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PATTERNS AND PREDICTORS OF WEIGHT CHANGE AMONG WOMEN

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ABSTRACT

Adults are getting heavier; however, there are few longitudinal data to provide information on factors associated with patterns of weight change within individuals during adulthood. The purpose of the present research was identifying relatively stable psychosocial, behavioral or contextual factors that have been consistently associated with weight status among adults, and to assess whether these factors predict weight change over time. Participants included non-Hispanic white women in central Pennsylvania recruited as part of a longitudinal study. Data were collected across an 8-year period, with 2-year intervals between assessments. Height and weight were measured in triplicate. Dietary restraint and disinhibition were assessed using the Eating Inventory. Global reports of dieting and specific weight control strategies were assessed by the Weight Loss Behavior Scale. Energy density was calculated from energy content of all foods (excluding beverages) at each occasion from three 24-hour recalls. A series of mixed effect models were used to examine the influence of several factors on weight change over time. Results revealed that (1) self reported dieting was associated with weight gain; (2) increases in dietary restraint may be protective against long-term weight maintenance by moderating the positive association between dietary disinhibition and weight gain among dieters; (3) assessing patterns of use of specific weight control strategies discriminated among women using different approaches to control weight; (4) different patterns of weight control use were predictive of differences in weight gain: use of healthy plus unhealthy weight control strategies was associated with greater weight gain; whereas only using healthy weight control strategies may promote weight maintenance; and (5) decreasing dietary energy density by increasing intake of water rich foods such as fruits and vegetables may be an effective weight maintenance strategy. Data indicate that, on average, women gained approximately 0.6 kg per year; however, several modifiable factors were identified that may promote weight maintenance. Results from all three studies have important implications for the development of recommendations and intervention programs promoting weight maintenance.

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Chapter 1

General Introduction

The prevalence of overweight has increased dramatically over the past three decades (1, 2). Specifically, epidemiological data reveal that the age-adjusted prevalence of obesity, defined as a body mass index (BMI) of 30 or higher, has increased from 22.9% in 1988-1994 to 30.6% in 2001-2002. Similarly, the prevalence of overweight (BMI $\geq$ 25) has increased 10% such that two-thirds of American adults are now overweight (1, 2). Comparing the distribution of BMI percentiles for 1999-2000 NHANES, NHANES III, and earlier surveys reveals that the entire distribution of BMI has shifted to the right, with a greater shift experienced by those in the upper percentiles. NHANES data also indicate that the distribution has become more negatively skewed suggesting an increase in BMI across the entire population (3). Longitudinal studies estimate that, on average, adults gain 0.5-1.0 kg per year, further suggesting that as adults get older they are also getting heavier (4, 5). However, there is undoubtedly substantial individual variation in adult weight gain.

Weight maintenance programs might have their greatest impact on future obesity by targeting individuals at high risk for weight gain. Premenopausal women have been identified as one such high-risk group that should be targeted for weight gain prevention for several reasons. First, cross-section data reveal that the prevalence of obesity is significantly higher among women than men (1). Secondly, women are at increased risk for accelerated weight gain during several periods of the life span including cohabitation or marriage (6-9), pregnancy (10-12), and menopause (13). Finally, there is a societal ideal for thinness that is often unattainable (14). The perceived pressure to be thin is often internalized by women and can result in body dissatisfaction and weight concern which may have negative consequences on eating behavior, and also on weight status (15-18). Research is needed that describes patterns of weight change, while also identifying individual and contextual factors that influence patterns of weight change among women.

Importance of Preventing Weight Gain

The fact that Americans are getting heavier across the life span is of concern because few weight loss approaches show evidence of long term success. Weight gain among adults, combined with poor long term weight control treatment outcomes, indicate that a major public health objective should be preventing further weight gain. A systematic review examining the effectiveness of interventions designed to treat obesity and maintain weight revealed that although weight loss treatment programs were effective in the short-term; however, most participants were not able to maintain weight loss longer than one year (19). In addition, greater weight losses are predictive of subsequent larger than average weight gains, suggesting that intentional weight loss is followed by unintentional weight gain (20, 21). Thus, most adults who successfully lose weight will ultimately regain weight lost during treatment, and gain more weight within several years, revealing the challenge of long term weight maintenance. Repeated attempts to lose weight actually result in weight gain, which has been associated with many leading causes of morbidity and mortality (22, 23).

The disease burden associated with obesity - attributable deaths in the United States is estimated to range from 280,000 to 400,000 (24, 25). These comorbidities include but are not limited to cardiovascular disease (26-29), diabetes mellitus (30, 31), stroke (31), metabolic syndrome (32), gallbladder disease (33, 34), some cancers (35), knee replacement, pancreatitis, chronic fatigue, insomnia (36), sleep-disordered breathing (37), asthma (38), and mobility disability (39, 40). In addition to the disease burden, there is also an economic burden associated with obesity such that 3.7% and 6.7% of medical spending is attributable to overweight and obesity, respectively, which translates to $75 billion dollars in annual expenditures in the United States (41). However, weight loss does reverse the risk of some obesity related comorbitities (42-44). Similarly, adults who are able to maintain weight over time have minimal progression of metabolic indicators of cardiovascular health and metabolic syndrome including blood pressure, triglycerides, fasting glucose, and cholesterol levels compared to weight gainers (45, 46). In combination, findings reveal that research is needed to identify factors that promote weight maintenance to guide the development of more effective treatment and prevention programs, thereby also decreasing risk of obesity related comorbitities.

Causes of Obesity

Understanding weight gain is, at one level, simple: weight gain results when energy intake chronically exceeds energy expenditure (47). However, epidemiological and cross-sectional studies often fail to link energy intake (1, 2, 48-53) and food intake patterns (54-56) with weight status. Several methodological challenges associated with measuring food intake (57-66) may reduce the ability to detect relationship to outcome variables (60). Specifically, overweight adults tend to systematically under-report energy intake and foods perceived as unhealthy such as fats, sweets, desserts and snacks (62, 67-71); under reporting bias is substantial and is a major challenge in assessing how energy and dietary patterns are implicated in the etiology of weight gain and obesity. Thus, it is unlikely that current measures of dietary intake estimate energy intake with enough precision to detect small energy imbalances which over time increase risk for weight gain. For example, an annual weight gain of 0.5 kg per year translates to an energy imbalance of 3850 kcals per year, or a cumulative positive balance of only 10 kcal per day (5). However, this perspective suggests that small behavioral changes that are sustainable over time could prevent weight gain.

An alternative approach to predicting patterns of weight change is to identify relatively stable psychosocial, behavioral, and contextual factors that are consistently associated with weight status among adults, and to assess whether these factors predict patterns of weight change. Existing literature suggests several promising candidates; and several of these are the focus of the research presented in the chapters that follow including: dietary restraint, disinhibition, patterns of use of specific dieting strategies, and the energy density of the diet.

Factors associated with Weight Change

Study 1: Dietary restraint, disinhibition and self reported dieting. Recently, Hill and colleagues (72) suggested that within our current environment, cognitive controls of eating are necessary to moderate weight gain; however, there are few longitudinal data to provide evidence for the impact this recommendation might have on weight maintenance. Dietary restraint and disinhibition are psychological constructs that assess behavioral control and attitudes toward food (73). Dietary restraint is defined as a tendency to consciously restrict or control food intake, whereas disinhibition is defined as a tendency to overeat in the presence of palatable foods or other disinhibiting stimuli such as emotional stress (74). Dietary disinhibition is positively associated with weight status

(75-78), but the association between dietary restraint and weight status remains unclear; some report a positive association (79-82), whereas others report no association (78, 83), or an inverse association (75-77, 84). However, other evidence indicates that it is not the independent effects of dietary restraint and disinhibiton, but rather the conjoint effect of restraint and disinhibition that is associated with weigh status; restraint moderates the impact of disinhibition on body weight (77, 78, 85). For example, Lawson and colleagues used a 2 X 2 factorial design (high/low restraint X high/low disinhibition) to examine this association and found that individuals who were high on restraint and disinhibition have significantly lower BMI's than individuals reporting low restraint but high disinhibition (85). Two prospective longitudinal studies have examined the independent effects of restraint and disinhibition on weight change (81, 86), yet these studies failed to examine the conjoint effect of restraint and disinhibition. Therefore, little is known about the long term effects of restraint and disinhibition on weight change in free-living women. Previous research has also examined the impact of self reported dieting on restrained eating, weight status, and weight change.

Self reported dieting has become normative among women of all ages and body weights; one in three Americans report currently trying to lose weight (87). The current preoccupation with weight loss and dieting is demonstrated by the fact that Americans now spend over $33 billion dollars on diet related products and services (88). Despite current preoccupation with weight loss and dieting, Americans continue to get heavier (1). This paradox is supported by Lowe and colleagues (89) who examined the effect of global reports of “dieting”. When participants were simply asked to self identify as currently dieting or not dieting to lose weight, results revealed that dieters gained three times as much weight as non-dieters. Similarly, French and colleagues (90) reported that women who reported dieting gained 2 pounds more than women who were not dieting to lose weight over 2 years. In contrast, another study by French and colleagues (91) found that global reports of dieting to lose weight were not associated with weight change

Dietary restraint is a multidimensional construct that includes both current and past history of dieting (92). Specifically, studies designed to differentiate dieting and restraint reveal that the effect of dietary restraint on weight status differs, depending on dieting status, suggesting that dieting to lose weight and dietary restraint are related, but different constructs (92-95). In combination, these findings suggest that weight change may be best understood by examining the collective influence of restraint, disinhibition, and dieting. The primary aim of Study 1 is to investigate the interactive effects of restrained eating, disinhibited eating, and dieting as predictors of weight change.

Study 2. Specific weight control practices and weight change. As indicated above, evidence linking self reported dieting attempts and weight change is inconclusive. One possible explanation for is that "dieting" is a broad construct that may have different meaning to different people. Limited evidence suggests that information regarding the use of specific weight control strategies may be more informative than simply asking women to identify as "dieting" (87, 96-98). To date, only one study has examined the independent effects of specific weight control strategies on weight change among adults (91). These findings revealed that several healthy weight control strategies were associated with less weight gain over three years among adults participating in a 4 year weight gain prevention study However, no study has examined the effect of practicing healthy and or unhealthy weight control strategies on weight change among free living women.

Thus, the primary aim of Study 2 is to investigate whether different patterns of use of weight control strategies predict weight change among free-living women. While current recommendations for successful weight loss include reducing caloric intake and increasing physical activity (99, 100), they do not provide guidance about specific strategies that can help individuals to meet their weight maintenance goals. Therefore, an understanding of how specific healthy and unhealthy weight control strategies influence weight change has important implications for the development of recommendations promoting weight maintenance that are more specific than current guidelines to “reduce caloric intake” to lose weight.

Study 3: Energy density and weight change. Energy density is defined as the amount of dietary energy in a given weight of food (i.e., kcal/g). Recent reports from the World Health Organization (31) and the U.S. Department of Health and Human Services (99) recommend consuming low energy dense foods as a strategy to reduce energy intake and prevent weight gain and obesity. However, this recommendation is largely based on cross-sectional studies revealing that energy density is positively associated with weight status (101-104) and three clinical trials showing that modest reductions in energy density were associated with long-term weight loss (105-107). Diets lower in energy density can be achieved by increased consumption of fruits and vegetables and reduction in fat intake (108, 109). Several laboratory-based studies have manipulated the energy density of foods by altering fat, carbohydrate and water content. Findings reveal that because individuals consume a consistent weight of food across energy density manipulations, they consume more energy when presented with higher ED foods than with similar foods of lower ED (110-113). However, only one longitudinal study, to date, has examined the influence of energy density on subsequent weight change which revealed mixed results: energy density was positively associated with weight gain in obese women, but inversely associated with weight gain in normal weight women (114). Thus, little is known about the long-term effect of energy density on patterns of weight change and in particular, on unintentional weight gain among free-living women. Therefore, the primary aim of Study 3 is to investigate the effect of energy density, assessed on 4 occasions, as a predictor of weight change.

Summary

Adults are getting heavier; however, there are few longitudinal data to provide information on factors associated with patterns of weight change within individuals during adulthood. While it is generally accepted that the underlying cause of weight change is an imbalance between energy intake and energy expenditure, the literature has failed to yield consistent results regarding the influence of energy intake and expenditure on energy balance, largely due to methodological challenges associated with measuring energy intake. An alternative approach to predicting patterns of weight gain over time would entail identifying relatively stable psychosocial, behavioral or contextual factors that have been consistently associated with weight status among adults, and to assess whether these factors predict weight change over time. This is the overall objective of the present research. Understanding how these factors influence weight change is necessary for the development of more effective weight maintenance and obesity prevention programs. The following is a list of study aims.

Specific Aims

Study 1: Dieting, dietary restraint, and disinhibition predict women's weight change over 6 years

1. To examine the effect of restrained eating, disinhibited eating, and dieting behavior and their interactions on weight change over time
2. To examine the interactive effects of restrained eating, disinhibited eating, and dieting behavior on weight change over time

Study 2: Differences in weight control strategies predict weight gain among women over 4 years

1. To use latent class analysis to determine whether distinct groups of women could be identified, based on their probability of using specific weight control strategies.
2. To examine differences in weight status, psychosocial, and contextual factors among women practicing different weight control strategies.
3. To determine whether patterns of weight control predicted differences in weight change in women, before and after adjusting for initial BMI

Study 3: Dietary energy density predicts women's weight change over 6 years

1. To investigate the effect of energy density on patterns of weight change.
2. To describe differences in patterns of dietary intake among women with diets differing in energy density.

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Chapter 2

Dieting, Dietary Restraint and Disinhibition Predict Women's Weight Change over 6 Years

ABSTRACT

While disinhibited eating is positively associated with higher weight status in women, it is not known whether restrained eating and dieting moderate the influence of disinhibited eating on weight change over time. The purpose of this study was to investigate the interactive effects of restrained and disinhibited eating and self reported dieting to lose weight as predictors of weight gain among women over 6 years. Data were collected from non-Hispanic, White women (N = 163) every two years. Height and weight were measured in triplicate. Dietary restraint and disinhibition were assessed using the Eating Inventory. Growth curve modeling was used to examine change in weight over time as a function of time-invariant and time-varying predictors including dietary restraint, dietary disinhibition, and self reported dieting. After adjusting for covariates, growth curve models revealed that within individual increases in restraint over time were associated with concurrent decreases in weight and moderated the positive association between dietary disinhibition and weight gain. Women who reported dieting were heavier at study entry and gained more weight over time than non-dieters. A significant interaction among restraint, disinhibition, and dieting revealed that among non-dieters, restraint does not moderate the effects of disinhibition on weight gain, but does moderate weight gain among dieters. Findings indicate that dieting was not an effective weight maintenance strategy, whereas higher levels of restraint may be beneficial in moderating weight gain

by attenuating the positive association between disinhibition and weight gain among dieting women. Understanding weight change requires examination of the interactive effects of restraint, disinhibition, and dieting.

INTRODUCTION

Dieting to lose weight is common among women of all ages and body weights; one in three American women report currently dieting to lose weight (1). However, dieting may result in reactive or compensatory overeating and weight gain, which then may result in cycles of dieting and weight gain (2-5); thus, contributing to the current obesity epidemic (6). Weight gain and obesity in the general population continues to be a major public health issue; longitudinal studies estimate that on average adults gain 0.5-1.0 kg per year (7, 8), yet we have few longitudinal data to provide information on factors associated with different patterns of weight change within individuals during adulthood.

Dietary restraint and disinhibition, as measured by the Eating Inventory (EI) (9), are psychological constructs that assess behavioral control and attitudes toward food. Dietary restraint is defined as a tendency to consciously restrict or control food intake, whereas dietary disinhibition is defined as a tendency to overeat in the presence of palatable foods or other disinhibiting stimuli such as emotional stress (10). Dietary disinhibition is positively associated with weight status (11-14), but the association between dietary restraint and weight status remains unclear (12-18). Recently, Hill and colleagues (19) argue that within the current environment, cognitive controls of eating are necessary to moderate weight gain. However, it is not the independent effects of restraint and disinhibition, but their interaction that predict body weight, with restraint moderating the impact of disinhibition on body weight (13, 14, 20). Specifically, whether higher levels of disinhibition are associated with higher weight status differs depending on the level of dietary restraint; individuals who are more disinhibited and also more restrained have lower BMI’s than individuals who are less restrained (20).

Few longitudinal studies have investigated links between dietary restraint and disinhibition and weight change other than those conducted during weight-reduction programs. Two prospective longitudinal studies have examined associations between dietary restraint or disinhibition and weight change in free-living individuals who were not enrolled in a clinical weight control program (17, 21); however, these studies did not examine the conjoint effects of dietary restraint and disinhibition (13, 14, 20). Therefore, little is known about long term effects of this interaction on weight change, and in particular unintentional weight gain, among free-living premenopausal women.

Research assessing the effect of self-reported dieting on weight status and weight change reveals that dieting is not an effective weight maintenance strategy and may promote weight gain over time (22-25). For example, Lowe and colleagues (23) reported that a history of dieting predicted greater weight gain and that women who self-reported that they were currently dieting to lose weight gained three times as much weight as non-dieters. However, studies examining current dieting and history of dieting have shown that the effect of dietary restraint on weight status differs depending on dieting status, suggesting that dieting to lose weight and dietary restraint are related, but different constructs (26-29). Taken together, these finding suggest that weight change over time is influenced by the conjoined effects of restraint, disinhibition and dieting. The present study is designed to investigate the effect of restraint, disinhibition, and dieting, and the interactions between these constructs on weight change.

Based on previous research (5, 12-14, 26), we expect that: 1) dietary restraint alone will not be a significant independent predictor of weight gain; 2) higher levels of disinhibition will predict greater weight gain over time; 3) dietary restraint will moderate the positive relationship between disinhibition and weight gain; however, 4) this association will vary across dieters and non-dieters; and 5) self reported dieting will be associated with greater weight gain.

METHODS

Participants

The study participants were part of a larger longitudinal study designed to examine parental influences on girls' growth and development (30-32). The larger study included 197 non-Hispanic white married couples and their daughters who were examined on four occasions, with 2-year intervals between assessments. Families with age-eligible female children within a 5-county radius were identified using available marketing information (Metromail Inc., Chicago). These families received mailings providing information about the study and were recruited using follow-up phone calls. Families were not recruited based on child or parent weight status or concern about weight. Only data for mothers are considered in this study. Only women with complete weight, dieting, dietary restraint and disinhibition data at all times of measurement were included in this study. Attrition was primarily due to family relocation outside of the study area. No significant difference was found between the initial weight status, dietary restraint or disinhibition of participants lost to follow-up (n = 34) and of participants remaining in the study through year 6 (n = 163).

Design and Procedures

Data were collected on four occasions across a 6-year period, with 2-year intervals between each time of measurement. At each time of assessment, women completed a series of self-report questionnaires during a scheduled visit to the laboratory.

The Pennsylvania State University Institutional Review Board approved all study procedures.

Measures

Participants completed a background questionnaire that assessed years of education, combined family income, weekly work hours, general health, and dieting. Specifically, participants were asked "Are you currently dieting to lose weight?"

Weight status and body mass index (BMI). Height and weight measurements were assessed in triplicate at each occasion by a trained staff member following the procedure outlined by Lohman and colleagues (33). Participants were dressed in light clothing and measured without shoes. Height was measured in triplicate to the nearest 10^{th} of a centimeter using a stadiometer (Shorr Productions stadiometer, Irwin Shorr, Olney, MD). Weight was measured in triplicate to the nearest 10^{th} of a kilogram using an electronic scale (Seca Electronic Scale, Seca Corp, Birmingham, UK). Average height and weight were used to calculate BMI [weight (kg)/height $(m)^2$]. Recommendations made by the World Health Organization (34), were used to classify women as overweight (BMI $\geq$ 25) and obese (BMI $\geq$ 30).

Restraint and disinhibition. The Eating Inventory (EI) developed by Stunkard and Messick (9) consists of 51 true-false items designed to tap three subscales: 1) dietary restraint (21 items), 2) dietary disinhibition (16 items), and 3) susceptibility to hunger (14 items). For the purpose of this study, only restraint and disinhibition subscales were used. The restraint scale measures cognitive control of eating (e.g. "I consciously hold back at meals in order not to gain weight"). The dietary disinhibition scale measures loss of cognitive control of eating (e.g. "Sometimes when I start eating, I just can't seem to stop").

Scores for each subscale are calculated by summing respective items. Internal consistency coefficients for restraint were 0.87, 0.86, 0.83, and 0.86 at times 1, 2, 3, and 4, respectively. Disinhibition also demonstrated good internal consistency with an α=0.83, 0.84, 0.83, and 0.82 at times 1, 2, 3, and 4, respectively.

Statistical Analyses

Model Specification. Linear mixed models (i.e., growth curve models) were estimated to examine the overall pattern of and individual differences in weight change (kg) among women over 6 years (35, 36). Weight change was examined as the primary outcome for two reasons: 1) height did not change among our sample of pre-menopausal women; and 2) long-term weight maintenance has been defined as a weight change of less than three percent of body weight (37). Because women differed in age at baseline, two options for modeling change over time were possible: a time-in-study model with age at baseline as a covariate, or an age-as-time model. A time-in-study model was selected because preliminary analyses suggested that the cross-sectional, between-person effect of age was not significant. Thus, change was specified as a function of time in study, and age at baseline was also included as a control variable.

Restricted maximum likelihood (REML) was used in reporting model parameters and to assess the significance of random effects; degrees of freedom were estimated using the Satterthwaite method. Time-in-study was centered at the first occasion such that the intercept represented initial status in all models. The interclass correlation from the unconditional means model (i.e., empty model; intercept only) was calculated as .92, indicating that that 92% of the variance for weight across 6 years occurred between persons. The interclass correlation from the unconditional means model was .65 for restraint and .77 for disinhibition, indicating that much of the variance for restraint and disinhibition was also between persons. All analyses were conduced using SAS PROC MIXED software (version 9.1, 2007, SAS institute, Cary NC).

RESULTS

Descriptive Characteristics

Descriptive statistics are located in **Table 2.1**. Mean age of women at study entry was 35.7 (*SD* = 4.7) ranging from 24.1 to 46.6 years. Women were, on average, well educated and approximately equal numbers of families reported incomes at entry into the study below $35,000, between $35,000 and $50,000, and above $50,000. At baseline, 64% reported being employed , working a mean of 19 hours per week. Over half of the sample was overweight at baseline. Specifically, 54% of participants were classified as overweight (BMI $\geq$ 25) at baseline; this proportion increased to 60% at 6 year follow-up, despite the fact that nearly 60% of women reported dieting at least once during the course of this study.

On average women gained 3.9 kg or 5.6% of their initial body weight across the 6 year period. **Table 2.2** displays descriptive statistics for all predictor and outcome variables at each occasion. Mixed model analysis using random coefficients revealed that both weight (kg) [weight = 70.28 + 1.26 * years; $p < 0.001$] and BMI [BMI = 26.01 + 0.47 * years; $p < 0.001$] increased significantly over time, such that 69% of women gained weight ($\geq$ 1 kg) from baseline to year 6. Similar analyses revealed that restrained eating [restraint = 9.38 - 0.41 * years; $p < 0.001$] and disinhibited eating [disinhibition = 7.50 – 0.25 * years; $p < 0.001$] decreased significantly over time.

Unconditional Polynomial Models for Weight Change

Polynomial models were first specified with a random intercept only. A fixed linear effect of time was significant ($p < .001$), such that average weight increased across time. The addition of a random linear effect (including covariance between the random intercept and random linear effect) resulted in a significant improvement to the model, REML deviance difference (2) = 61, $p < .001$. The mean weight at baseline was 72 kg, with a 95% random effects CI of 39 to 105 kg. The mean linear rate of change was 0.65 kg per year, with a 95% random effects CI of -0.83 to 2.1, indicating that not all women were expected to gain weight over time. The addition of fixed and random quadratic effects did not significantly improve the fit of the model, indicating no acceleration/deceleration of change over time.

Conditional Polynomial Models for Weight Change

We then estimated conditional (predictive) models to examine the interactive effects of restraint, disinhibition, and dieting on weight change over time. To facilitate interpretation of main effects and interactions across levels of analysis, the effects were separated into between-person (i.e., whether or not a women was higher or lower on a factor, relative to other women in the sample) and within-person (i.e., whether a woman increased or decreased in a factor from study entry) variables. The between-person effects of dietary restraint and disinhibition were represented by the baseline value of each predictor (which was then centered at 8.5 for restraint and at 7.0 for disinhibition). Within-person effects were then represented as each person’s deviation (change) from their own baseline value at each occasion. The between-person effect of dieting was represented with a dummy code for “ever-dieting” during the course of the study, and the within-person effect of dieting was represented with a dummy code for currently dieting. Results are presented in **Table 2.3**.

The effects of dietary restraint were examined first, in which higher scores indicated greater restraint. As shown in Model 1, there were no significant between-person effects of dietary restraint at baseline on weight at baseline (main effect of restraint) or across all four time points (interaction of baseline restraint with time). The within-person effect of dietary restraint was significantly negatively associated with weight status, such that within-person increases in restraint were associated with within-person decreases in weight at the same time point. Although this within-person effect of dietary restraint did not vary over time, it did vary significantly over individuals, as indicated by a significant model improvement upon adding its random effect, REML deviance difference (3) = 27, $p < .001$. Thus, our first hypothesis that dietary restraint would not be a significant predictor of weight gain was partially supported; between person differences in baseline restraint were not related to weight change but within-person increases in restraint did covary with concurrent within-person decreases in weight.

The effects of dietary disinhibition were examined next, in which higher scores indicated greater disinhibition. As shown in Model 2, there was a significantly positive between-person effect of dietary disinhibition at baseline, such that greater levels of disinhibition at baseline were related to higher levels of weight at baseline, and this relationship was strengthened over time, as indicated by a significant interaction of baseline disinhibition and time. Thus, higher levels of disinhibition at study entry predicted a greater amount of weight change. There was also a significantly positive within-person effect of dietary disinhibition, such that within-person increases in disinhibition were related to concurrent within-person increases in weight. The random effect of disinhibition was also tested, but not significant. Thus, our second hypothesis was supported such that disinhibition was positively associated with weight both between- and within-persons.

Model 3 examined the third hypothesis that dietary restraint would moderate the positive association between dietary disinhibition and weight. First, we added the interaction of between-person restraint and between-person disinhibition, which was significantly negative, meaning that higher levels of restraint at baseline were related to a less positive effect of disinhibition at baseline on weight status. In other words, the positive association between disinhibition and weight is modified when you consider level of between-person dietary restraint. Next, we added an interaction of between-person disinhibition and within-person restraint. This interaction was also significantly negative, such that while greater levels of disinhibition at baseline were associated with higher levels of weight over time, the positive effect of baseline disinhibition on weight gain was more negative at times when persons had higher levels of dietary restraint (i.e., higher than baseline). The interaction of within-person disinhibition and between-person restraint and the interaction between within-person restraint and disinhibition were also tested; neither emerged as significant predictors of weight change. Thus, our third hypothesis that dietary restraint would moderate the positive relationship between disinhibition and weight gain was supported both between-persons and within-persons.

We then examined the effects of self reported dieting to lose weight. There were significantly positive between-person effects of ever dieting, such that women who reported dieting had higher weights at baseline (main effect of ever dieting) and greater weight gain over time (interaction of ever dieting with time). However, there was not a significant within-person effect of current dieting on current weight. Thus, our fourth hypothesis that dieting would be related to weight gain was supported between-persons (i.e., dieters gain more weight over time), but not within-persons (i.e., weight is not lower in dieters when actually dieting).

Finally, we also tested a three-way interaction (after including all relevant main effects and two-way interactions) to examine whether the degree of moderation of the disinhibition effect by restraint would vary across dieters and non-dieters, this interaction was significant, as shown in Model 4. The interaction is depicted in **Figure 2.1 and Figure 2.2**, which shows predicted weight change over time for prototypical levels of the covariates (i.e., ± 1 SD). As shown in Figure 2.1, restraint at baseline does not moderate the effect between baseline disinhibition and weight gain in non-dieters (i.e., comparing panels A and C: the effect of higher versus lower levels of disinhibition remained the same whether an individual had higher or lower restraint). However, the association between disinhibition and weight is moderated by restraint in dieters (i.e., Figure 2.1, comparing panels B and D: higher disinhibition predicts higher weight status and more weight change in dieters when restraint is low, but higher disinhibition does not predict higher weight status in dieters when restraint is high). Thus, restraint only modified the relationship between disinhibition and elevated weight status in dieters, not for non-dieters. However, the difference between dieters and non-dieters does not vary significantly as a function of restraint or disinhibition when each is at their mean (i.e., no two-way interactions of ever dieting by restraint or ever dieting by disinhibition), but the difference between dieters and non-dieters is reduced at lower levels of both restraint and disinhibition (Figure 2.2, Panel A) OR at higher levels of both restraint and disinhibition (Figure 2.2, Panel D). At disparate levels of restraint or disinhibition (i.e., low/high or high/low), the differences between dieters and non-dieters are larger (Figure 2.2, Panel B and C). Model 4 was also examined using BMI as the outcome, revealing similar results (data not shown).

DISCUSSION

This study was designed to examine the independent and combined effects of dieting, dietary restraint and disinhibition on weight gain in women over a 6 year period. On average, women gained 3.9 kilograms (8.5 pounds) over 6 years. Moreover, the prevalence of overweight increased from baseline (54%) to follow-up (60%). Large individual differences in weight change were also noted, ranging from a weight loss of 20.9 kg to a weight gain of 30.1 kg. The average weight gain noted among our sample is consistent with other longitudinal studies, which have revealed that adults tend to gain 0.5-1.0 kg per year. Growth curve models indicated that higher levels of dietary disinhibition and self reported dieting were associated with higher initial weight and weight gain. Thus, findings provide additional evidence that self reported dieting may not be an effective weight control strategy. Also consistent with previous literature, individual differences in restraint were not predictive of weight change, but restraint did moderate the effects of disinhibition and dieting on weight change. Specifically, weight increased among those who showed increases in disinhibition over time, combined with declines in restraint over time. These findings reveal that in general, restraint is not an effective weight maintenance strategy by itself, but that restraint may moderate weight gain among disinhibited dieters. This interaction demonstrates the importance of examining the conjoined effects of restraint, disinhibition and dieting on weight gain over time.

This study is not without limitations. First, this sample was racially and demographically homogenous, and included only women, which prevents us from generalizing to men or to other racial and socioeconomic groups. Moreover, while the present study assessed predictors and weight status on several occasions (i.e., every 2 years) over 6 years, more frequent assessments of weight status and dieting may better capture changes in eating behavior and weight cycling; we may have missed short term fluctuations in dieting, weight gain, and weight loss may be inadvertently missed. Furthermore, individuals that cycle through weight lose and weight gain usually gain significantly more weight over time than weight maintainers (38). Another potential limitation of this study is that duration of dieting (i.e., months) or type of dieting (i.e., healthy versus unhealthy) were not assessed which may also interact to influence body weight change (22). Finally, these data were self reported. Thus, there is the potential for reporting bias.

The primary aim of the present study was to test a three-way interaction among dietary restraint, dietary disinhibition, and dieting based on previous research suggesting that dietary restraint is a multidimensional construct, encompassing both past and current dieting (26). To better understand these results, it is important to first discuss the two-way interactions. In support of the third hypothesis, restraint moderated the positive association between disinhibition and weight gain. In other words, while disinhibition and dieting predict increases in weight over time, these effects decreased among women who showed increases in restraint over time. Therefore, baseline restraint itself was not an independent predictor of weight or weight change, but rather moderated the positive association between disinhibition and weight gain, a finding consistent with previous cross-sectional research (13, 14, 20). For example, a study that assessed this interaction in premenopausal women using a 2 X 2 factorial design (high/low restraint X high/low disinhibition) found that individuals reporting low restraint but high disinhibition were significantly heavier than the other three groups, whereas the low restraint and low disinhibition groups had the lowest BMI (20).

The significant three-way interaction shown in Figures 2.1 and 2.2 revealed that restraint only moderated the positive effects of disinhibition on weight gain among dieters, but not non-dieters. This finding is consistent with previous research findings that restrained non-dieters may be more likely to overeat and gain weight than restrained dieters, which thereby motivates them to enter a new weight-loss diet (26-29). Specifically, research designed to differentiate how restraint and dieting impact weight change revealed that, in terms of weight loss, dieters who were also restrained lost significantly more weight than restrained and unrestrained non-dieters (29). Therefore, being highly restrained while currently dieting was an effective strategy to promote short term weight loss; however, a history of repeated dieting may be a proxy risk factor for unsuccessful eating control, weight cycling, and weight gain over time. These findings are consistent with those of Hill and colleagues (19) who argue that chronic cognitive control over eating is needed to moderate weight gain in our current environment. In combination, these findings indicate that increases in dietary restraint may be useful in moderating weight gain and weight maintenance among women who report dieting to lose weight. Thus, dieting status may play a causal role in producing a vulnerability to disinhibited eating and weight gain. However, further longitudinal analyses are needed to confirm these findings in other samples of free-living adults while also examining potential sex differences.

As predicted, and consistent with previous research (11-14, 16, 17, 39), interpretation of the main effects revealed that baseline dietary restraint scores were not associated with weight status or weight change over time, whereas women reporting higher baseline dietary disinhibition scores were significantly heavier at baseline and gained more weight over time. Our findings are consistent with those of Lauzon-Guillain and colleagues (17) who assessed relations between eating behavior and adiposity over a 2-year period and found that baseline restraint was not associated with subsequent adiposity changes; however, baseline restraint was positively associated with BMI in normal-weight adults. Similarly, a cross-sectional study conducted by Hays and colleagues (14) revealed that disinhibition was a significant predictor of weight gain and BMI, whereas restraint was not an independent predictor of weight change. In combination, these findings suggest that disinhibition may be a stronger predictor of weight gain over time.

Much of the existing literature noted above has either been cross-sectional or only assessed eating behavior on 2 occasions and thereby use a change score to predict weight gain. For example, a prospective study assessing changes in weight from baseline to 6-year follow-up revealed that higher restraint behavior and decreases in restraint promoted weight gain over time (21). To date, the present study is the first to examine how changes in restraint, disinhibition and dieting (within-person effects) across 4 occasions of measurement predict changes in weight status over time in free-living individuals. Although differences in dietary restraint between individuals were not predictive of weight gain, within-person increases in restraint over time were associated with concurrent decreases in weight over time. These results are consistent with those of a weight loss intervention conducted by Foster and colleagues (16) who found that greater increases in restraint during a weight loss treatment program were associated with significantly greater weight loss. Moreover, a study evaluating variables associated with long term weight maintenance revealed that an increase in dietary restraint during weight loss was a significant predictor of weight maintenance over 2 years (40). One potential explanation for this association is that highly restrained individuals have been shown to consume lower daily energy intake, avoid low fat foods, and consume “diet foods” more often compared to low restrainers (41) which in turn promote weight loss. Therefore, it is not surprising that women who increased their restrained eating over time had concurrent decreases in weight status. While causality cannot be determined in the present study, findings suggest that the effects of interventions to encourage moderate levels of dietary restraint, especially among disinhibited eaters and self reported dieters should be explored, as the present study reveals that increasing dietary restraint might be effective in promoting weight maintenance by moderating weight gain.

In support of our fourth hypothesis, and consistent with previous research (2, 3, 5), women who dieted gained significantly more weight over time than women who did not report dieting to lose weight. Among our sample, weight among dieters was not lower when dieting suggesting that dieting may not be an effective long-term weight loss strategy. These findings reveal that dieting is not effective at preventing weight gain over time. This is congruent with a recent review by Hill (5) who concluded that being overweight makes women more likely to diet rather than dieting causing someone to gain weight over time. However, the effect of dieting on short-term weight loss still remains unclear.

In conclusion, our findings provide evidence that self reported dieting to lose weight was associated with weight gain and was not an effective weight maintenance strategy; however increases in dietary restraint may be protective against long-term weight gain by attenuating the positive association between disinhibition and weight gain in free-living women. This research and other recent reports (5, 19) confirm that being a chronically restrained eater may be an effective weight control strategy as opposed to dieting; thus, providing further evidence that dietary restraint is independent of dieting. Moreover, high levels of disinhibited eating were associated with higher initial weight status and greater gains. Thus, new approaches need to be developed to lessen disinhibited eating and continued weight gain during adulthood while promoting moderate levels of restrained eating.

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Table 2.1. *Sample Characteristics at Baseline (n = 163)*

	N	%	*M*	Range	*SD*
BMI			26.5	17.7 - 56.2	6.2
Height (cm)			164.3	150.5 - 186.1	3.1
Weight (kg)			71.4	45.5 - 149.1	16.7
Age			35.7	24.1 - 46.6	4.7
Education (years)			14.7	12 - 20	2.3
Self-Reported Dieting [z]					
No	67	41.1			
Yes	96	58.9			

Notes. [z] Self-reported dieting to lose weight at one or more times of measurement

Abbreviations: *M* = Mean; *SD* = Standard deviation; BMI = body mass index

Table 2.2. *Mean (M) and standard deviation (SD) of Outcome and Predictor Variables at Each Occasion*

	Baseline	Year 2	Year 4	Year 6
Weight (Kg)				
N	196	192	182	176
M	71.1	72.5	74.2	75.1
SD	16.3	16.6	16.9	17.8
Missing Data (%)	1 (0.5%)	5 (2.5%)	15 (7.6%)	21 (10.7%)
Dietary restraint				
N	197	192	182	176
M	9.1	8.5	8.1	7.9
SD	5.9	4.9	4.7	4.8
Missing Data (%)	NA	5 (2.5%)	15 (7.6%)	21 (10.7%)
Dietary disinhibition				
N	197	192	182	176
M	6.9	7.1	7.0	6.2

SD	3.9	3.9	3.9	3.7
Missing Data (%)	NA	5 (2.5%)	15 (7.6%)	21 (10.7%)
Dieting to lose weight				
Yes	148 (76%)	133 (69%)	134 (74%)	122 (69%)
No	47 (24%)	59 (31%)	48 (26%)	54 (31%)
Missing Data (%)	2 (1.0%)	5 (2.5%)	15 (7.6%)	21 (10.7%)

Table 2.3. *Parameters estimates and model fit statistics predicting weight change in women: Multilevel Mixed Model analysis, Model 1 predictor includes restraint, Model 2 includes disinhibition, Model 3 includes an interaction between restraint and disinhibition, and Model 4 includes a three-way interaction among restraint, disinhibition, and dieting*

	Model 1 Restraint			Model 2 Restraint + Dis.			Model 3 + Res. X Dis.			Model 4 + Res. X Dis. X Diet		
Term	Est	SE	p	Est	SE	p	Est	SE	p	Est	SE	p
Fixed Effects												
Intercept	71.55	1.29	0.00	71.71	1.08	0.00	72.27	10.09	0.00	69.36	2.22	0.00
Age at baseline	0.03	0.27	0.90	0.10	0.23	0.66	0.10	0.22	0.67	0.24	0.23	0.30
Linear time in study	0.63	0.08	0.00	0.65	0.08	0.00	0.64	0.08	0.00	0.40	0.13	0.01
Between-person restraint at baseline	0.14	0.29	0.63	-0.32	0.25	0.21	-0.37	0.25	0.14	-0.35	0.52	0.51
Between-person restraint by time	-0.00	0.02	0.89	-0.02	0.02	0.32	-0.01	0.08	0.41	-0.03	0.02	0.16
Within-person change in restraint	-0.37	0.07	0.00	-0.39	0.07	0.00	-0.35	0.07	0.00	-0.37	0.07	0.00
Between-person disinhibition at baseline				2.46	0.30	0.00	2.45	0.30	0.00	3.00	0.59	0.00
Within-person change in disinhibition				0.24	0.10	0.01	0.21	0.10	0.02	0.20	0.09	0.04
Between-person disinhibition by time				0.06	0.02	0.01	0.04	0.2	0.05			

	Model 1			Model 2			Model 3			Model 4		
	Restraint			Restraint + Dis.			+ Res. X Dis.			+ Res. X Dis. X Diet		
Term	Est	SE	p	Est	SE	p	Est	SE	p	Est	SE	p
BP disinhibition by BP restraint							-0.15	0.08	0.05	0.10	0.14	0.46
BP disinhibition by WP restraint							-0.08	0.02	0.00	-0.08	0.02	0.00
Between-person ever dieting										4.87	2.71	0.07
Between-person ever dieting by time										0.38	0.18	0.03
Within-person currently diet										0.26	0.51	0.61
BP restraint by ever dieting										-0.10	0.63	0.88
BP disinhibition by ever dieting										-0.69	0.74	0.35
BP restraint by BP disinhibition by ever dieting										-0.41	0.19	0.03
<u>Variance Components</u>												
Residual Variance	12.26	1.04	0.00	12.19	1.03	0.00	12.12	1.01	0.00	11.99	1.00	0.00
Intercept Variance	253.40	29.18	0.00	173.86	20.41	0.00	169.59	19.89	0.00	159.09	18.72	0.00
Intercept-Slope Covariance	3.19	1.31	0.02	2.16	1.12	0.05	2.16	1.08	0.05	2.11	1.08	0.05
Linear Slope Variance	0.27	0.13	0.02	0.28	0.13	0.02	0.27	0.12	0.01	0.29	0.12	0.01

	Model 1 Restraint			Model 2 Restraint + Dis.			Model 3 + Res. X Dis.			Model 4 + Res. X Dis. X Diet		
Intercept-Restraint Change Covariance	-2.82	1.19	0.08	-0.44	0.10	0.66	-0.40	0.86	0.64	-0.28	0.83	0.74
Linear Slope-Restraint Change Covariance	0.01	0.07	0.92	0.08	0.08	0.30	0.03	0.06	0.62	0.05	0.06	0.45
Change in Restraint Variance	0.23	0.08	0.00	0.21	0.07	0.00	0.13	0.06	0.02	0.13	0.06	0.01

Abbreviations: *Est* = Parameter estimate; *SE* = Standard error, Res = restraint, Dis = Disinhibition, Diet = Dieting at least once during study

FIGURE CAPTIONS

Figure 2.1. Three-way interaction model depicting the effect of disinhibition by dieting status and dietary restraint level on weight change over time. High and low restraint and disinhibition were calculated as $\pm$1 standard deviation of the mean; restraint ($\pm$ 5) and disinhibition ($\pm$ 4). Dashed lines represent high disinhibition; solid lines represent low disinhibition.

Figure 2.2. Three-way interaction model depicting the effect of dieting status by dietary restraint and disinhibition level on weight change over time. High and low restraint and disihibition were calculated as $\pm$1 standard deviation of the mean; restraint ($\pm$ 5) and disinhibition ($\pm$ 4). Solid lines represent non-dieters; dashed lines represent.

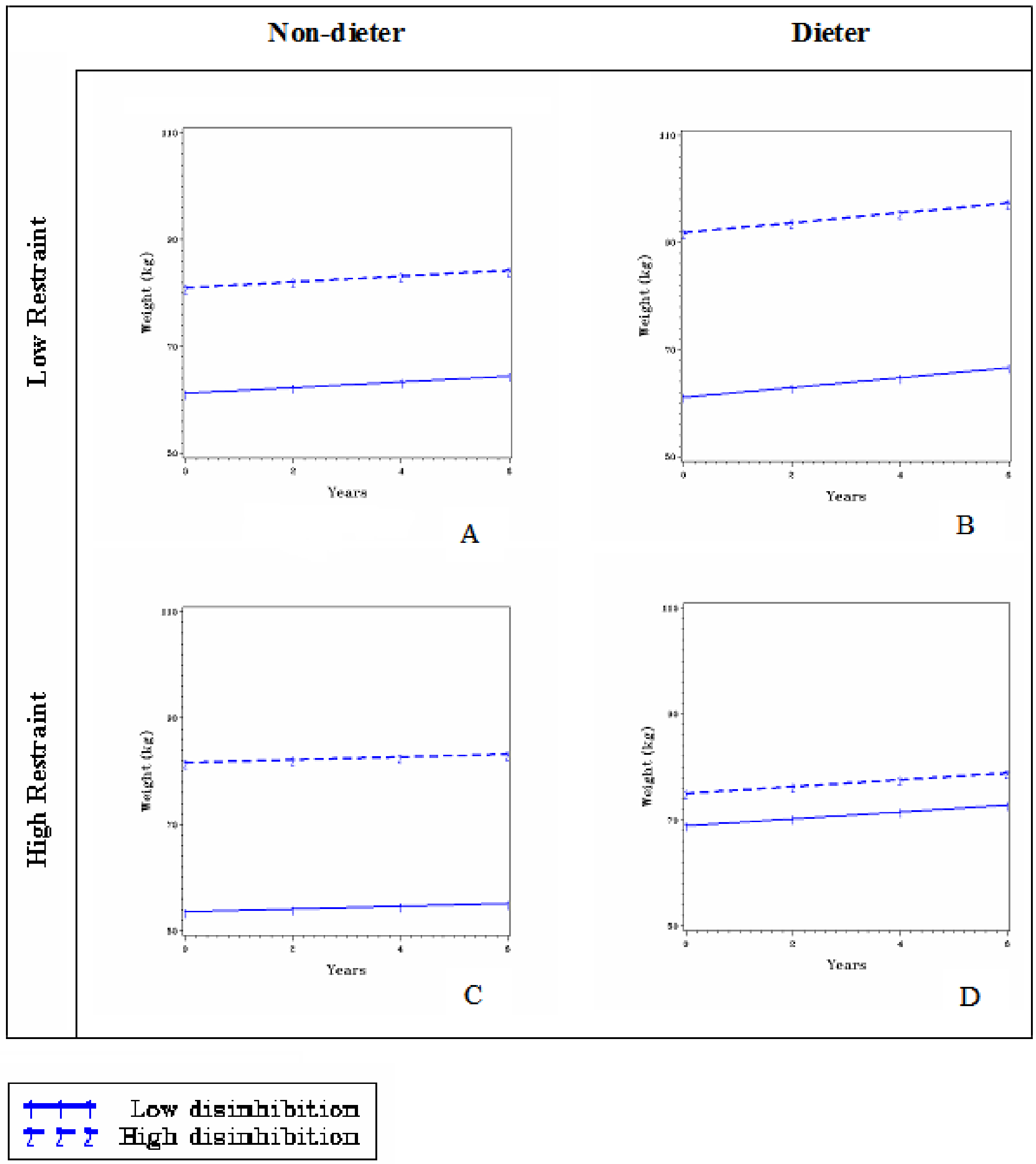
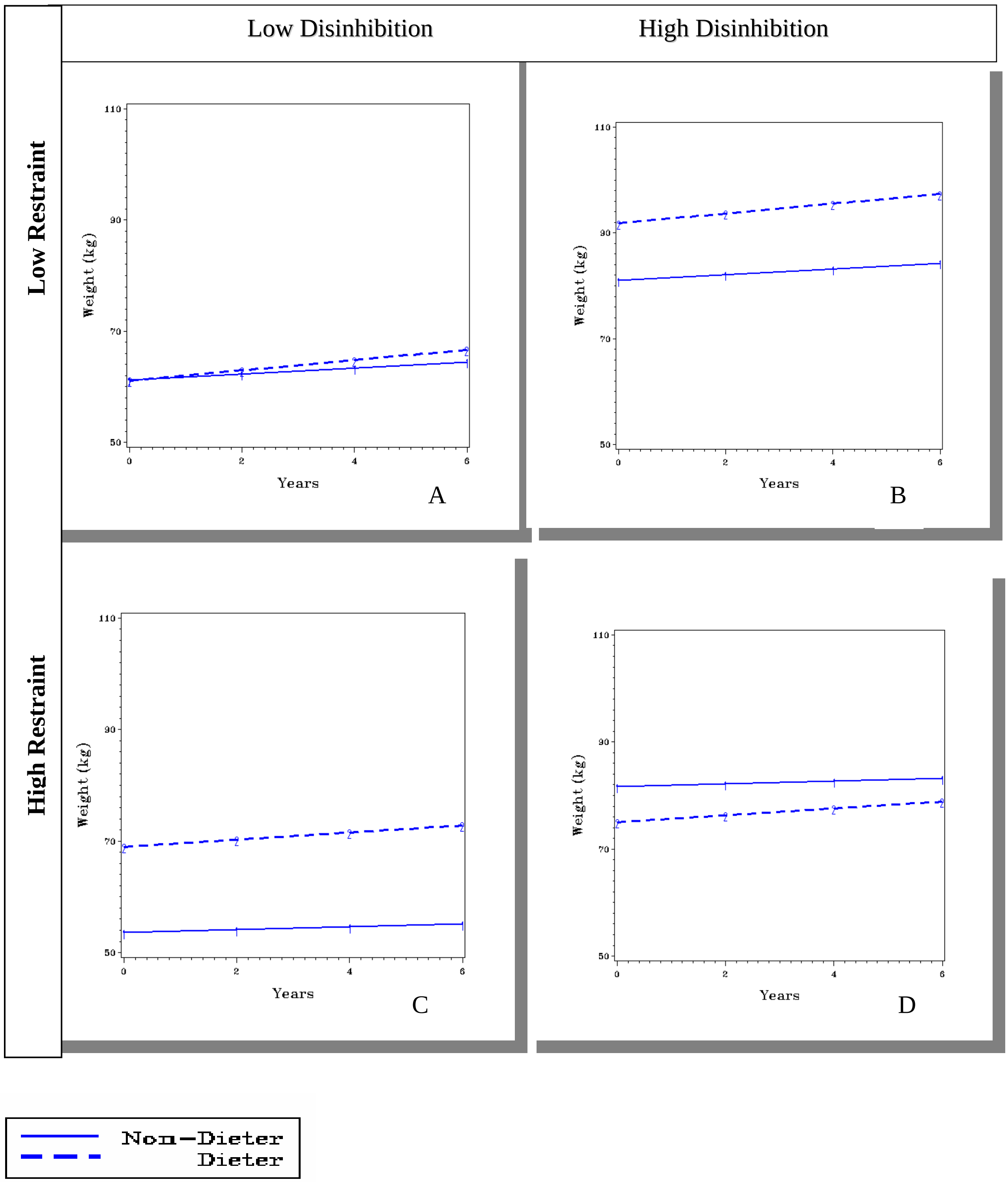

Non-dieter
Dieter
Low Restraint
High Restraint
Weight (kg)
Years
A
B
C
D
Low disinhibition
High disinhibition

Figure 2.1



Low Disinhibition
High Disinhibition
Low Restraint
High Restraint
Weight (kg)
110
90
70
50
0
2
4
6
Years
A
B
C
D
Non-Dieter
Dieter

Figure 2.2

Chapter 3

Differences in Weight Control Strategies Predict Weight Gain among Women over 4 Years

ABSTRACT

The purpose of this study was to explore whether differences in patterns of weight control strategies predict 4 year weight change among women. Participants (n = 176), were assessed biennially on 3 occasions over 4 years. Weight control strategies were assessed by the Weight Loss Behavior Scale. Height and weight were measured to calculate BMI [weight (kg)/height (m) ^{2}]. Weight concerns, eating style, eating attitudes, and body dissatisfaction were assessed. Latent class analysis (LCA) identified underlying types based on use of weight control strategies. Repeated measures mixed-effect models assessed effects of using different types of weight control strategies on weight change, before and after adjusting for initial BMI. Use of healthy weight control strategies were more commonly reported than unhealthy weight control strategies (Healthy: eliminate sweets and junk food = 74%, increase exercise = 74%, eat more fruits and vegetables = 72%; Unhealthy: skipping meals = 51%; fasting = 19%; diet pills = 16%). LCA results provided a three class solution: (1) none (NU); (2) healthy (H); and (3) healthy plus unhealthy (H+U). The NU group had the lowest initial BMIs. Women's pattern of weight gain was dependent on latent class membership: the H+U group gained more weight (4.46 $\pm$ 7.2 kg) than the NU group (1.33 $\pm$ 3.7 kg) and H group (0.99 $\pm$ 4.9 kg), before and after adjusting for initial BMI. H+U weight control group had higher scores on weight concerns, dietary restraint, and eating attitudes than H or NU women. Patterns of use of specific types of weight control strategies predicted differences in weight change. Findings indicate that public health messages for weight control should include specific recommendations regarding weight strategies to use or avoid, rather than limiting advice to "reduce caloric intake".

INTRODUCTION

Dieting to lose weight is common among women of all ages and body weights; in 2000, 46% of American women report currently dieting to lose weight (1). Despite current preoccupation with weight loss and dieting, obesity continues to be a major public health issue; approximately 60% of adults in the United States are now overweight or obese (2). Longitudinal studies estimate that on average, adults gain 0.5-1.0 kg per year (3, 4), which, over time, increases risk of many leading causes of morbidity and mortality (5). While a major public health objective is to identify factors associated with successful weight maintenance, few longitudinal studies have examined the influence of the use of specific strategies for weight control on patterns of weight change during adulthood. The objective of this study was to address whether differences in patterns of use of specific weight-control strategies predicted differences in weight change over time among women.

Much of the existing research examining the prevalence of specific weight control behaviors has been cross-sectional (1, 6-9). These studies reveal that women trying to lose weight frequently report using healthy weight control strategies but that a smaller percentage reports engaging in unhealthy weight control behavior. However, unhealthy weight control strategies are also defining characteristics of eating pathology (10). For example, fasting, self-induced vomiting, and use of laxatives, enemas, diuretics, or diet pills to lose weight are part of the diagnostic criteria for eating disorders (11). Furthermore, although greater body dissatisfaction, higher levels of eating attitudes, and greater weight concerns have been associated with self reported dieting (12-14), their association with the use of specific healthy and/or unhealthy weight control strategies is less well understood. Thus, a second aim of this research is to assess whether differences in these factors are associated with women's reported use of healthy or unhealthy weight control strategies.

For successful weight loss, both the U.S. Department of Health and Human Services Dietary Guidelines (15) and The National Heart, Lung, and Blood Institute (16) recommend reducing caloric intake and increasing physical activity, but they do not provide guidance about specific strategies to use or avoid that help individuals to meet their goals for weight management. Results from the few longitudinal studies that have examined the effect of self-reported dieting on weight change reveal that dieting is not an effective weight maintenance strategy (17-19). For example, Lowe and colleagues (17) reported that a history of dieting predicted greater weight gain and that women who self-reported that they were currently dieting to lose weight gained three times as much weight as non-dieters. However, in that research, women did not provide information regarding the specific strategies they were using when they were dieting.

One study (19) has examined the independent effects of specific weight control strategies on weight change in US adults. French and colleagues reported that although reports of dieting were not significantly related to weight change, calorie reduction, increasing fruit and vegetable intake, fat reduction, eliminating sweets and reducing the amount of food eaten were associated with gaining less weight. Therefore, little is known about the long term effects of practicing healthy and/or unhealthy weight control strategies on weight change among free-living women. An understanding of how using specific healthy and unhealthy weight control strategies influences weight change has important implications for the development of recommendations promoting weight maintenance that are more specific than simple guidance to "eat fewer calories" to lose weight. The present study will use the Weight Control Scale developed by French and colleagues (9) to address this question.

The first aim of this study was to use latent class analysis to determine whether distinct groups of women could be identified, based on their probability of using specific weight control strategies. The second aim was to examine differences in weight status, psychosocial, and contextual factors among women practicing different weight control strategies. The third aim was to determine whether latent class membership predicted differences in weight change over a 4 year period in women before and after adjusting for initial BMI. Based on previous research (7, 9, 12, 13, 17, 20), we hypothesized that 1) healthy weight control will be common, but a small percentage will report engaging in unhealthy weight control; 2) women using weight control strategies will report greater body dissatisfaction and weight concerns than non-users; and 3) unhealthy weight control efforts would be ineffective, with individuals using unhealthy weight control strategies gaining more weight over time compared to non-users.

METHODS

Participants

Participants included 183 non-Hispanic white women living in central Pennsylvania recruited as part of a longitudinal study designed to examine parental influences on girls' growth and development; the sample was not recruited based on weight status. Families with age-eligible female children within a 5-county radius were identified using available marketing information (Metromail Inc., Chicago). These families received mailings providing information about the study and were recruited using follow-up phone calls. Eligibility criteria focused on daughters' characteristics including the absence of severe food allergies or chronic medical problems affecting food intake and the absence of dietary restrictions involving animal products. Only data for mothers are considered in this study. At time 1, participants included 183 women, of whom 177 and 168 women were reassessed at time 2 and time 3, respectively, representing a 92% retention rate. Attrition was primarily due to family relocation outside of the study area. Women who were missing weight control strategy data at time 2, were excluded from all analyses, leaving a final sample of (*n* = 176).

Design and Procedures

Data were collected on three occasions of measurement across a 4-year period, with 2-year intervals between assessments. At each time of assessment, women completed a series of self-report questionnaires during a scheduled visit to the laboratory. The Pennsylvania State University Institutional Review Board approved all study procedures, and women provided consent for their family's participation in the study before the initiation of data collection. **Table 3.1** provides a list of study measures and information on the time points when each measure was obtained. Background characteristics and correlates of weight control strategies were collected at study entry; height and weight were collected at all three occasions. At time 2, data on weight control strategies used during the previous two years were collected; these data were used in the LCA analyses and to predict patterns of weight change over the study period.

Measures

Background characteristics. Women completed a Background Questionnaire that assessed family background characteristics including combined family income and mothers' and fathers' years of education at study entry. Participants chose from four income categories: less than $20,000/yr, $20,000 to $35,000/yr, $35,000 to $50,000/yr, or $50,000+/yr. For education, women indicated whether they had the following degrees/diplomas: high school, associates, technical/vocational school, bachelors, masters, PhD, MD, JD, or other. In addition, women retrospectively reported on their weight as a child using a 3-point scale: 1 = underweight; 2 = average weight; and 3 = overweight.

Weight status and body mass index (BMI). Height and weight measurements were assessed in triplicate at each occasion by a trained staff member following the procedure outlined by Lohman and colleagues (21). Participants were dressed in light clothing and measured without shoes. Height was measured in triplicate to the nearest 10^{th} of a centimeter using a stadiometer (Shorr Productions stadiometer, Irwin Shorr, Olney, MD). Weight was measured in triplicate to the nearest 10^{th} of a kilogram using an electronic scale (Seca Electronic Scale, Seca Corp, Birmingham, UK). Average height and weight were used to calculate body mass index [BMI;weight (kg)/height $(m)^2$]. Recommendations made by the World Health Organization (22) were used to classify women as overweight (BMI = 25-29.9) and obese (BMI $\geq$ 30). Finally percent weight change over 4 years was calculated by taking the difference between Time 1 and Time 3 body weight (kg) and dividing by Time 1 body weight. Weight maintenance was defined as a weight change of $\leq$ 3% of initial body weight (23).

Weight control strategies. Healthy and unhealthy weight control strategies were assessed using an amended version of the Weight Loss Behavior Scale (9). This measure consists of 24 items assessing the use of a set of specific weight control strategies used to lose or maintain weight during the past 2 years (Refer to **Table 3.2** for example items). Items are measured on a 5-point response scale ranging from 1 (*never*) to 5 (*always*). Principal components factor analysis was conducted to gain insight into the dimensionality of the revised measure in the current sample, revealing the best combination of variables assessing weight control strategies (see **Table 3.2**). The factor solution was rotated using a Varimax procedure. Two factors were identified on the basis of examination of loading values, the scree plot, eigenvalues, and the interpretability of the factor solution (24). Eleven weight control items loaded on the first factor which is similar to those comprising the healthy weight control factor as reported by French and colleagues (9). The second factor included 9 relatively harmful or unhealthy weight control methods, 7 of which were the same as the strategies that loaded on French and colleagues unhealthy weight control factor. Item loadings ranged from 0.36 to 0.86. Eigenvalues for the healthy and unhealthy weight control factors were 6.80 and 3.03, respectively. Decreasing alcohol intake, attending weight loss groups, vomiting, and "other" weight control strategies did not load on either factor and were dropped from further consideration. Internal consistency for the healthy and unhealthy factor were α=0.94 and α=0.73, respectively. In addition, participants were asked, "*Are you currently dieting to lose or maintain weight?" and "How successful were you in the past year in losing weight?*"

Weight concerns. An amended version of the Weight Concern Scale (25) was used to measure fear of weight gain, worry over weight and body shape, importance of weight, diet history, and perceived fatness at study entry. The measure consists of 5 items, on a 5-point Likert type response scale. Item three was amended from "*When was the last time you went on a diet*?" to "*Have you ever gone on a diet*" to assess the frequency of dieting in the past. An average weight concerns score was created by calculating the mean of all 5 items. In the current study, internal consistency score of weight concerns was 0.83.

Restraint and disinhibition. The Eating Inventory (EI) developed by Stunkard and Messick (26) was used to assess dietary restraint (21 items) and dietary disinhibition (16 items) at study entry. The restraint scale measures cognitive control of eating (e.g. “I consciously hold back at meals in order not to gain weight”). The dietary disinhibition scale measures loss of cognitive control of eating (e.g. “Sometimes when I start eating, I just can't seem to stop”). Scores for each subscale are calculated by summing respective items. Internal consistency coefficients for restraint and disinhibition subscales were both 0.83.

Eating Attitudes Test (EAT). The EAT is a 26-item self-report instrument that assesses maladaptive or problematic eating attitudes and behaviors at study entry. Participants rate their responses using a 6-point Likert scale ranging from 1 to 6. A higher score is representative of more problematic or maladaptive eating attitudes and a cutoff of 20 is indicative of eating disorder pathology. In the current study, the internal consistency score of the EAT was excellent (α = .78).

Body satisfaction. The Body Figures Rating Scale developed by Stunkard, Sorenson and Schulsinger measures perceptions about body size and is made up of nine body figures varying in shape (27). The figures are numbered and placed in order and participants are asked to indicate the figure that represents their ideal self and the figure that represents their actual self. The difference between these ratings is a discrepancy score that is considered to represent the individual’s level of body satisfaction. Responses were reverse coded. Thus, a positive value indicates the desire to be thinner or lose weight, zero values indicate body satisfaction, and negative values indicate the desire to be bigger.

Statistical Analyses

Data were analyzed using the SAS software (version 9.1, 2001, SAS institute, Cary NC) (28). Descriptive information was generated for all variables of interest. Both predictor and outcome variables were assessed for normality.

Model specification. Latent class analysis was used to identify a set of discrete, mutually exclusive latent classes of individuals based on their reported weight control strategies. A detailed description of this procedure is described elsewhere (29, 30). Briefly, the goal of latent class analysis (LCA) is to identify the minimum number of latent classes that describe the association among manifest variables (specific weight control strategies). LCA estimates two sets of parameters: the prevalence of each class (latent class membership probability) and the probability of endorsing each specific weight control strategy given membership in a certain class (item-response probabilities). LCA parameters are estimated by maximum likelihood using an EM algorithm, and missing data is assumed to be missing at random (MAR). LCA is based upon the assumption of conditional independence; thus, within a latent class, the probabilities of endorsement are assumed to be independent. In the present study, the items from the Weight Loss Scale were used to create binary indicators of specific weight control strategies; however, because every additional item included in the latent class model increases sparseness, certain healthy and unhealthy weight control strategies were aggregated based on 1) factor analyses results (**Table 3.2**) and 2) Pearson's correlation coefficients (**Appendix A**) which assess linear associations among weight control strategies. Aggregated weight control strategies include: 1) eliminating sweets and junk food and eliminating snacks; 2) reducing the amount of food consumed, reducing calories, and eating low-calorie foods; 3) use of diet pills, liquid diets, and appetite suppressants; and 4) use of laxatives or enemas and diuretics. The final set of 14 indicators included eight healthy and six unhealthy weight control strategies. The best fitting model was determined using three criteria. The first is using the G^2 fit statistic. The second is examining the Bayesian Information Criteria (BIC) and Akaike Information Criterion (AIC). The third criterion was the interpretability of the estimated parameter results: measurement parameter estimates that were close to zero and one, signaling non-random responses to indicators, and latent status membership estimates that were not too small were desired. Indicators were removed from the final model if they did not discriminate between latent classes.

Once a final model was selected, each individual was assigned to the latent class corresponding to their maximum posterior probability of membership. Latent class membership was then used to assess differences among weight control groups on measures of continuous and categorical data using ANOVA with Tukey HSD pos hoc tests and Chi-Square tests. A series of univariate logistic regression analyses (Proc LOGISTIC) were used to examine whether there were significant differences between each weight control group in the percentage of women as a function of BMI category (normal, over, obese). Variables were arranged so that the three class contrasts made by SAS would be a) NU versus women practicing H+U weight control strategies, (b) NU versus women practicing H weight control strategies, and (3) women practicing H versus H+U weight control strategies. Finally, latent class membership was used to examine whether differences among weight control groups predict different patterns of weight change using repeated measures mixed effect models.

Longitudinal Analyses: Predicting Patterns of Weight Change over Time

A mixed modeling approach (Proc MIXED) was used to assess the effect of weight control strategy use on change in body weight (kg) over 4 y. Mixed modeling is a useful tool for analyzing repeated measures over time, and a major advantage is its ability to retain cases with one or more missing data points (51). Determination of model fit was based on several criteria: (1) model convergence, (2) a positive definite G matrix and (3) statistical fit comparison based on the Akaike Information Criteria (AIC) (52). An unstructured covariance matrix was selected, as determined by the aforementioned model fit criteria; main effects of time, weight control group, and weight control group by time interaction were tested to predict patterns of weight change. This model was tested before and after adjusting for initial BMI based on evidence that women who use weight control strategies are heavier than non-users (7, 9, 31). Finally, a three-way interaction among BMI category (normal versus overweight), weight control group, and time (after including all relevant main effects and 2-way interactions) was tested to examine whether the association between weight control group and time would vary across normal and overweight women. Inclusion of the interaction of weight control group by time provided a test of the major hypothesis, as a significant interaction effect provides evidence for a differential pattern of change over time among weight control groups.

RESULTS

Descriptive Characteristics

Mean age of women at study entry was 39.5 (± 4.8) ranging from 28.0 to 50.7 years. Women were in general well-educated, with a mean of 14.8 (± 2.3) years of education and approximately an equal proportion of families at entry into the study reported incomes below $35,000, between $35,000 and $50,000, and above $50,000. On average, women were slightly overweight (BMI: *M* = 27.38, *SD* = 6.3). Of the 176 participants, 54 (31%) were classified as overweight (BMI = 25-29.9) and 47 (27%) were obese (BMI ≥ 30) at baseline.

Prevalence of Reported Weight Control Strategies

Table 3.2 shows the percentage of women using specific weight control strategies. Reported use of healthy weight control practices for weight control was common; more than 50% of women reported using each healthy strategy, with the exception of eating less meat and less carbohydrates. Elimination of sweets and junk food, increased exercise, increased fruit and vegetable intake, and decreased fat intake were most common, reported by more than 70% of women. Weight control strategies that were considered unhealthy or harmful were not frequently reported, with the exception of skipping meals.

Aim 1: Identifying groups differing in probability of using weight control strategies: Selection of LCA model

One- to five-class solutions were investigated. The first set of models included all 14 indicators. However, examining the participant response patterns of our hypothesized model revealed that the parameter estimates for two of the unhealthy weight control strategies, cigarette smoking and attending diet centers, were not close to 0 or 1, so these were items were removed from the final model. As shown in **Table 3.3**, the drop in G^2 relative to the drop in degrees of freedom is substantial with each additional class up to the four-class model; the addition of classes beyond four provided no improvement in fit. However, the BIC and AIC were lower for the three-class solution than the four-class solution. Thus, in combination with the interpretability of the models, the three-class solution was chosen as the best model.

Results for the three-class model appear in **Table 3.4**. Parameter estimates from the three-class model indicated that the classes are distinguishable and nontrivial, and meaningful labels could be assigned to each. **Table 3.4** shows, for each class, the assigned label and probability of group membership, as well as the item-response probabilities for endorsing each item. For example, 21% of women were predicted to belong to a class defined by not using any weight control strategies, Non Users (NU); these individuals were not expected to endorse any weight control strategies. The largest of the three classes was the Healthy (H) Weight Control class (43%). Among the Healthy class, the probability of endorsing the following strategies ranged from 81% to 93%:1) reducing caloric intake and amount of food eating; 2) eliminating snacks, sweets, and junk food; 3) increased exercise; 4) increased fruit and vegetable intake; and 5) decreasing fat intake; however, they are not expected to endorse unhealthy weight control strategies. The remaining class was the Healthy plus Unhealthy (H + U) weight control group (35%); this class had very high probabilities of endorsing all 12 weight control strategies. For example, the probability of endorsing was 1.00 for 1) decreasing fat intake; 2) reduce caloric intake and amount of food consumed; 3) eliminate sweets, snacks, and junk food; and 4) skipping meals. In addition, the probability of the H+U class to endorse fasting was 55% and the probability of endorsing the use of diet pills, liquid diets, and appetite suppressants for weight control was 38%.

Aim 2: Differences among Weight Control Strategy Groups

Initial weight status, psychosocial and contextual factors. **Table 3.5** displays descriptive statistics for all background, correlates of weight control use, and outcome variables at study entry for the total sample and by latent class weight control strategy group. At baseline, weight control groups did not differ on measures of socioeconomic status or age. However, the NU group had significantly lower initial body weight and BMI compared to women using H or H+U weight control strategies. Women in the NU group also reported being more underweight as a child than the H or H+U groups. In addition, women practicing

H+U strategies had significantly higher scores on weight concerns and dietary restraint than either the H or NU groups. H and H+U groups also had higher dietary disinhibition, maladaptive or problematic eating attitudes, and body dissatisfaction scores than the NU group. Finally, NU women reported significantly lower weight concerns, dietary restraint, dietary disinhibition, and body dissatisfaction than either the H or H+U groups.

Normal weight, overweight, or obese? The chi-square analysis assessing the independence of BMI category (normal, overweight, obese) at baseline on weight control group indicated that women disproportionately fell into each of the weight control groups as a function of initial BMI classification [χ^2 (4, N =176) = 15.13, p < .01]. As shown in **Figure 3.1**, among the NU group, 70% were normal weight, while among the H and H+U groups, these percentages were 37 and 33 percent, respectively. Results from the logistic regression analyses indicated that women who were not using weight control strategies were about 6 times more likely to be normal weight than obese [B = 1.74, OR = 5.7 (CI = 0.61 – 2.87), p < .01] and approximately 5 times more likely to be normal weight than overweight [B = 1.47, OR = 4.7 (CI = 0.56 – 2.40), p < .01]. In addition, the percentages of normal, overweight, and obese women differed across weight control strategy groups. Among the H+U group, only 28% of women were normal weight. This figure increased to 41% and 43% when women were classified as overweight or obese, respectively.

As shown in **Table 3.6,** chi-square tables of BMI category by weight control group over time revealed that the percent of women classified as normal weight, overweight and obese changed over time for NU and H+U weight control groups. Among the NU group, the number of women classified as normal weight decreased from 70% at Time 1 to 61% at Time 3; whereas the number of overweight NU increased from 19% to 33%. Similarly, among the

H+U group, there was a shift from 32% being classified as obese at study entry to 54% at Time 3. However, among the H weight control group, the number of women in each BMI category remained fairly stable.

Longitudinal Analyses: Predicting Patterns of Weight Change over Time

Unconditional polynomial models were first specified with a random intercept only. A fixed linear effect of time was significant ($p < .001$), indicating that average weight increased across time. The mean weight at baseline was 70.43 kg. The mean linear rate of change was 1.21 kg (2.7 pounds) every two years, with a 95% random effects CI of -0.83 to 2.1, indicating that not all women were expected to gain weight over time, although on average, women gained 2.4 kg (5.3 pounds) across the 4 year period.

Conditional (predictive) models were estimated next to examine the effect of weight control strategy group (NU, H, and H+U) on patterns of weight change. As shown in **Figure 3.2**, results of the mixed-model analyses revealed a significant weight control group by time interaction (p<.01) such that a woman's pattern of weight gain was dependent on which weight control strategy group she was in (i.e., NU, H, or H+U weight control). Specifically, the increase in body weight over the 4 year period was significantly greater among women using H + U weight control strategies ($M_{\Delta T1-T3} = 4.46 \pm 7.2$ kg), than for NU women ($M_{\Delta T1-T3} = 1.33 \pm 3.7$ kg) ; $t(173)= 3.5$, $p<.0001$) or women who only used H weight control strategies ($M_{\Delta T1-T3} = 0.99 \pm 4.9$ kg); $t(173)= 3.0$, $p<.05$). The pattern of weight change was not significantly different between the NU and H weight control strategy groups. This model was also tested adjusting for initial BMI based on findings that women in the H and H+U groups were significantly heavier than women in the NU group; results were similar (see **Appendix B**). Comparable results were obtained when the same models were used to predict BMI change (data not shown). Finally, a three-way interaction was tested (after including all relevant main effects and two-way interactions) to examine whether the association between weight control group and time would vary across normal and overweight women. However, the 3-way interaction was not significant; indicating that patterns of weight change among the weight control groups did not differ for normal weight and overweight women (data not shown).

Finally, follow-up analyses examined the influence of using specific weight control practices on weight maintenance. On average, women gained 3.2% of their initial body weight from Time 1 to Time 3. However, percent weight change was significantly greater among the H+U weight control group (M = 5.7%, SD = 9.0) compared to the H weight control group (M = 1.7%, SD = 6.2). Chi-square analysis assessing the independence of weight control strategy group on whether women maintained (percent weight change $\leq$ 3%) or gained weight over time indicated that women disproportionably fell into the weight maintenance and gaining group as a function of weight control strategy group membership [χ^2 (2, N =163) = 12.28, $p < .01$]. Specifically, 60% and 64% of the NU and H weight control users maintained weight, respectively, whereas only 34% of the H+U weight control group maintained weight over 4 years.

Global Reports of Dieting

Data on global reports of "dieting" were also collected at Time 2. Comparable to national data, among the total sample, 48% of women responded "*Yes*" when asked, "*Are you currently dieting to lose or maintain weight.*" When asked "*How successful were you in the past year in losing weight*", among women who reported dieting, 43% responded "*not at all*", 43% responded "*fairly successful*", and 15% responded "*very successful*." Finally, women who self identified as dieting gained significantly more weight from Time 2 to Time 3 (*M* = 1.97 kg, *SD* = 4.9) than women who reported not dieting (*M* = 0.11 kg, *SD* = 5.3; $p < 0.05$). Similarly, percent weight gain was significantly greater among self identified dieters (*M* = 2.6%, *SD* = 6.6) than non-dieters (*M* = 0.36%, *SD* = 6.3; $p < 0.05$).

DISCUSSION

The purpose of this study was to examine the influence of specific weight control strategies on patterns of weight change over time, while also examining correlates associated with reported use of healthy and unhealthy weight control strategies. Latent class analysis results provided a three class solution, which characterized as women using: (1) none; (2) healthy; or (3) healthy plus unhealthy weight control strategies. These data indicate that during the 4 year period, on average, women gained 2.4 kg (range = - 17 to 27 kg) or 0.6 kg per year, which is consistent with other longitudinal studies that estimate adults tend to gain 0.5-1.0 kg per year (3, 4). Latent class membership predicted different patterns of weight gain; women who practiced Healthy and Unhealthy weight control strategies gained 4.5 kg over 4 years whereas women who used None or only Healthy weight control strategies gained 1.3 and 1.0 kg, respectively. Women who reported using none or only Healthy weight control strategies were also more likely to maintain weight than women using Healthy and Unhealthy weight control strategies. In addition, women reporting not using any weight control strategies weighed significantly less than women who reported using weight control strategies. Finally, in accordance with previous literature (9, 13, 14, 32-36), women practicing unhealthy weight control strategies reporter higher weight concerns, restraint, disordered eating attitudes and body dissatisfaction than women who only used healthy weight control strategies. These findings provide evidence that self reported weight control attempts do not necessarily lead to large weight gains, but the amount of weight gain depends on what weight control strategies were employed. Thus, the present study provides information that can inform the development of better weight control guidance; and perhaps more importantly specific practices that should be avoided.

In support of the first hypothesis and consistent with previous research (7, 9), reported use of healthy weight control strategies was common while a smaller percentage of women reported engaging in unhealthy weight control practices. Eliminating sweets and junk food, increasing exercise, eating more fruits and vegetable, and eating less fat were the most common strategies and were reported by more than 70% of women. In addition, approximately 50% and 20% of women reported skipping meals and fasting, respectively, to lose or maintain weight. However, it is possible that women in the current study tended to over-report socially desirable “healthy” behaviors while under-reporting socially undesirable “unhealthy” behaviors. Similarly, French and colleagues reported that the use of healthy weight control strategies including increasing exercise, eating less fat, eliminating sweets, and increasing fruit and vegetable intake was common, but a smaller percentage reported employing unhealthy weight control strategies such as skipping meals and fasting for weight control (19). In contrast, the percentages reported in the present study are greater than those reported in the National Health Interview Survey (7). Despite study findings that weight control practices are normative, to date, it has been unclear whether these strategies promote weight loss or maintenance.

The primary aim of this research was to use latent class analysis to assess whether differences in patterns of use of specific weight control strategies predicted patterns of weight change. In support of our third hypothesis, the three distinct patterns of weight control strategies that were identified using latent class analysis predicted differences in weight gain among women. On average, women using healthy and unhealthy weight control strategies gained 4.5 kg over 4 years whereas women who used none or only healthy weight control strategies gained 1.3 and 1.0 kg, respectively. These differences persisted when controlling for initial weight status, which is not surprising considering that 43% of women reported unsuccessful weight loss attempts in the past year. While there was no specific hypothesis, the present study also examined a three-way interaction among weight control group, BMI classification based on findings that women disproportionately fell into each of the weight control groups as a function of BMI category(data not shown). However, the 3-way interaction was not significant; indicating that associations between weight control group and patterns of weight gain did not differ for normal weight and overweight women. Finally, percent weight change among the Healthy plus Unhealthy weight control group (5.7% of their initial body weight) was significantly greater than women using none or only Healthy weight control strategies who successfully maintained weight. Previous literature indicates that the percent weight gain experienced by women using both Healthy and Unhealthy weight control strategies may be substantial enough to cause negative shifts in metabolic indicators of cardiovascular disease and metabolic syndrome (23, 37-39).

One potential explanation for the differences in patterns of weight gain between the H and H+U groups is that women who choose healthy weight control strategies are able to sustain these behaviors long-term, promoting weight maintenance or loss. Women practicing unhealthy strategies may lose weight in the short term but are not able to sustain the stringent restriction demanded by the unhealthy strategies which may lead to loss of control, overeating and weight gain over time (40-42). However, it is also possible that overweight women use more desperate or extreme measures because they are overweight or initiate use of weight control strategies in response to weight gain. Thus, addition research is warranted to examine the directionality of association between weight status and use of specific weight control strategies.

The present study is the first to examine how using different patterns of specific weight control strategies predicts weight change over 4 years in free-living women. However, one other study has examined the independent effect of practicing specific weight control strategies on weight change in a sample of adults participating in a weight prevention program. Similar to our findings, French and colleagues (19) found that calorie reduction, increased fruit and vegetable intake, fat reduction, elimination of sweets, and reducing the amount of food consumed were associated with less weight gain over time; however, they found no association between the use of unhealthy weight control strategies and weight change. In combination, these findings suggest that normal and overweight women should be advised to increase fruit and vegetable intake, exercise more, reduce fat and caloric intake, reduce the amount food consumed, and eliminate snacks, sweets and junk food. Perhaps the most important implication of these finding is that there are strategies that women should be advised to avoid because they are ineffective and may lead to weight gain; women who added unhealthy weight control strategies such as skipping meals, fasting, using diet pills, liquid diets, or appetite suppressants, to healthy strategies gained significantly more weight over 4 years. However, to test the effectiveness of avoiding unhealthy weight control strategies, a clinical trial is needed.

Another aim of the present study was to examine factors associated with weight control class membership. As previously reported (7, 9, 31), women who reported not using weight control strategies weighed significantly less than the H and H+U weight control groups at study entry. In addition, women in the NU group retrospectively reported being "*slightly underweight*" whereas women in the H and H+U groups reported being "*average*" weight as a child. Thus, while causality cannot be determined in the present study, women who did not report using weight control efforts have a history of being thinner which suggests that they may be constitutionally thin, thereby, they had no need to initiate the use of weight control behavior for weight maintenance (43).

Finally, in support of our second hypothesis, women in the H+U reported significantly greater weight concerns, disordered eating attitudes, and body dissatisfaction than H and NU weight control users. These findings are in agreement with previous studies, suggesting that individuals who are concerned with their weight tend to engage in unhealthy weight control behaviors such as fasting, purging, and diet pill use (13, 36) and have disordered eating attitudes (14, 35). Also similar to previous reports (9, 32-34), women practicing H+U weight control strategies reported greater body dissatisfaction, restrained and disinhibited eating, which may have contributed to their weight gain. However, whether higher disinhibition scores among the H+U group is a cause or consequence of the use of highly restrictive strategies cannot be determined in the present study. Thus, interventions aimed at enhancing body satisfaction while preventing the use of unhealthy weight control strategies may potentially reduce the incidence of disordered eating attitudes and disinhibited eating; however, more research is needed.

This study is not without limitations. First, this sample was racially and demographically homogenous, and included only women, which prevents us from generalizing to men or to other racial and socioeconomic groups. Similarly, different patterns of weight control may be observed in other age groups because our sample is limited to young, middle adulthood mothers. Another potential limitation is that this study did not assess frequency or duration (i.e., days, weeks, or months) of specific weight control strategy use which may also influence weight change (19). Thus, additional research is warranted to explore the duration and frequency of using specific weight control strategies is required to promote weight maintenance. Finally, these data were self reported; thus, there is the potential for reporting bias.

Much of the existing literature on weight control efforts and weight status has used global measures of “dieting”. In the present study, when participants were asked whether they were “dieting” or “not dieting” to lose weight, women who reported dieting gained significantly more weight than non-dieters, consistent with other (17, 18). For example, Lowe and colleagues (17) found that college-aged females who self-reported that they were currently dieting to lose weight gained three times as much weight as non-dieters across eight months. One potential explanation for this association is that “dieting” is associated with bouts of uncontrolled, disinhibited overeating and weight gain, resulting in cycles of dieting which ultimately leads to weight gain over time (44-47). In contrast, another study examining the global report of dieting in a sample of adults participating in the Pound of Prevention study (POP) revealed that reports of “dieting” and “doing something” to try to lose weight did not predict weight change (19). One possible reason for these conflicting results is that “dieting” is a broad construct that has different meaning to different people. In addition, global reports of “dieting” may reflect intention for weight loss as opposed to actual changes in weight control behavior. Thus, the global effect of dieting on weight change remains unclear.

In conclusion, findings provide evidence that many women who were trying to lose or maintain weight were using ineffective strategies that were associated with greater weight gain. Specifically, use of healthy and unhealthy weight control strategies was associated with weight gain over time; whereas only using healthy weight control strategies was more effective in moderating weight gain. Furthermore, although women using healthy weight control strategies were heavier than non-users at study entry, using healthy weight control tactics was associated with weight maintenance; similar to women who reported not using weight control strategies. Therefore, women should be encouraged to increase their fruit and vegetable intake, exercise more, reduce fat and caloric intake, reduce the amount of food consumed, and eliminate snacks, sweets, and junk food while also being encouraged to avoid unhealthy weight control strategies, such as skipping meals and fasting. Additional research is needed to examine the effect of frequency and duration of using specific weight control strategies has on patterns of weight change. Current recommendations provide no specific guidance about specific strategies to use or avoid to successfully “reduce energy intake”. In our current obesogenic environment in which women often fail to maintain weight, public health messages for weight control need to provide specific weight control guidance about strategies to use, and perhaps more importantly to avoid to prevent future weight gain.

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Table 3.1. List of study constructs, measures, and time of measurement

Constructs	Measures	Time Points
Family Background		
Demographic information	Family Background Questionnaire	1
Weight status		
Absolute weight (Kg)	Weight	1, 2, 3
Body mass index (BMI)	Height and weight	1, 2, 3
Weight Control Strategies		
Healthy and unhealthy weight control	Weight Loss Behavior Scale	2
Correlates of weight control behavior		
Weight concerns	Weight Concern Scale	1
Dietary restraint and disinhibition	The Eating Inventory	1
Maladaptive or problematic eating	Eating Attitudes Test (EAT)	1
Body satisfaction	Body Figures Scale	1

Table 3.2. Percentage of women reporting specific weight control strategies from items on the Weight Loss Behavior Scale and factor loadings for healthy and unhealthy weight control strategies (n=176)

		Factor Loadings	
	% responding yes	1	2
Healthy Weight Control Strategies			
Eliminate sweets and junk food	74%	0.84	0.08
Increasing exercise	74%	0.73	0.03
Eat more fruits and vegetables	72%	0.83	0.11
Eat less fat	72%	0.86	0.10
Reduce amount of food	69%	0.84	0.14
Eliminate snacking	64%	0.73	0.10
Change type of foods eaten	59%	0.76	0.09
Reduce calories	56%	0.83	0.21
Eat low-calorie foods	54%	0.82	0.12
Eat less high-carbohydrate foods	43%	0.66	0.11
Eat less meat	28%	0.56	0.32
Unhealthy Weight Control Strategies			
Skipping meals	51%	0.38	0.43
Fasting	19%	0.21	0.54
Diet pills	16%	0.01	0.78
Liquid diets	13%	0.12	0.52

Unhealthy Weight Control Strategies			
Appetite suppressants	10%	0.05	0.81
Increase cigarettes smoked	33% *	0.07	0.41
Diuretics	2.3%	0.05	0.36
Diet centers with food	2.3%	0.04	0.57
Laxatives or enemas	1.7%	0.05	0.40

Notes: Principal components factor analysis was performed to identify subscales of weight control strategy; Practicing a healthy weight control strategy was identified when responding 3 (*sometimes*); Practicing an unhealthy weight control strategy was identified when responding 2 (*rarely*) or greater.

* Among the 13.64% of women who report currently smoking

Table 3.3. Comparison of baseline Latent Class Analysis models

Number of classes	Likelihood-Ratio G^2	Degrees of Freedom	AIC	BIC
2	932.3	4070	468.6	547.9
3	**903.3**	**4057**	**436.7**	**557.2**
4	876.8	4044	409.6	571.3
5	860.7	4031	403.6	606.5

Note: Bold font indicates the selected model

Table 3.4. Latent class item-response probabilities for the 3 class solution: Probabilities of endorsing each weight control strategy, given latent class membership

	Latent Class		
	Non-Users (21%)	Healthy Users (43%)	Healthy + Unhealthy Users (35%)
Healthy weight control strategies			
Eat more fruit & vegetables	0.13	0.83	0.95
Increasing exercise	0.22	0.88	0.86
Eat less fat	0.08	0.81	1.00
Reduce calories and amount of food	0.03	0.94	1.00
Eliminate sweets/junk food/snacks	0.14	0.89	1.00
Eat less meat	0.02	0.24	0.52
Eat less high-CHO foods	0.03	0.45	0.66
Change type of foods eaten	0.06	0.65	0.86
Unhealthy weight control strategies			
Skipping meals	0.11	0.36	1.00
Fasting	0.00	0.05	0.55
Use of diet pills, liquid diets, appetite suppressants	0.03	0.18	0.38
Use of laxatives, enemas, diuretics	0.00	0.01	0.09

Table 3.5. Mean (*M*) and standard deviations (*SD*), background and outcome measures for the total sample, and for weight control strategy latent classes [1]

		Latent Class		
	Total sample (N= 176)	Non-Users (n = 37)	Healthy Users (n = 76)	Healthy + Unhealthy Users (n = 63)
	M (*SD*)	*M* (*SD*)	*M* (*SD*)	*M* (*SD*)
Individual characteristics at baseline				
Age (years)	39.5	39.0	40.4	38.6
	(4.8)	(4.4)	(4.5)	(4.7)
Family income [2]	2.4	2.4	2.4	2.5
	(0.8)	(0.7)	(0.8)	(0.7)
Education [3]	14.8	15.3	14.9	14.3
	(2.3)	(2.7)	(2.2)	(2.1)
Weight (kg)	734.0	66.4 [a]	75.1 [b]	77.0 [b]
	(17.1)	(12.9)	(17.5)	(17.4)
BMI	27.4	24.2 [a]	27.7 [b]	28.8 [b]
	(6.3)	(4.4)	(6.7)	(6.2)
Weight as a child [4]	0.9	0.6 [a]	1.0 [b]	1.1 [b]
	(0.7)	(0.7)	(0.7)	(0.7)

	Total sample	Non-Users	Healthy Users	Healthy + Unhealthy Users
	M (*SD*)	*M* (*SD*)	*M* (*SD*)	*M* (*SD*)
Covariates				
Weight concerns	1.7	1.1 [a]	1.7 [b]	2.1 [c]
	(0.8)	(0.7)	(0.7)	(0.8)
Restraint	8.2	3.5 [a]	8.5 [b]	10.6 [c]
	(4.7)	(2.5)	(4.3)	(4.2)
Disinhibition	6.9	5.0 [a]	7.1 [b]	7.9 [b]
	(3.9)	(3.8)	(4.0)	(3.4)
Eating attitudes	4.8	2.7 [a]	4.3 [a]	6.6 [b]
	(5.2)	(2.8)	(3.7)	(7.1)
Body dissatisfaction	1.2	0.7 [a]	1.3 [b]	1.4 [b]
	(0.9)	(0.7)	(0.8)	(0.9)

Notes. [1] Weight control strategy groups were identified using latent class analysis (LCA) posterior probabilities from the Weight Loss Behavior Scale.

[2] Family income where 0 is < $20,000, 1 = $20,000 - $35,000, 2 = $35,000 – $50,000 and 3 is > $50,000.

[3] Education where 1 = high school, 2 = Associates, 3 = Technical, 4 = Bachelor Degree, 5 = Masters Degree, 6 = PhD/MD.

[4] Weight as a child where 0 = underweight, 1 = average, 2 = overweight

Superscripts indicate significant group differences (p <.05); Analysis of variance was used to test group differences

Table 3.6. Percentage of normal, overweight, and obese women by weight control class over time

		Study entry	Year 2	Year 4
Weight Control Class				
Non Users (n = 37)				
	Normal weight	70%	64%	61%
	Overweight	19%	28%	33%
	Obese	11%	8%	6%
Healthy (n = 76)				
	Normal weight	37%	37%	34%
	Overweight	33%	30%	34%
	Obese	30%	33%	32%
H + Unhealthy (n = 63)				
	Normal weight	33%	28%	21%
	Overweight	35%	30%	25%
	Obese	32%	42%	54%

Notes. Weight control strategy groups were identified using latent class analysis (LCA) posterior probabilities from the Weight Loss Behavior Scale; BMI category: Normal weight (BMI<25 kg/ m^2); Overweight (BMI 25-29.9 kg/ m^2); Obese (BMI 25-29.9 kg/ m^2)

Figure captions

Figure 3.1: Influence of BMI category (normal weight, overweight, obese) on weight control class

Note: Different letters indicate significant differences ($p<.01$) between groups in the likelihood of normal weight versus obese women not dieting based on the results of logistic regression analysis.

Figure 3.2: Repeated Measures Mixed Model results using weight control strategy class assignments based on posterior probabilities to predict weight gain over 4 years in women

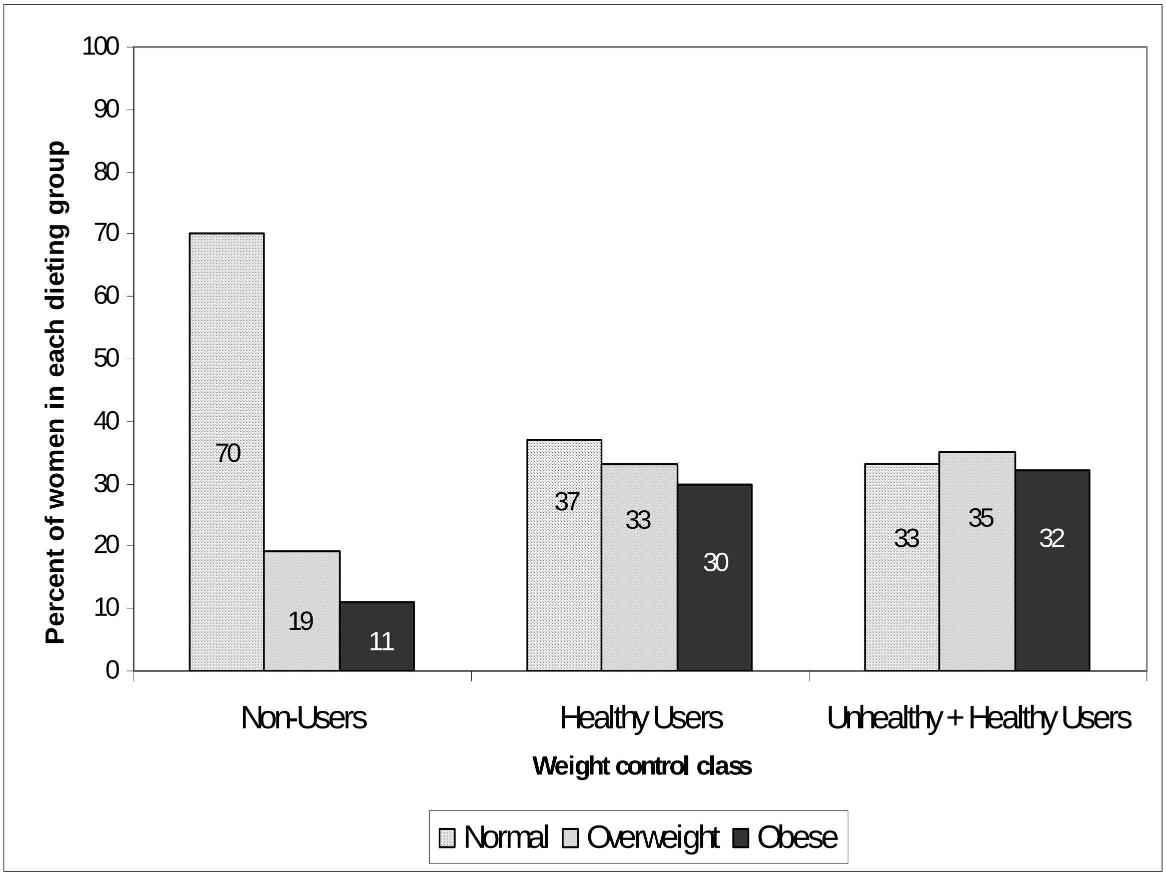
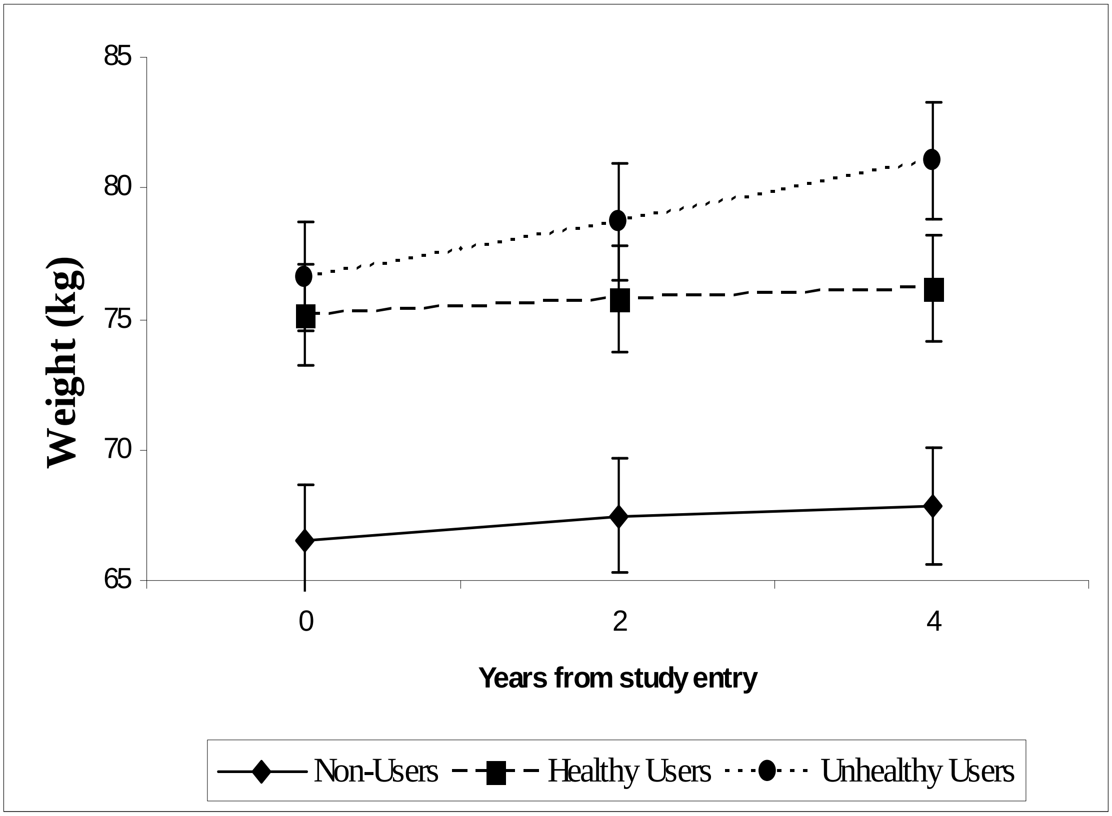

Percent of women in each dieting group
100
90
80
70
60
50
40
30
20
10
0
70
19
11
37
33
30
33
35
32
Non-Users
Healthy Users
Unhealthy + Healthy Users
Weight control class
Normal
Overweight
Obese

Figure 3.1



85
80
75
70
65
Weight (kg)
0
2
4
Years from study entry
Non-Users
Healthy Users
Unhealthy Users

Figure 3.2

Chapter 4

Dietary Energy Density Predicts Women's Weight Change Over 6 Years

ABSTRACT

Dietary energy density (ED) is positively associated with energy intake, but little is known about long-term effects on weight change. We assessed whether dietary ED predicts weight change over 6 years among a sample of non-Hispanic, white women. Participants were part of a longitudinal study (n = 186), assessed biennially on 4 occasions. ED (kcal/g) was calculated from energy content of all foods (excluding beverages) at each occasion using three 24-hour recalls. Height and weight were measured in triplicate to calculate BMI. Repeated measures (Proc Mixed) were used to examine the influence of ED on weight change over time, before and after adjusting for initial weight status. Food choices were examined among individuals consuming low-, medium-, and high-ED diets at study entry. Results revealed that ED was positively associated with weight gain and higher BMI over time; this association did not vary by BMI classification. Food group data revealed that compared to women consuming higher-ED diets, those consuming lower-ED diets reported significantly lower total energy intakes and consumed fewer servings of baked desserts, refined grains, and fried vegetables, and more servings of vegetables, fruits, and cereal. Women consuming lower-ED diets also ate more meals at the table and fewer meals in front of the television. Findings indicate that consumption of a lower-ED diet moderates weight gain, which may promote weight maintenance. Lower-ED diets were achieved through dietary patterns consistent with US Dietary Guidelines to consume more servings of fruits and vegetables, and limiting intake of high fat foods.

INTRODUCTION

The prevalence of overweight has increased dramatically in recent years; approximately 60% of adult men and women in the United States are now overweight or obese (1). Longitudinal studies estimate that, on average, adults gain 0.5-1.0 kg per year (2-5), which, over time, increases overweight prevalence and the risk of many leading causes of morbidity and mortality including diabetes mellitus, coronary heart disease, and stroke (6). To reduce energy intake and prevent weight gain, the World Health Organization (6) and the U.S. Department of Health and Human Services (7) recommend consuming low energy dense foods. Energy density (ED) is defined as the amount of dietary energy in a given weight of food (i.e., kcal/g). The objective of the present study was to investigate energy density, assessed on 4 occasions, as a predictor of weight change.

Diets lower in ED can be achieved by increasing consumption of fruits and vegetables and reducing fat intake (8, 9). Results of laboratory-based studies, manipulating the ED of foods by altering fat and water content reveal that because individuals consume a consistent weight of food across ED manipulations, they consume more energy when presented with higher ED foods than with similar foods of lower ED (10-13). Three clinical trials designed to test the effectiveness of consuming low ED foods on weight loss revealed that modest dietary ED reductions were associated with long-term weight loss (14-16), and cross-sectional studies demonstrate that lower ED is associated with lower weight status (17-20).

Few longitudinal studies have assessed the role of ED on weight change during adulthood among individuals who were not enrolled in clinical weight loss trials. One prospective longitudinal study investigating the influence of ED on subsequent 5-year weight change provided mixed results regarding the relation between dietary ED and weight gain: ED was positively associated with weight gain in obese women, but inversely associated with weight gain in normal weight women (21). In summary, little is known about the long-term effect of ED on weight change and, in particular, on unintentional weight gain among free-living women.

The major purpose of the present study was to examine the relation of ED to weight change over time among free-living women, using longitudinal data. A secondary aim was to describe differences in patterns of dietary intake among women with diets differing in ED including information on food group intake, meal frequency, and the contexts in which eating occurred at study entry. An understanding of how different food choices and the overall ED of a women's diet influence weight change has important implications for the development of recommendations to prevent unintentional weight gain over time. Based on previous research (11, 14, 20, 22), we hypothesized that: 1) ED would be a significant predictor of weight and weight change over time; 2) ED of the diet would be positively associated with total energy intake; and 3) women reporting low ED diets would be consuming higher quality diets than those reporting high ED diets.

METHODS

Participants

Participants included 192 non-Hispanic white women living in central Pennsylvania recruited as part of a longitudinal study designed to examine parental influences on girls' growth and development; the sample was not recruited based on weight status. Families with age-eligible female children within a 5-county radius were identified using available marketing information (Metromail Inc., Chicago). These families received mailings providing information about the study and were recruited using follow-up phone calls. Eligibility criteria focused on daughters' characteristics including the absence of severe food allergies or chronic medical problems affecting food intake and the absence of dietary restrictions involving animal products. Only data for mothers are considered in this study. At study entry, participants included 192 women, of whom 183, 177, and 168 women were reassessed at year 2, year 4 and year 6, respectively, representing an 88% retention rate. Attrition was primarily due to family relocation outside of the study area. Women who were missing body weight data at years 2 through 6 were excluded from all analyses, resulting in a final sample of 183 women. No significant difference was found between the initial weight status or ED of participants with missing data (n = 9) and of participants remaining in the study through year 6.

Design and Procedures

Data were collected on four occasions across a 6-year period, with 2-year intervals between assessments. At each time of assessment, women completed a series of self-report questionnaires during a scheduled visit to the laboratory. The Pennsylvania State University Institutional Review Board approved all study procedures, and mothers provided consent for their family's participation in the study before the initiation of data collection.

Measures

Background characteristics. Women completed a Background Questionnaire, developed in our laboratory, which assessed family background characteristics including combined family income and mothers' and fathers' years of education. Participants chose from four income categories: less than $20,000/yr, $20,000 to $35,000/yr, $35,000 to

$50,000/yr, or $50,000+/yr. For education, women indicated whether they had the following degrees/diplomas: high school, associates, technical/vocational school, bachelors, masters, PhD, MD, JD, or other.

Weight status and body mass index (BMI). Height and weight measurements were assessed in triplicate at each occasion by a trained staff member following the procedure outlined by Lohman and colleagues (23). Participants were dressed in light clothing and measured without shoes. Height was measured in triplicate to the nearest 10^{th} of a centimeter using a stadiometer (Shorr Productions stadiometer, Irwin Shorr, Olney, MD). Weight was measured in triplicate to the nearest 10^{th} of a kilogram using an electronic scale (Seca Electronic Scale, Seca Corp, Birmingham, UK). Average height and weight were used to calculate body mass index [BMI;weight (kg)/height $(m)^2$]. Recommendations made by the World Health Organization (24), were used to classify women as overweight (BMI $\geq$ 25).

24-hour energy intake. Twenty-four-hour recall interviews were conducted at the Dietary Assessment Center at the Pennsylvania State University at each occasion by trained staff using the computer-assisted Nutrition Data System for Research (NDS-R) software (Database Version 4.01_30, Nutrition Coordinating Center, University of Minnesota, Minneapolis, MN). The NDS-R software itself provides a structured, guided controlled platform where questions, and probes are standard and the process of conducting the 24-hour recall is standard. The NDS-R time-related database updates analytic data while maintaining nutrient profiles true to the bastion used for data collection. The NDS-R is updated annually. Furthermore, interviewers were required to complete 40 hours of intensive training and are subject to reliability tests. To assess reliability, a nutritionist administers three standard dietary recalls in a mock telephone interviews to all newly trained interviewers. Reliability among interviewers is based on interclass correlation of 0.95 or higher (25). Women provided three 24-hour recalls within a 2-to 3-week period, including 2 weekdays and 1 weekend day. These dates were randomly selected and recalls were conducted from June through October. Participants were mailed a poster depicting 2-dimensional representations of food portions (2D Food Portion Visual, Nutrition Counseling Enterprises, Framingham, MA) as a visual aid for estimating amounts of food eaten.

Energy density (kcal/g) was calculated from the three 24-hour recalls, using energy content of all foods, excluding all beverages, for each individual at all 4 time points. Beverages were omitted based on previous findings indicating that the inclusion of beverages may diminish associations with outcome variables due to the increased day to day variance within individual respondents (26). To calculate ED, energy and gram intakes for each eating occasion were summed for each of the 3 days. Next, total energy intake from the food consumed for each of the 3 days was divided by the total weight of food consumed for each of the 3 days. For each participant, a mean ED value was derived by taking the average of the three daily ED values at the 4 time points.

Food group and subgroup data were averaged across 3 days to obtain an estimate of the number of servings reported consumed based on the *2005 Dietary Guidelines for Americans* (7) and US Department of Agriculture Food Guide Pyramid Guidelines (27). Mixed dishes were disaggregated into the corresponding components, and the sum of the gram weights of the components was used to calculate the number of servings for each food group. Finally, at time 2, interviewers were instructed to ask participants "*Where did you eat each meal?*" (i.e., in front of the television, at a table, etc.). These data were used to determine the specific location of each meal.

Statistical Analyses

Data were analyzed using the SAS software (version 9.1, 2001, SAS institute, Cary NC) (28). Descriptive information was generated for all variables of interest. Each outcome variable was assessed for normality.

Longitudinal analyses. For the primary analyses of interest, a mixed modeling approach (Proc MIXED) was used to assess the effects of ED on body weight and BMI change over 6 years. Mixed modeling is a useful tool for analyzing repeated measures over time, and a major advantage is its ability to retain cases with one or more missing data points (29). Determination of model fit was based on several criteria: (1) model convergence, (2) a positive definite G matrix and (3) statistical fit comparison based on the Akaike Information Criteria (AIC) (30). For the models predicting weight status (kg), a compound symmetry covariance matrix was selected, as determined by the aforementioned model fit criteria; main effects of time, ED, and an ED by time interaction were tested before (Model 1) and after adjusting for initial BMI (Model 2). For Model 3, the main effect of BMI classification (normal versus overweight), the interaction between BMI classification, ED, and time, and all lower order (2-way) interactions were considered. Finally, for the models predicting BMI change over time, an unstructured covariance matrix provided the best fitting model; similar predictors were tested before (Model 4) and after adjusting for initial weight status (Model 5). In all models, inclusion of the interaction of ED by time provided a test of the major hypothesis, as a significant interaction effect provides evidence for a differential pattern of change over time for women consuming diets varying in ED.

Cross-sectional analyses. To address the second aim of the study, and to further explore differences in dietary patterns among women whose diets differed in ED, analysis of variance (ANOVA) with Tukey HSD post hoc tests were examined at study entry. Tertile cutoffs were used to classify women by the ED of their diet (low, medium, or high). Low-, medium-, and high-ED diets were defined by mean daily ED values less than 1.5 kcal/g, 1.5 to 1.85 kcal/g, and more than 1.85 kcal/g, respectively. Specifically, analyses tested for differences in energy intake, food group intake, meal frequency, and the contexts in which eating occurred. P values <0.05 were considered significant.

RESULTS

Descriptive Characteristics

Mean age of women at study entry was 35.7 ($\pm$ 4.7) ranging from 24.1 to 46.6 years. Women were in general well-educated with a mean of 14.6 ($\pm$ 2.2) years of education. Approximately an equal proportion of families at entry into the study reported incomes below $35,000, between $35,000 and $50,000, and above $50,000. The sample was, on average, slightly overweight (BMI: $M = 27.0$, $SD = 6.2$). Of the 183 participants, 105 (57%) were classified as overweight (BMI $\geq$ 25) at baseline.

Longitudinal Analyses: Repeated Measures Mixed Effect Models

On average, women gained weight across the 6 year period ($M = 3.73$ kg, $SD = 7.8$). **Table 4.1** displays descriptive statistics for all predictor and outcome variables at each occasion. Mixed model analysis using random coefficients revealed that both weight (kg) [weight = 70.43 + 1.21 * years; $p < 0.001$] and BMI [BMI = 26.09 + 0.45 * years; $p < 0.001$] increased significantly over time, such that 66% of women gained weight from baseline to year 6. Similar analyses revealed that ED [ED = 1.68 + 0.01 * years; $p = 0.47$] remained stable over time.

Association of energy density with body weight and weight gain over time. In Model 1, the predictive model for body weight (kg), results of the mixed-model analyses revealed a significant main effect of time ($p < 0.001$) indicating a general trend for women to gain weight over time. There was a significant main effect of ED ($p < 0.05$) such that individuals with higher ED had higher weight at all time points. Finally, a significant interaction between ED and time was evident ($p < 0.01$). Therefore, a woman's pattern of weight gain was dependent on energy density group membership. For example, women consuming higher ED diets (ED $\geq$ 1.85), on average gained 6.4 kilograms (kg) over 6 years; whereas women consuming lower ED diets (ED $\leq$ 1.5) only gained 2.5 kg. Those consuming intermediate ED diets (ED 1.5 to 1.85) gained 4.8 kg. In Model 2, similar results emerged after adjusting for initial BMI (data not shown).

In Model 3, we tested a three-way interaction (after including all relevant main effects and two-way interactions) to examine whether the association between ED and time would vary across normal and overweight women (BMI Classification). However, the 3-way interaction was not significant; indicating no effect of BMI classification on the effect of ED on weight change. Thus, overweight women consuming higher ED diets did not gain significantly more weight over time than normal weight women on higher ED diets. Therefore, the model was reduced to only consider the 2-way interactions and main effects. There was a significant interaction between BMI classification and time such that overweight women increased in weight at a greater rate over time than normal weight women ($p < .001$). In addition, a significant interaction was identified between ED and time ($p < 0.01$); as ED increased, weight increased over time. Finally, there was no significant interaction between

ED and BMI classification. Therefore, the association between ED and weight did not vary by BMI classification.

Association of energy density with BMI and BMI change over time. In Model 4, when the predictive model for BMI was considered, results revealed a significant main effect of time ($p < 0.001$) and ED ($p < 0.05$). A significant interaction between ED and time was also evident ($p < 0.01$). Thus, a women's pattern of BMI change over time was dependent on energy density group. For example, BMI increased 2.5 units among women consuming higher ED diets, whereas BMI only increased 0.9 units over 6 years for women reporting lower ED diets. Similar results emerged after adjusting for initial BMI (Model 5). In addition, when including BMI classification in the model, results were in agreement with Model 2, predicting weight gain (kg) (data not shown).

Cross-Sectional Analyses: Differences among ED groups

Because ED did not vary across time, women were grouped by ED at baseline, and differences among ED groups in energy and macronutrient intake, food choices and meal location were examined. These analyses provide information on how dietary choices result in ED differences, which were associated with differences in weight change.

As shown in **Table 4.2**, women with a lower-ED diet consumed a greater weight of food than women in the high ED diet ($p < 0.0001$), but had lower energy intakes. Women consuming the lowest energy dense diet consumed approximately 225 kcal/d less than women in the high-ED group ($p < 0.01$). Energy intakes from caloric beverages did not differ by ED group, which further supports the exclusion of beverages when calculating ED. In addition, dietary ED was positively associated with percent energy from fat and negatively associated with percent energy from carbohydrate and fiber intake. No differences in protein intake were noted across ED groups.

Food Choices. As shown in **Figure 4.1**, dietary ED was linked to specific patterns of food consumption. Following the Food Guide Pyramid, the foods were aggregated into 6 major USDA food groups. Women in the higher-ED group reported consuming significantly more servings from the Grain, Meats, and Fats groups than the low-ED group, whereas, the low-ED group consumed significantly more servings from the Vegetable and Fruit groups than the high-ED group. Specifically, the lower-ED group reported consuming approximately 5 servings (2.5 cups) of Fruits and Vegetables whereas the lower-ED group consumed an estimated 2.7 servings or 1.35 cups. There were no group differences for servings of Dairy or Sweets.

Grain subgroup intakes are shown in **Figure 4.2**; women in the high-ED group reported consuming significantly more servings than the low-ED group from the Bread and Baked Desserts subgroups, but significantly fewer servings from the Cereal subgroup. For whole versus refined grains, women consuming the high-ED diet consumed significantly fewer servings of Whole grains than women in the low-ED group (0.7 servings/d versus 1.1 serving/d), but also reported consuming more servings of Refined grains (5.0 servings/d versus 3.9 servings/d). With respect to reported intake from the Vegetable group, the high-ED group reported consuming significantly more servings of the French Fry and Potato Chip subgroup than the low-ED group, whereas the low-ED group ate significantly more servings of Dark Green, Yellow, and Red Vegetable subgroup (**Figure 4.3**).

Meal frequency and location. Dietary ED was not associated with the total number of eating occasions over three days (**Table 4.2**). However, women consuming the high-ED diet reported eating significantly more meals and snacks in front of the television as well as eating fewer dinners at the table as a family.

DISCUSSION

Data from this longitudinal study were used to examine the association between ED and weight change over time among free-living women, while also providing information on food and macronutrient selection patterns of women consuming diets varying in ED. These data indicate that during the 6 year period, on average, women gained 3.7 kg or approximately 5% of their initial body weight. Differences in dietary ED were associated with differences in weight gain; women consuming higher ED diets over this period gained nearly three times as much weight as women on lower ED diets. Results extend previously reported relations between ED and weight status observed in cross-sectional (18-20) and intervention studies (14, 15). Together, these finding provide evidence that consumption of a lower ED diet moderates weight gain and promotes weight maintenance. Consistent with previous findings (22), women consuming lower ED diets had higher quality diets, which included more fruits, vegetables, and whole grains than did those with higher ED diets.

In support of our first hypothesis, dietary ED was a significant positive predictor of weight gain before and after adjusting for initial weight status. On average, over 6 years women consuming lower ED diets gained 2.5 kg, while those consuming higher ED diets gained 6.4 kg or approximately 8.5% of their initial body weight. Previous literature indicates that the weight gain by women on higher ED diets may be substantial enough to cause negative shifts in metabolic indicators of cardiovascular health and metabolic syndrome components, including blood pressure, triglycerides, fasting glucose, and cholesterol levels (31-34). It is important to note that women consuming lower ED diets still gained weight over time; albeit less than those consuming higher ED diets. Lower ED diets were effective at moderating, but not preventing, weight gain. One potential explanation for this finding is that women consuming low ED diets were not eating enough servings of water-rich foods. For example women in the low ED group only reported consuming 2.5 cups of fruits and vegetables per day; although recommendations are to consume 4.5 cups per day based on a 2000 kcal diet (7). These findings suggest that women may need better dietary guidance on how to select foods to achieve a lower ED diet (i.e., selecting water rich dishes, rich in fruits and vegetables, while also reducing fat intake) as a means of reducing daily energy intakes to avoid weight gain.

While there was no specific hypothesis concerning the three-way interaction among ED, BMI classification, and time, this study found that the 3-way interaction was not significant; indicating that the positive association between ED and weight gain did not differ for normal weight and overweight women. Thus, reducing ED has important public health implications in both normal weight and overweight women. Our findings differ from those of the only other longitudinal study to date examining the influence of ED on weight change in which there was not a significant effect of ED on weight change (21). Iqbal and colleagues (21) also reported that the effects of ED were moderated by weight status; ED was positively associated with weight gain among obese and inversely associated with weight gain in normal weight women. Further longitudinal analyses are needed in other samples of free-living adults to confirm findings that the association between ED and weight gain does not vary by BMI classification, while also examining potential sex differences in the relation between ED and weight change.

As predicted in our second hypothesis, and consistent with previous research (20, 22, 35), women with lower ED diets reported consuming lower energy intakes, but consumed more food, by weight, compared to women with higher ED diets. This finding confirms that eating a low ED diet allows one to eat fewer calories, but more food. Thus, prescribing diet plans that advise women to consume low energy dense foods, by increasing their intake of water-rich food sources such as fruits and vegetables may moderate weight gain, and serve as a more effective weight maintenance strategy than dieting, which tends to be ineffective, or promote weight gain (36-39). In addition, dietary ED was positively associated with percent energy from fat and negatively associated with percent energy from carbohydrate; however, there was no difference in percent energy from protein. Our findings are consistent with those of Bell and colleagues (35) who varied the ED of foods by 30% over 2 days and found that participants failed to compensate for changes in ED by altering the amount (weight) of food consumed; thus, significantly more energy was consumed in the higher ED condition. Similarly, cross-sectional data from NHANES III reveal that ED was positively associated with total energy and fat intake and inversely associated with weight of food consumed and carbohydrate intake (40).

In support of our third hypothesis, we observed that women reporting low ED diets consumed higher quality diets than those reporting high ED diets. Specifically, compared to women with higher ED diets, those with lower ED diets consumed more servings of vegetables, fruits, cereal, and whole grains and fewer servings of baked desserts and fried vegetables. ED was also inversely associated with fiber intake; however, only 4% of women reported consuming more than 25 grams of fiber per day. These findings are consistent with Ledikwe and colleagues (22) who explored associations between ED and diet quality in a nationally representative sample and found that, compared to adults consuming higher ED diets (ED > 2.0 kcal/g), a higher percentage of adults with lower ED diets (ED < 1.6 kcal/g) consumed cereal, fruits, vegetables, and grains diets and a lower percentage consumed baked goods and fried potatoes. Together, these findings provide evidence that lower ED diets can be achieved through dietary patterns consistent with US Dietary Guidelines for Americans (7). However, it is important to note that women in the present study are not meeting recommendations to consume a total of 4.5 cups of fruits and vegetables (2 cups of fruit and 2.5 cups of vegetables) per day, based on a 2000 kcal diet. For example, women with low ED diets only consumed 1 cup of fruit and 1.5 cups of vegetables per day. Moreover, consumption of whole grain foods fell well below current recommendations to consume 3 ounces per day; the low ED group only consumed 1.1 ounces per day. Thus, population based efforts are needed to encourage fruit, vegetable, and whole grain intake based on evidence that meeting Dietary Guidelines ensures nutrient adequacy and decreases risk of chronic diseases (7).

This study is not without limitations. This sample was racially and demographically homogenous, and included only women, which prevents us from generalizing to men or to other racial and socioeconomic groups. Another potential limitation is the use of self reported dietary recall data. Based on previous studies suggesting that overweight women are more likely to selectively under-report intakes of energy dense, nutrient poor foods perceived as unhealthy such as high fat foods (41), ED estimates may be lower than actual intakes. However, if this is the case, it is likely that under-reporting by obese women would actually weaken associations between ED and weight status, suggesting that our findings may actually underestimate the magnitude of the association between ED and weight gain. Thus, additional research is warranted to explore how reporting accuracy influences calculations of dietary ED and associations with weight status over time.

To date, the present study is the first to describe differences in meal location and frequency among free-living women with diets differing in ED. Women consuming lower ED diets reported eating fewer meals and snacks in front of the television and more dinners as a family at the table, although ED groups did not differ in total number of eating occasions. The findings suggest that among these women, television viewing was associated with intake of high energy dense foods, while eating meals as a family was associated with consumption of lower ED foods. Thus, ED could be a marker for unhealthy dietary and lifestyle patterns. Fitzpatrick and colleagues (42) found that eating dinner as a family was positively associated with serving fruits and vegetables; however, this association decreased when the television was on during dinner. Similarly, a recent study found that watching television increased the amount of high-density, palatable, familiar foods eaten by adults (43). These findings suggest particular eating contexts, such as eating in front of the television, may promote weight gain. However, the underlying mechanism linking television viewing and weight status remains unclear.

In conclusion, our findings provide evidence that dietary energy density is positively associated with weight gain over time among free-living women over a 6 year period, revealing that diets lower in ED can moderate weight gain among normal and overweight women. These results support recommendations by the World Health Organization (6) and Dietary Guidelines 2005 (7) to decrease ED as a means to prevent weight gain and obesity. Lower ED diets were achieved through dietary patterns consistent with Dietary Guidelines 2005 to consume more servings of fruits and vegetables, and limiting intake of high fat foods such as baked goods and fried vegetables. Therefore, decreasing ED by increasing fruit and vegetable consumption may be an effective weight maintenance strategy among free-living women. This strategy may be particularly effective at preventing obesity because consuming lower ED diets allows individuals to consume a greater weight of food while decreasing total energy intake. However, our findings revealed that even women who were consuming lower ED diets were not generally successful in maintaining weight at initial levels across the six year period, suggesting the need for additional dietary guidance focused on providing effective strategies for reducing dietary ED.

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Table 4.1. *Weight Status and Energy Density Characteristics of the Study Sample*

	Baseline (*N* = 193)	Year 2 (*N* = 183)	Year 4 (*N* = 177)	Year 6 (*N* = 168)
Weight (Kg)				
M	72.6	74.3	75.1	76.4
SD	16.6	16.8	17.8	18.3
Range	46-142	46-139	46-153	47-147
BMI				
M	26.9	27.5	27.8	28.3
SD	6.2	6.3	6.5	6.7
Range	18.1-53.5	18.4-52.3	18.6-57.6	18.7-55.4
Energy Density				
M	1.7	1.7	1.7	1.7
SD	0.4	0.4	0.4	0.4
Range	0.95-2.85	0.98-2.93	0.97-2.97	0.77-3.09

Note: Energy density (kcal/g) calculated from food only (excludes beverages)

Abbreviations: *M* = Mean; *SD* = standard deviation, BMI = Body Mass Index

Table 4.2. *Cross sectional analyses at Baseline: Mean and Standard Deviation Scores for the Total Sample and ED groups* [*]

	Total Sample (*n* = 183) *M (SD)*	Low-ED (*n* = 61) *M (SD)*	Medium-ED (*n* = 63) *M (SD)*	High-ED (*n* = 59) *M (SD)*
Energy density	1.7	1.3 [a]	1.7 [b]	2.1 [c]
	(0.4)	(0.2)	(0.1)	(0.2)
Gram food intake (g/d)	879	1022 [a]	864 [b]	751 [c]
	(275)	(332)	(203)	(205)
Energy intake (kcal/d)				
Total energy intake (kcal/d)	1639	1514 [a]	1649 [ab]	1737 [b]
	(421)	(437)	(394)	(409)
Food intake (kcal/d)	1443	1336 [a]	1450 [ab]	1545 [b]
	(391)	(426)	(340)	(382)
Beverage intake (kcal/d)	189	178	198	192
	(135)	(136)	(136)	(134)
Fat (% energy)	31.8	27.7 [a]	31.6 [b]	36.3 [c]
	(6.8)	(6.1)	(6.5)	(5.9)
Carbohydrate (% energy)	53.0	56.3 [a]	54.1 [a]	48.5 [b]
	(8.3)	(8.4)	(6.5)	(8.0)
Protein (% energy)	15.6	16.4	15.1	15.2
	(3.2)	(3.6)	(2.8)	(3.1)

	Total Sample	Low-ED	Medium-ED	High-ED
Fiber (g)	13.6	13.6 [a]	15.6 [ab]	11.7 [b]
	(5.4)	(4.4)	(6.4)	(4.6)
Total # of eating occasions	12.7	13.0	12.5 (2.3)	12.6 (3.3)
	(2.9)	(2.9)		
Eating location [†]				
% Snacks eaten at TV	23.8	15.5 [a]	26.0 [ab]	28.1 [b]
	(26.6)	(17.6)	(26.7)	(31.4)
% Eating occasions at TV	11.1	7.4	12.2 [ab]	13.0 [b]
	(12.6)	(9.4) [a]	(12.5)	(14.5)
# Breakfast eaten at table	1.8	2.0	1.8	1.6
	(1.0)	(0.9)	(1.0)	(1.2)
# Lunches eaten at table	1.6	1.7	1.8	1.5
	(1.0)	(1.0)	(1.0)	(0.9)
# Dinners eaten at table	2.4	2.6	2.4 [ab]	2.2 [b]
	(0.8)	(0.6) [a]	(0.8)	(0.8)

Notes. Energy density (kcal/g) calculated from food only (excludes beverages)

[*] Energy density groups (kcal/g) were identified using tertile cutoffs;

[†] Eating location was assessed at year 2

Superscripts indicate significant group differences ($p < .05$); Analysis of variance was used to test group differences; Normal weight (BMI<25 kg/ m^2); Overweight (BMI 25-29.9 kg/ m^2); Obese (BMI 25-29.9 kg/ m^2)

Abbreviations: *M* = Mean; SD = Standard deviation; TV = Television Viewing

Figure Captions

Figure 4.1. Different superscripts within Food groups indicate significant differences among energy density groups ($p < 0.05$, Tukey HSD comparison). Energy density groups (kcal/g) were identified using tertile cutoffs: Low-, medium-, and high-ED diets were defined by ED values less than 1.5 kcal/g, 1.5 to 1.85 kcal/g, and more than 1.85 kcal/g, respectively.

Figure 4.2. Different superscripts within Grain subgroups indicate significant differences among energy density groups ($p < 0.05$, Tukey HSD comparison). Energy density groups (kcal/g) were identified using tertile cutoffs: Low-, medium-, and high-ED diets were defined by ED values less than 1.5 kcal/g, 1.5 to 1.85 kcal/g, and more than 1.85 kcal/g, respectively.

Figure 4.3. Different superscripts within Vegetable subgroups indicate significant differences among energy density groups ($p < 0.05$, Tukey HSD comparison). Energy density groups (kcal/g) were identified using tertile cutoffs: Low-, medium-, and high-ED diets were defined by ED values less than 1.5 kcal/g, 1.5 to 1.85 kcal/g, and more than 1.85 kcal/g, respectively.

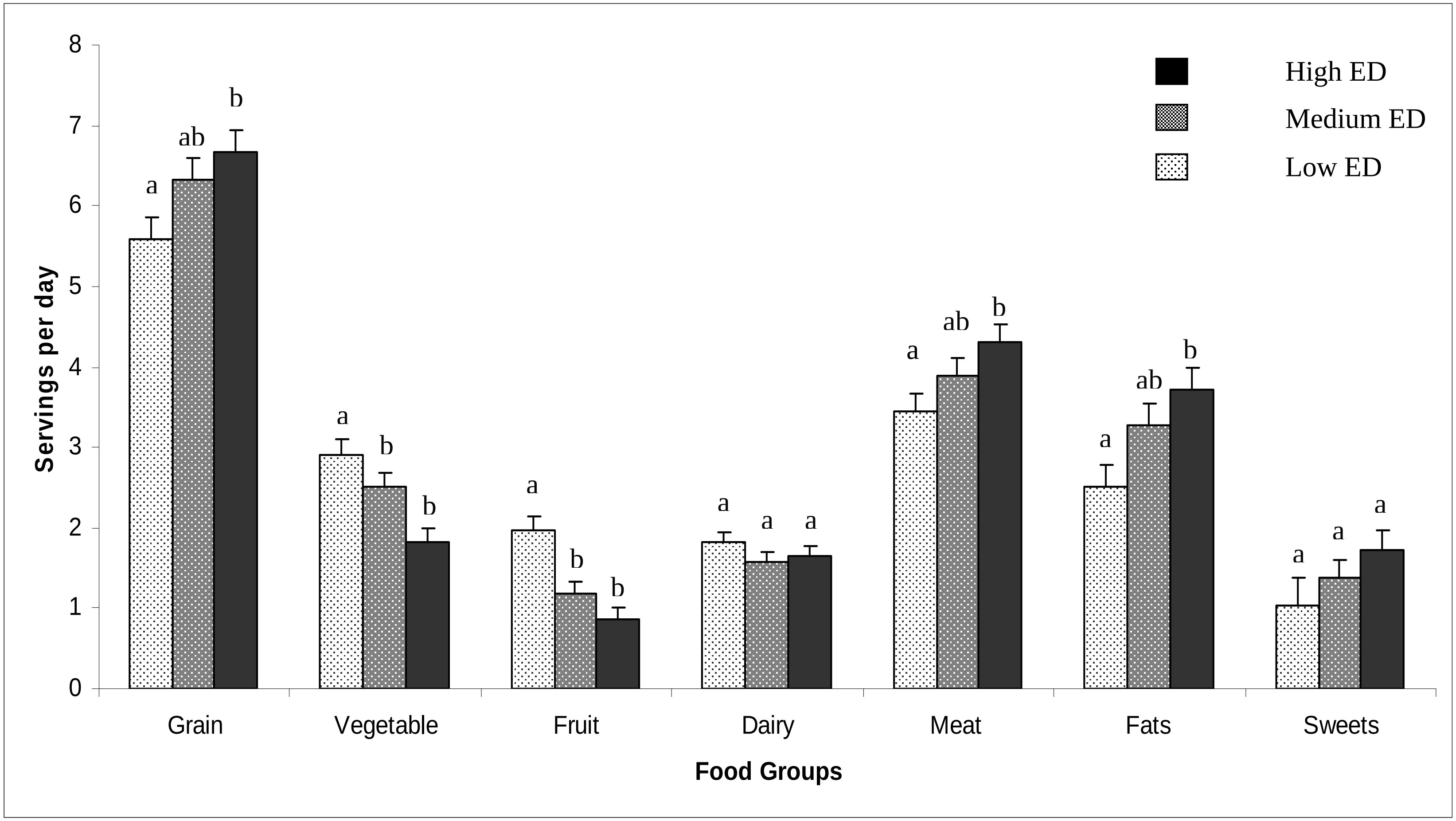

8
7
6
5
4
3
2
1
0
Servings per day
High ED
Medium ED
Low ED
a
ab
b
a
b
b
a
b
b
a
a
a
a
ab
b
a
ab
b
a
a
a
Grain
Vegetable
Fruit
Dairy
Meat
Fats
Sweets
Food Groups

Figure 4.1

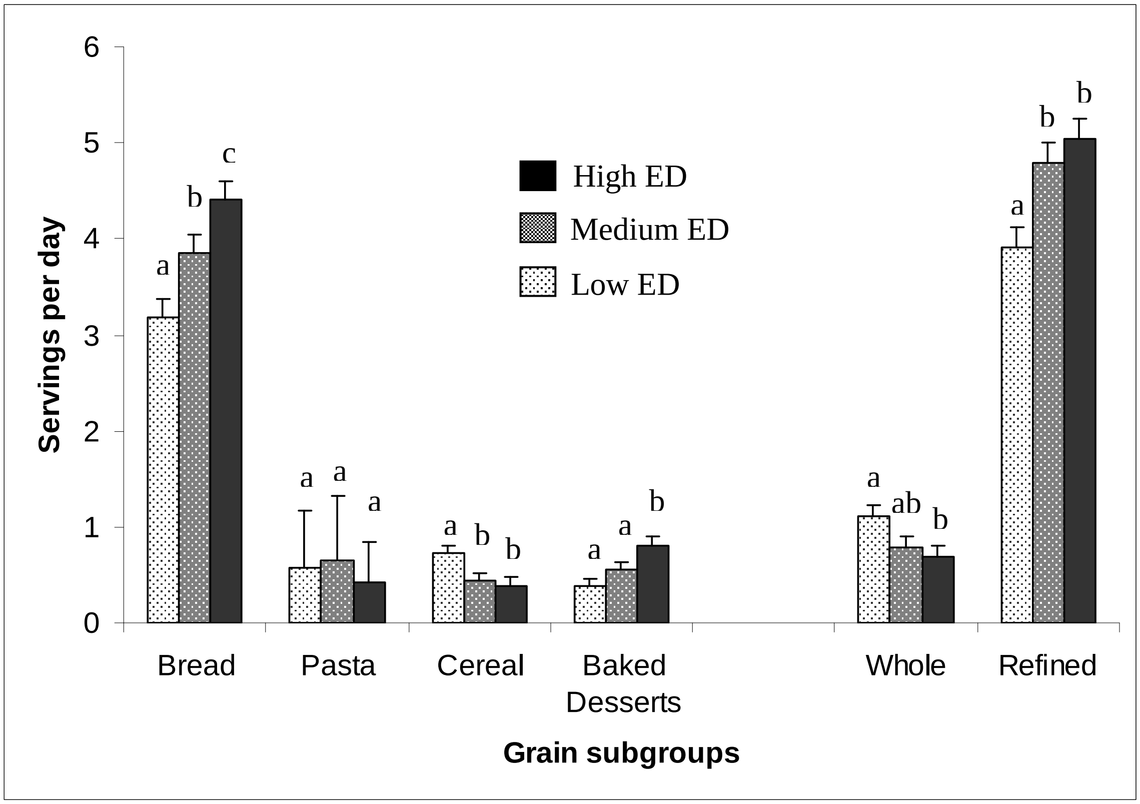
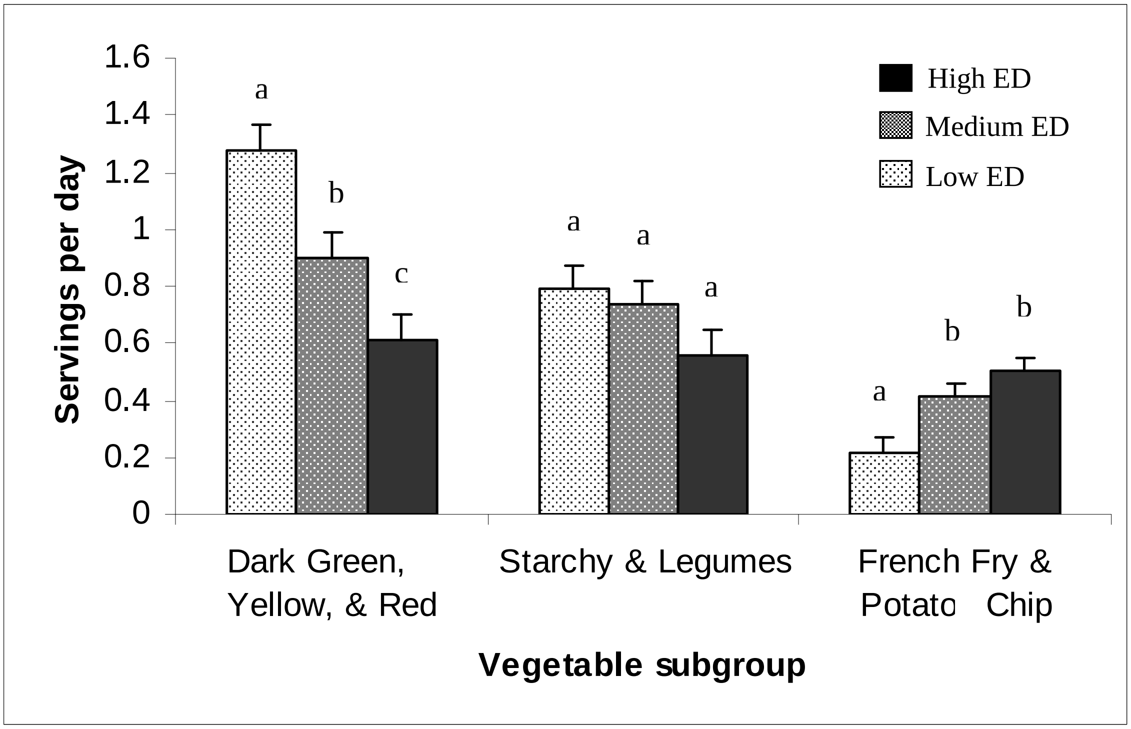

6
5
4
3
2
1
0
Servings per day
High ED
Medium ED
Low ED
a
b
c
a
a
a
a
b
b
a
a
b
a
ab
b
a
b
b
Bread
Pasta
Cereal
Baked Desserts
Whole
Refined
Grain subgroups

Figure 4.2



1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
Servings per day
High ED
Medium ED
Low ED
a
b
c
a
a
a
a
b
b
Dark Green, Yellow, & Red
Starchy & Legumes
French Fry & Potato Chip
Vegetable subgroup

Figure 4.3

Chapter 5

General Conclusion

The overall objective of the present study was to identify relatively stable psychosocial, behavioral or contextual factors that predict weight change among free living women. Results from the 3 studies presented in the preceding chapters provide evidence that among women: (1) self reported dieting was associated with weight gain; (2) increases in dietary restraint may be protective against long-term weight maintenance by moderating the positive association between dietary disinhibition and weight gain among dieters; (3) latent class analysis discriminated among women using different patterns of specific weight control strategies; (4) use of healthy plus unhealthy weight control strategies was associated with greater weight gain than the use of healthy weight control strategies that promote weight maintenance; and (5) decreasing dietary energy density by increasing intake of water rich foods that are low in fat such as fruits and vegetables may be an effective weight maintenance strategy. Consistent with previous literature, we also observed that energy intake and dietary intake patterns were not predictive of weight change (data not shown).

Study 1 was designed to examine the independent and combined effects of dieting, dietary restraint and dietary disinhibition on weight gain. This research contributes to our understanding of the collective influence of between person differences (i.e. whether or not a woman was higher or lower on a factor, relative to other women in the sample) and within person differences (i.e., whether a woman increased or decreased in a factor from study entry) on weight change. Consistent with previous literature (1-7), higher levels of dietary disinhibition and self-reported dieting were associated with higher initial weight and greater weight gain. Results also revealed that restraint was not independently related to weight maintenance, but moderated weight gain among highly disinhibited women; consistent with prior research (4, 5, 8). However, as hypothesized, this was only the case among non-dieters, providing additional support for the view that dietary restraint is a multidimensional construct, encompassing both past and current dieting (9). The greatest weight gains were among dieters who were higher in disinhibition and lower in dietary restraint; whereas the non-dieters with low disinhibition and high restraint gained the least weight. Therefore, being highly restrained while currently dieting may be an effective strategy to promote short term weight loss. However, a history of dieting may be a risk factor for weight gain over time.

In combination, findings from Study 1 suggest that interventions targeted towards dieters that decrease disinhibited eating while encouraging moderate levels of restrained eating may promote weight maintenance by preventing future weight gain. Our findings are congruent with those of Hill and colleagues (10) who argue that chronic cognitive control over eating is needed to moderate weight gain in our current obesigenic environment. However, results from Study 2 indicate that the specific type of dieting women engage in may also influence weight change.

Study 2 elaborates on the results of study 1 by further examining the effect of specific weight control strategies on weight change among women. Specifically, limited evidence suggests that obtaining information regarding the use of specific weight control strategies may be more informative than simply asking women to report whether they are "dieting" or "not-dieting" (6, 7, 11). While research to date has examined the influence of specific weight control behavior among women participating in weight gain prevention programs, research has not assessed the influence of these factors in free-living women. In this study, latent class analysis was used to identify whether distinct groups of women could be identified, based on their probability of using specific weight control strategies. Latent class analysis results provided a three class solution: (1) none; (2) healthy; and (3) healthy plus unhealthy weight control strategies. The primary aim was to assess whether differences in patterns of use of specific weight control strategies predicted patterns of weight change. Results revealed that women's patterns of weight change were dependent on latent class membership: women practicing healthy and unhealthy weight control strategies gained more weight (4.5 kg) than women only using healthy (1.3 kg) or no (1.0 kg) specific weight control strategies. Although healthy dieters were heavier than non-dieters at study entry, using healthy weight control tactics was associated with less weight gain, and was, similar to weight maintenance among women who reported not using any weight control strategies, and who were lighter at study entry. In accordance with previous literature (12-19), women practicing unhealthy weight control strategies reporter higher weight concerns, restraint, disordered eating attitudes and body dissatisfaction than women who only used healthy weight control strategies.

Results from Study 2 suggest that women could benefit from weight control guidance about specific strategies to use for weight maintenance, and guidance on strategies that should be avoided. Based on these findings, women should be encouraged to increase fruit and vegetable intake, exercise more, reduce fat and caloric intake, reduce the amount food consumed, and eliminate snacks, sweets and junk food while also being encouraged to avoid unhealthy weight control strategies such as skipping meals and fasting. These findings, combined with those of Study 1 suggest that weight gain prevention programs may need to promote "healthy" restrained eating behavior such as reducing the amount of food consumed as opposed to “unhealthy” restrained eating behavior such as fasting. Findings also indicate that women who did not use weight control strategies were thinner as children; suggesting that overweight women may use weight control strategies because they are overweight. However, it is also possible that women initiate use of weight control strategies in response to weight gain. Thus, causality or directionality between weight status and use of weight control tactics could not be determined in the present studies; additional research is needed.

Finally, Study 3 investigated the effect of energy density as a predictor of weight change. While epidemiological and cross-sectional studies often fail to link energy intake (20-27) and food intake patterns (28-30) with weight status, several cross-sectional studies have shown that dietary energy density is associated with weight status (31-34). However, only one study has examined the influence of energy density on weight change. In contrast to those findings of Iqbal and colleagues (35), our findings revealed that consumption of a lower energy density diet was predictive of less weight gain among normal and overweight women. However, women consuming lower energy density diets still gained weight; albeit less than those consuming higher energy density diets. Analysis of dietary patterns revealed that even those consuming lower energy density diets were not eating the recommended servings of fruits and vegetables that are rich in fiber, suggesting that additional increases in fruit and vegetable consumption may promote weight maintenance.

In combination, findings from Study 3 reveal that decreasing energy density by consuming more servings of fruits and vegetables, as recommended by US Dietary Guidelines (36), may be an effective weight maintenance strategy among free-living women. This strategy may be particularly effective at preventing weight gain because consuming a lower energy diet allows individuals to consume a greater weight of food while decreasing total energy intake.

Studies 1, 2, and 3 contribute to the obesity literature as they identify relatively stable but modifiable factors that are associated with weight change among free living women. Results from all three studies have important implications for the development of recommendations promoting weight maintenance. First, interventions should be targeted based on individual's specific dieting history (i.e., whether they self identify as dieting versus not dieting). However, rather than just obtaining information about "dieting" or not, study 2 suggests that the type of weight control strategies that women report engaging in influences weight change differently. Therefore our second recommendation is that women should be encouraged to engage in "healthy" weight control strategies and avoid use of "unhealthy" weight control strategies that have been associated with weight gain. Thus, future research examining associations between dieting and weight status should obtain detailed information on what strategies individuals are engaging in to lose or maintain weight rather than simply asking women to self-report dieting status. The third recommendation is that dietary restraint and disinhibition should be examined together, as the interaction between the two was found to influence weight gain. Specifically, if dieting women are higher in disinhibition, their level of restraint may alter the effect of disinhibition on weight. Women could be screened for these characteristics which would allow future interventions to be tailored to match the particular profile of an individual to target their specific behavior modification needs. Finally, consuming lower energy density diets allows women to eat more food, but fewer calories which may prevent disinhibitied eating, thereby, promoting weight maintenance. Therefore, promotion of lower energy density diets may be an effective public health message for both normal and overweight. However, women may need better dietary guidance on how to select foods to achieve a lower ED diet (i.e., selecting water rich dishes, rich in fruits and vegetables, while also reducing fat intake) as a means of reducing daily energy intakes to avoid weight gain.

Strength of all three studies is that longitudinal data were used to identify predictors of different patterns of weight change. Specifically, the longitudinal design allowed us to make stronger causal inferences than cross-sectional studies using concurrent time points. However, these studies are not without limitations. Although weight status was assessed on several occasions, every 2 years, more frequent assessments of weight status and possible predictors might better capture individual changes in weight status and temporal patterns among dieting practices, restraint, disinhibition and weight change. Secondly, our sample was racially and demographically homogeneous, and included only women, which prevents us from generalizing to men or other racial and socioeconomic groups. Therefore, further longitudinal analyses are needed to confirm study findings in other samples of free-living adults while also examining potential sex differences. Thirdly, data were self reported, with the exception of weight status; thus, there is the potential for reporting bias. For example, we did not consider the possibility of women selectively under-reporting intakes of energy dense, nutrient poor foods perceived as unhealthy. Thus, future research is needed to explore how reporting accuracy influences calculations of dietary energy density and associations with weight status over time. Another potential limitation is that the first two studies did not assess frequency or duration of specific weight control strategy use, which may influence weight status. Therefore, additional research is warranted to explore whether the duration and frequency of using weight control strategies influences weight maintenance. Finally, it is unclear whether dieting is ineffective and causal of weight gain or that dieting is a proxy for an obesigenic lifestyle via other domains; thus, additional research is needed.

As previously mentioned, although weight status was assessed on several occasions in the present studies, more frequent assessment of weight status and predictors may better identify patterns and predictors of weight change. Much of the current literature examining patterns of weight change, including the present studies, is based on between person comparisons (i.e., individual differences in weight or BMI, relative to other women in the sample); few data provide information on within-person changes (i.e., whether a woman increased or decreased in weight status over time). Because it is likely that different factors influence individual weight change differently, person-specific data on within-person changes in weight are needed. Moreover, when examining the dynamics of weight change, it is important that both predictor and outcome variables are on the same time scale. In the present studies, we selected trait characteristics that were relatively stable over time because we only collected data every 2 years; however, weight change was largely variable. These findings further suggest that a person-specific time series analyses may be required to examine within-person changes in weight status. Time series analyses would require more frequent assessment of weight status and predictors to examine what factors predict an individual's change in weight over time. These analyses would provide detailed information that could be used for developing targeted weight maintenance interventions that fit an individual's system.

In conclusion, our data indicate that, on average, women gained approximately 0.6 kg per year which is consistent with other longitudinal studies (37, 38); however, large individual differences in weight change were also noted. For example, in study 1, weight change ranged from a weight loss of 20.9 kg to a weight gain of 30.1 kg over 6 years. Findings also revealed that using factors previously associated with weight status can predict weight change over time; providing new insight into what kind of guidance might help to moderate weight gain. Factors that may promote weight maintenance include (1) the interaction between restrained and disinhibited eating; (2) practicing “healthy” weight control strategies; (3) avoiding use of “unhealthy” weight control strategies; and (3) consuming a lower energy density diet that can be achieved by following “healthy” weight control strategies such as increasing fruit and vegetable intake and changing the types of foods eaten. In addition, findings from these studies suggest that the “one size fits all” strategy may actually promote weight gain. Thus, weight maintenance programs might have their greatest impact on future obesity by targeting specific modifiable characteristics of an individual to meet their needs. Finally, understanding weight change requires examination of how factors interact to influence weight change. In our current obesigenic environment in which women often fail to maintain weight, findings from the present studies suggest that small behavioral changes in addition to following recommendations for specific weight control strategies to use, and perhaps more importantly avoid, may prevent future weight gain.

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Appendix A

Chapter 3: Correlations among Healthy and Unhealthy Weight Control Strategies

Appendix A. Correlations among healthy and unhealthy weight control strategies

	1	2	3	4	5	6	7	8	9	10	11
Healthy weight control strategies †											
1. Eliminate sweets/junk food	-	.60	.63	.68	.68	**.77**	.64	.58	.61	.62	.44
2. Increasing exercise		-	.67	.60	.55	.43	.49	.54	.57	.39	.31
3. Eat more fruit & vegetables			-	.76	.65	.49	.58	.63	.63	.52	.48
4. Eat less fat				-	.68	.57	.60	.72	.75	.50	.50
5. Reduce amount of food					-	.66	.61	**.72**	**.67**	.49	.50
6. Eliminate snacking						-	.54	.54	.54	.42	.33
7. Change type of foods eaten							-	.58	.59	.66	.33
8. Reduce calories								-	**.77**	.52	.46
9. Eat low-calorie foods									-	.52	.55
10. Eat less high-CHO foods										-	.22
11. Eat less meat											-

	1	2	3	4	5	6	7	8	9
Unhealthy weight control strategies									
1. Skipping meals	-	.56****	.19**	.11	.17*	.37****	.11	.12	.15
2. Fasting		-	.21**	.22**	.21**	.46****	.04	.18**	.16*
3. Diet pills			-	**.38*****	**.79******	.11	.19**	.34****	.20**
4. Liquid diets				-	**.40******	.03	.08	.20**	.09
5. Appetite suppressants					-	.17*	.25***	.38****	.26***
6. Increase cigarettes smoked						-	.03	.11	.13
7. Diuretics							-	.26***	.15*
8. Diet centers with food								-	.17*
9. Laxatives or enemas									-

† All healthy weight control strategies significant at p < .0001

* p < 0.05

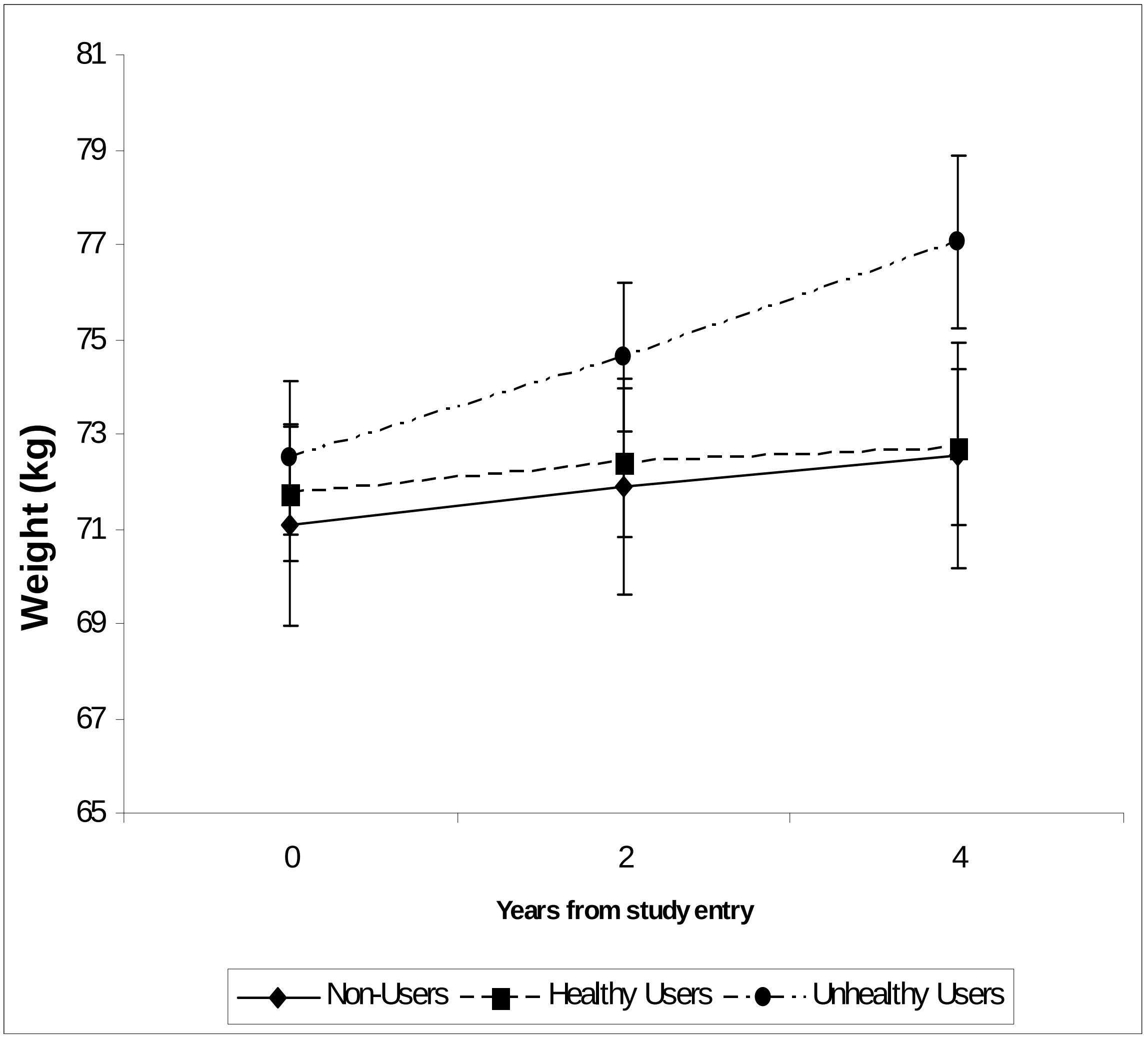
** P < 0.01

*** P < 0.001

*** P < 0.0001

Appendix B

Chapter 3: Repeated Measures Mixed Model using Weight Control Class Assignment to Predict Weight Gain over 4 Years, Adjusting for BMI Category



Weight (kg)
81
79
77
75
73
71
69
67
65
0
2
4
Years from study entry
Non-Users
Healthy Users
Unhealthy Users

Appendix C

Eating Inventory Scale

EATING INVENTORY QUESTIONNAIRE

For the following questions, please circle T if it is true for you, or F if it is false. It is very important to answer each question.

		True (1)	False (0)
1.	When I smell freshly baked cookies or pizza I find it very difficult to keep from eating, even if I have just finished a meal.	T	F
2.	I usually eat too much at social occasions, like parties and picnics.	T	F
3.	I am usually so hungry that I eat more than three times a day.	T	F
4.	When I have eaten my quota of calories, I am usually good about not eating any more.	T	F
5.	Dieting is so hard for me because I just get too hungry.	T	F
6.	I deliberately take small helpings as a means of controlling my weight.	T	F
7.	Sometimes things just taste so good that I keep on eating even when I am no l longer hungry.	T	F
8.	Since I am often hungry, I sometimes wish that while I am eating, an expert would tell me that I have had enough or that I can have something more to eat.	T	F
9.	When I feel anxious, I find myself eating.	T	F
10.	Life is too short to worry about dieting.	T	F
11.	Since my weight goes up and down, I have gone on reducing diets more than once.	T	F
12.	I often feel so hungry that I just have to eat something.	T	F
13.	When I am with someone who is overeating, I usually overeat too.	T	F
14.	I have a pretty good idea of the number of calories in common food.	T	F
15.	Sometimes when I start eating, I just can't seem to stop.	T	F
16.	It is not difficult for me to leave something on my plate.	T	F
17.	At certain times of the day, I get hungry because I have gotten used to eating then.	T	F
18.	While on a diet, if I eat food that is not allowed, I consciously eat less for a period of time to make up for it.	T	F

		True (1)	False (0)
19.	Being with someone who is eating often makes me hungry enough to eat also.	T	F
20.	When I feel blue, I often overeat.	T	F
21.	I enjoy eating too much to spoil it by counting calories or watching my weight.	T	F
22.	When I see a real delicacy, I often get so hungry that I have to eat right away.	T	F
23.	I often stop eating when I am not really full as a conscious means of limiting the amount that I eat.	T	F
24.	I get so hungry that my stomach often seems like a bottomless pit.	T	F
25.	My weight has hardly changed at all in the last ten years.	T	F
26.	I am always hungry so it is hard for me to stop eating before I finish the food on my plate.	T	F
27.	When I feel lonely, I console myself by eating.	T	F
28.	I consciously hold back at meals in order not to gain weight.	T	F
29.	I sometimes get very hungry late in the evening or at night.	T	F
30.	I eat anything I want, any time I want.	T	F
31.	Without even thinking about it, I take a long time to eat.	T	F
32.	I count calories as a conscious means of controlling my weight.	T	F
33.	I do not eat some foods because they make me fat.	T	F
34.	I am always hungry enough to eat at any time.	T	F
35.	I pay a great deal of attention to changes in my figure.	T	F
36.	While on a diet, if I eat a food that is not allowed, I often then splurge and eat other high calorie foods.	T	F

Appendix D

Weight Loss Behavior Scale

Weight Loss Behavior Scale

Please read each weight loss strategy listed and indicate how often you have used this strategy **IN THE PAST TWO YEARS** to lose weight or to maintain weight.

If you have never used a strategy, or you have never dieted, please indicate so by marking never.

Weight Loss Strategy	Never	Rarely	Sometimes	Often	Always
1. Increase Exercise	1	2	3	4	5
2. Eat more fruit and vegetables	1	2	3	4	5
3. Eat less fat	1	2	3	4	5
4. Eliminate Snacking	1	2	3	4	5
5. Eliminate sweets and junk	1	2	3	4	5
6. Reduce Calories	1	2	3	4	5
7. Reduce amount of food	1	2	3	4	5
8. Eat low-calorie food	1	2	3	4	5
9. Skip meals	1	2	3	4	5
10. Eat less meat	1	2	3	4	5
11. Fast	1	2	3	4	5
12. Diet Pills	1	2	3	4	5
13. Vomiting	1	2	3	4	5
14. Eat less high-carbohydrate foods	1	2	3	4	5

15. Change type of food eaten	1	2	3	4	5
16. Appetite suppressants	1	2	3	4	5
17. Liquid diets	1	2	3	4	5
18. Drink less alcohol	1	2	3	4	5
19. Increase cigarettes smoked	1	2	3	4	5
20. Laxatives or enemas	1	2	3	4	5
21. Diet centers with food	1	2	3	4	5
22. Weight loss groups	1	2	3	4	5
23. Diuretics	1	2	3	4	5
24. Other*	1	2	3	4	5

Describe Other:____

Appendix E

Weight Concern Scale

WEIGHT CONCERN SCALE

Please circle the number that corresponds to your answer for the following questions:

1. How much more or less do you feel you worry about your weight and body shape than other women your age?
   0. I worry a lot less than other women
   1. I worry a little less than other women
   2. I worry about the same as other women
   3. I worry a little more than other women
   4. I worry a lot more than other women

2. How afraid are you of gaining 3 pounds?
   0. I'm not afraid of gaining 3 pounds
   1. I'm slightly afraid of gaining 3 pounds
   2. I'm moderately afraid of gaining 3 pounds
   3. I'm very afraid of gaining 3 pounds
   4. I'm terrified of gaining 3 pounds

3. How often have you dieted in the past?
   0. Never
   1. Rarely
   2. Occasionally
   3. Frequently
   4. I am always dieting.

4. Compared to other things in your life, how important is your weight to you?
   0. My weight is not important compared to other things in my life
   1. My weight is a little less important than some other things in my life
   2. My weight is as important than other things in my life
   3. My weight is more important than most, but not all, things in my life
   4. My weight is the most important thing in my life

5. Do you ever feel fat?
   0. Never
   1. Rarely
   2. Sometimes
   3. Often
   4. Always

Appendix F

Eating Attitudes Test

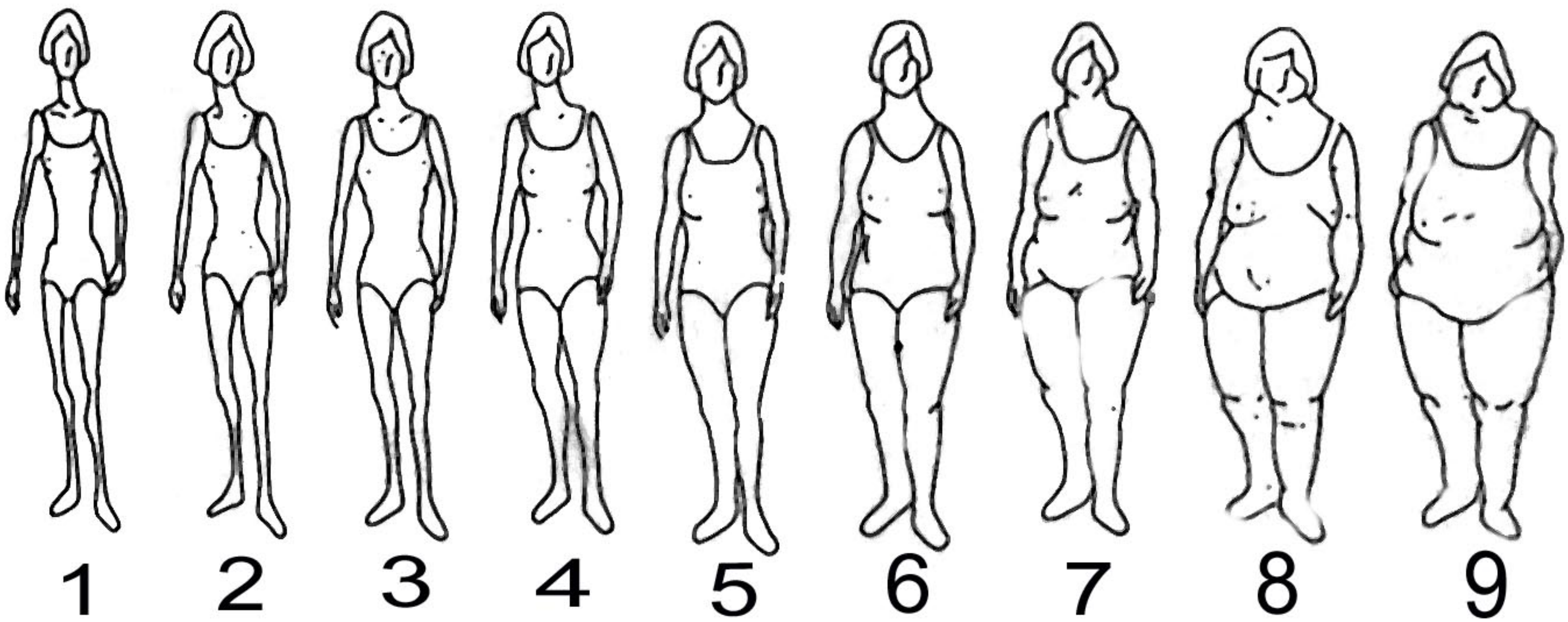
Eating Attitudes Test

	Always	Usually	Often	Sometimes	Rarely	Never
I am terrified about being overweight.	1	2	3	4	5	6
I avoid eating when I am hungry.	1	2	3	4	5	6
I find myself preoccupied with food.	1	2	3	4	5	6
I have gone on eating binges where I feel that I may not be able to stop.	1	2	3	4	5	6
I cut my food into small pieces.	1	2	3	4	5	6
I am aware of the calorie content of the foods I eat.	1	2	3	4	5	6
I particularly avoid food with a high carbohydrate content (breads, potatoes, rice).	1	2	3	4	5	6
I feel that others would prefer if I ate more.	1	2	3	4	5	6
I vomit after I have eaten.	1	2	3	4	5	6
I feel extremely guilty after eating.	1	2	3	4	5	6
I am preoccupied with a desire to be thinner.	1	2	3	4	5	6
I think about burning up calories when I exercise.	1	2	3	4	5	6
Other people think I'm too thin.	1	2	3	4	5	6
I am preoccupied with the thought of having fat on my body.	1	2	3	4	5	6
I take longer than others to eat my meals.	1	2	3	4	5	6
I avoid foods with sugar in them	1	2	3	4	5	6
I eat diet foods	1	2	3	4	5	6
I feel that food controls my life	1	2	3	4	5	6
I display self-control around food	1	2	3	4	5	6
I feel that others pressure me to eat	1	2	3	4	5	6
I give too much time and thought to food	1	2	3	4	5	6
I feel uncomfortable after eating sweets	1	2	3	4	5	6
I engage in dieting behavior	1	2	3	4	5	6
I like my stomach to be empty	1	2	3	4	5	6
I have the impulse to vomit after meals	1	2	3	4	5	6
I enjoy trying new rich foods	1	2	3	4	5	6

Appendix G

Body Figures Rating Scale

Mother's Figures



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