D. (2002). Obesity: Responding to the global epidemic. *Journal of Consulting and Clinical Psychology, 70*, 510-525. doi:10.1037/0022-006X.70.3.510

Wadden, T.A., & Foster, G.D. (2000). Behavior therapy for obesity, *Medical Clinics of North America, 84*, 441-461. doi:10.1016/S0025-7125(05)70230-3

Wadden, T.A., Stunkard, A.J., & Liebschutz, J. (1988). Three year follow-up of the treatment of obesity by very low calorie diet, behavior therapy, and their combination. *Journal of Consulting and Clinical Psychology, 56*, 925-928. doi:10.1037/0022-006X.56.6.925

Wadden, T.A., & Osei, S. (2002). The treatment of obesity: an overview. In T.A. Wadden & A.J. Stunkard (Eds.), *Handbook of Obesity Treatment* (pp. 229-248). New York: Guilford Press.

Willett, W.C., Dietz, W.H., & Colditz, G.A. (1999). Guidelines for Healthy Weight. *New England Journal of Medicine, 341,* 427-434. doi:10.1056/NEJM199908053410607

Wing, R.R. (1998).Behavioral approaches to the treatment of obesity. In: Bray GA, Bouchard C, James WPT, eds. *Handbook of Obesity.* New York: Marcel Dekker, Inc. pp. 855–73.

Wing, R.R. (2004). Behavioral approaches to the treatment of obesity. In: Bray GA, Bouchard C, eds. *Handbook of Obesity: Clinical Applications*. New York, NY: Marcel Dekker. pp. 147-167.

Wing, R. R. (2002). Behavioral weight control. In T. A. Wadden & A. J. Stunkard (Eds.), *Handbook of Obesity Treatment* (pp. 301-316). New York: Guilford Press.

Wing, R.R. & Hill, J.O. (2001). Successful weight loss maintenance. *Annual Review of Nutrition, 21,* 323-341. doi:10.1146/annurev.nutr.21.1.323

Wing, R.R. & Phelan, S. (2005). Long-term weight loss maintenance. *American Journal of Clinical Nutrition, 82*, 222S-225S.

Wofford, M.R. & Hall, J.E. (2004). Pathyphysiology and treatment of obesity hypertension. *Current Pharmaceutical Design, 10*, 3621-3637. doi:10.2174/1381612043382855

Wolf, A.M. & Colditz, G.A. (1998). Current estimates of the economic cost of obesity in the United States. *Obesity Research, 6*, 97-106.

World Health Organization (1978) *Cerebrovascular disorders: A clinical and research classification*. Geneva: Author.

World Health Organization (1998) *Obesity: Preventing and managing the global epidemic. Report of a WHO Consultation on Obesity, Geneva, June 3-5, 1997* (Publication No. WHO/NUT/NCD/98.1). Geneva: Author.

Wyatt, H.R., Grunwald, G.K., Mosca, C.L., Klem, M.L., Wing, R.R., & Hill, J.O. (2002). Long-term weight loss and breakfast in subjects in the National Weight Control Registry. *Obesity Research, 10*, 78-82. doi:10.1038/oby.2002.13

Yon, B.A. Johnson, R.K., Harvey-Berino, J. & Gold, B.C. (2006). The use of a Personal Digital Assistant for dietary self-monitoring does not improve the validity of self-reports of energy intake. *Journal of the American Dietetic Association, 106,* 1256-1259. doi:10.1016/j.jada.2006.05.004

Yon, B.A. Johnson, R.K., Harvey-Berino, J., Gold, B.C., & Howard, A.B. (2007). Personal digital assistants are comparable to traditional diaries for dietary self-monitoring during a weight loss program. *Journal of Behavioral Medicine, 30*, 165-175. DOI: 10.1007/s10865-006-9092-1. doi:10.1007/s10865-006-9092-1

Zhang, Y., Proenca,R., Maffie, M., Barone, M., Leopold, L., & Friedman, J.M. (1994). Positional cloning of the mouse obese gene and its human homologue. Nature, 372, 425-432. doi:10.1038/372425a0

BIOGRAPHICAL SKETCH

Ninoska “Nini” DeBraganza was born in Goa, India and moved to Fort Lauderdale, Florida at the age of three. She was educated at Pine Crest School and attended the University of Florida, where she graduated with a Bachelor of Science in psychology and a minor in classical studies in 2001.

She began graduate school at the University of Florida and completed a Master of Science in Exercise and Sport Science with a specialization in sport and exercise psychology in 2004; Ninoska completed her thesis examining ethnicity as a moderator of media effects of the ideal physique on negative mood under the mentorship of Dr. Heather A. Hausenblas. During her time in her master’s program, Ninoska began volunteering in the Department of Clinical and Health Psychology in the area of weight management. She was accepted into the doctoral program in the Department of Clinical and Health Psychology at the University of Florida in 2004 under the mentorship of Dr. Michael G. Perri, and was provided with the opportunity to facilitate weight management groups in medically underserved rural settings.

Ninoska completed her pre-doctoral clinical internship at Rush University Medical Center in Chicago, Illinois. Upon graduating with her doctorate, she plans to begin a post-doctoral fellowship in clinical psychology and obtain her licensure to practice psychology. Her clinical and research interests within health psychology include health promotion and health behavior change processes, with a specific focus on the treatment of obesity and related co-morbidities, physical activity and body image disturbance.