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Changes in Disinhibition, Restraint and Hunger and Associated Characteristics during a Weight Loss Intervention

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Abstract

Background: Understanding how diet composition and personal characteristics relate to eating behaviors of individuals in weight loss programs could better inform the development and expectations of prescribed weight loss regimens. The purpose of this study was to examine whether diet composition has a significant effect on eating behaviors of individuals participating in a weight loss intervention and what characteristics significantly correlate with changes in such behaviors.

Methods: The Eating Inventory questionnaire was used to assess eating behaviors of restraint, disinhibition and hunger at baseline and 6 months among individuals participating in a weight loss intervention who were prescribed a standard reduced-energy-density diet or a walnut-enriched reduced-energy diet as one component of a behavioral weight loss intervention.

Results: After 6 months of intervention, there were significant improvements in both study arms on all scales and most subscales, with overall restraint increasing, disinhibition decreasing and hunger decreasing. Other correlations were that as restraint increased, weight loss increased; as hunger decreased, disinhibition decreased; and as physical activity increased, disinhibition decreased. Among personal characteristics, restraint was significantly associated with sex, age and education at baseline, with women reporting higher restraint than men, younger participants reporting lower restraint than older individuals, and college graduates reporting lower restraint than non-college graduates. Over the course of the weight loss program, there were significant correlations between increased restraint and being male as well as decreased hunger and being a college graduate.

Conclusion: Our results highlight the significance of restraint among the three eating behaviors as it was the only behavior significantly correlated with weight loss and was also correlated with several personal characteristics. Disinhibition and hunger showed other significant correlations with one another that do not directly correlate with weight loss but may be important in other aspects of weight control such as weight loss maintenance.

Keywords: Eating inventory; Restraint; Disinhibition; Hunger; Weight loss; Diet composition

Introduction

Overweight and obesity continue to be prevalent in the US today. There are more obese women than men, and there are more obese individuals in the 40-59 year age range than other subgroups [1]. A number of strategies are recommended to achieve weight loss, and individuals are encouraged to combine a reduced-energy diet, increased physical activity and behavioral therapy [2]. Treatments that target eating behavior should be included in the first line of intervention for individuals who are overweight and obese [2] and behavioral weight loss programs have been shown to induce a 5-10% weight loss [3]. Several behavioral aspects of eating, including disinhibition, restraint and hunger, have been identified and examined as potentially important factors in weight loss and weight maintenance [4-7]. However, the specific role of such factors in weight loss and long-term weight management remains less clear.

The three behavioral mechanisms that are most frequently studied include restraint, disinhibition and hunger. These behaviors are often evaluated using the Eating Inventory Questionnaire (EI) [8], and subscales have been developed [9-11] that further define and interpret aspects of these factors, which can inform understanding of the impact of these factors on long-term weight management. Disinhibition is described as the frequent tendency to overeat in response to various stimuli such as environment or mood. Restraint is considered the conscious restriction of food intake such as practicing portion control or deliberately avoiding foods perceived to be unhealthy. Hunger is the desire to eat in response to physiological signals and external cues.

In most previous studies, a higher degree of restraint has been positively associated with weight loss, and higher pre-treatment levels of restraint have been associated with more weight loss. It has also been observed that for individuals seeking weight loss treatments, restraint increases with weight loss. Furthermore, higher levels of restraint after weight loss are associated with less weight regain during weight maintenance [12-14]. Disinhibition has been negatively associated with weight loss, with greater decreases in disinhibition associated with greater weight loss. Sustained disinhibition after weight loss has been associated with more successful weight loss maintenance and increased disinhibition after weight loss has been associated with weight regain [12,13,15,16]. Fewer studies have focused on hunger,

however it has been shown that reduced hunger at baseline and over time is a predictor of greater weight loss success [6].

While studies have examined the relationship between eating behaviors and weight loss in the overweight and obese, there are few that focus on such changes as they compare among different types of diet strategies, such as a standard reduced-energy-density diet *vs.* a diet including walnuts, and thus, typically higher fat consumption. Furthermore, previous studies have not thoroughly explored how eating behavior changes correlate with demographic and other characteristics. These factors have been studied in weight loss in women alone and more specifically in single age groups of women [12,13,17,18]. They have also been compared among women and men in the context of degree of adiposity [19]. There has been less discussion specifically of eating behavior changes throughout weight loss programs as they compare between genders as well as other factors such as age and education level. It is valuable to further examine the changes in these behaviors with weight loss as they relate to these factors, in order to better understand what relates to successful weight loss and weight maintenance among different personal characteristics and how these behaviors may be targeted differently to personalize interventions.

To add to existing knowledge, we examined whether there were significant differences in the changes in eating behaviors between participants in a 6-month weight loss intervention prescribing either a standard reduced-energy-density diet or a walnut-enriched reduced-energy diet. It has been proposed that regular consumption of nuts facilitates weight management, possibly because of their high satiety property [20,21]. Examining the degree to which dimensions of eating behaviors change and improve in association with different diet composition could help explain whether different strategies are more effective in the weight loss and maintenance process. We hypothesized that participants prescribed a walnut-enriched reduced-energy diet might have greater improvements in eating behaviors such as reduced disinhibition, increased restraint and reduced hunger, due to increased meal satiety. We further hypothesized that personal and demographic characteristics could be associated with differential patterns in eating behavior and attitudes of participants in a weight loss intervention.

Materials and Methods

Study participants

As previously described [22], overweight and obese men and women (N=100) were enrolled into a 6-month weight loss intervention and assigned to either a standard reduced-energy-density diet or a walnut-enriched reduced-energy diet. Participants reported demographic data on a questionnaire, and weight was measured at clinic visits at baseline and 6 months. At study end, weight loss did not differ between the two diet plans. Details of the study intervention and main results are reported elsewhere [22]. All study procedures were approved by the Institutional Review Board of the University of California, San Diego, and all participants provided written informed consent prior to enrollment and data collection.

Intervention

In both study arms, subjects met with a registered dietitian to develop an individualized dietary plan to accommodate individual preferences and adhere to the goals of the diet prescription. Walnuts were provided to participants in the walnut-enriched reduced energy diet arm, who were instructed to consume an average of 1-1.5 ounces/day and also given recipes and examples of how to achieve the walnut-consumption goals. Participants assigned to the standard reduced-energy-density diet arm were instructed to abstain from nut consumption during the study. The cognitive-behavioral therapy was provided in closed group sessions to both arms and included strategies such as self-monitoring of food intake, physical activity and weight; guidance to increase physical activity; realistic goal setting; addressing body image concerns; training and role playing in problem solving; and relapse prevention through cognitive restructuring. Subjects in both groups participated in individualized counseling and group sessions with in-person, telephone, e-mail and text message contacts to provide support and behavioral guidance strategies. Participants in both arms were encouraged to increase physical activity with lifestyle changes, planned aerobic exercises and strength training. Follow-up data for these analyses were collected in person 6 months after randomization.

Anthropometric measures

Study data were collected and managed using a REDcap database hosted at the University of California, San Diego [23]. At baseline and 6-month follow-up data collection clinic visits, weight, height (baseline only), and waist circumference were measured; body mass index (BMI, kg/m^2) was calculated; and questionnaires were collected.

Eating inventory questionnaire

At baseline and 6-month clinic visits, participants were asked to complete the three-factor Eating Inventory (EI) [8], a 51-item questionnaire that assesses eating attitudes and behavior across three scales: dietary restraint (21 items), disinhibition (16 items), and hunger (14 items) as well as subscales of these constructs.

Each of the three eating behaviors can be further described and examined by a set of subscales. Restraint can be characterized by rigid restraint and flexible restraint. Rigid restraint is defined by an all or nothing approach to dieting, eating or weight. In contrast, flexible restraint is a more gradual and forgiving approach to dieting, eating and weight. Either of these patterns may predominate a person's dietary restraint. It is suggested that predominantly rigid restraint is associated with more disturbed eating behaviors such as binging, which is not helpful in weight loss or maintenance. Predominantly flexible restraint is associated with more successful weight loss and maintenance [9].

Disinhibition has been characterized in several ways in which there is some overlap. One approach defines the locus of disinhibition as external or internal. The questions in the EI that are used to describe external disinhibition describe situations external to the individual, such as watching a friend overeat or being at a party. The questions in the EI that are used to describe internal disinhibition describe thoughts internal to the individual, such eating to console loneliness [10]. Another approach is by defining the pattern of susceptibility to disinhibition as habitual, emotional or situational. Habitual susceptibility is a pattern of disinhibition triggered by routine circumstances, emotional susceptibility is disinhibition that is triggered by negative mood, and situational susceptibility is disinhibition triggered by specific environmental circumstances, such as parties [11].

Hunger has been characterized as being triggered by an internal or external locus, i.e. hunger that is regulated internally and

physiologically or hunger that is triggered by external cues such as seeing a food considered to be a delicacy [11].

Statistical analysis

Demographic associations between scores on the three scales (disinhibition, restraint, and hunger) were compared by personal characteristics (sex, age, education level, race/ethnicity, marital status, and initial body mass index category). Analysis used two-sample t-tests for binary predictors (sex, education, and marital status), and linear regression models to examine associations with continuous or categorical associated factors (e.g., age, BMI).

Scales and subscales are presented for each diet group at each time point, baseline and 6-months. Data for the two study groups were compared at each time point using 2-sample t-tests. Also, we assessed the degree of change within each group using paired t-tests.

We then examined the Spearman correlation coefficients between changes in each of the EI scales with change in physical activity, % change in weight, and 4 demographic variables. All analyses were conducted in SAS version 9.4 (Cary, NC, USA), and significance level for type 1 error was set at alpha=0.05.

Results

Data were collected from 100 participants at baseline and 94 participants at 6 months. EI Questionnaires were completed by the majority of participants at study end (96% of the walnut-enriched reduced-energy group and 92% of the standard reduced-energy-density diet group). The mean age of participants was 52.8 years and the mean BMI was 32.4. Sixty-nine percent of the participants were college graduates and 73% were non-Hispanic white. Thirty-two percent were considered to be overweight, 48% were considered to be obese class 1, and 20% were considered to be obese class 2 (Table 1).

Demographic Variable	N	Hunger Scale	Disinhibition Scale	Restraint Scale
Sex				
Female	79	4.82 (0.32)	7.89 (0.33)	10.76 (0.42) *
Male	21	5.29 (0.79)	7.67 (0.76)	8.43 (0.82) *
Age, years				
27-44	21	5.24 (0.61)	7.76 (0.73)	8.65 (0.71) *
45-65	29	5.17 (0.62)	8.10 (0.49)	9.97 (0.74) *
55-64	41	5.08 (0.44)	8.27 (0.49)	11.20 (0.59) *
65-74	9	2.67 (0.82)	5.22 (0.76)	10.56 (1.42) *
Education				
Not a college graduate	31	4.57 (0.54)	8.03 (0.57)	12.0 (0.71) *
College graduate	69	5.07 (0.36)	7.75 (0.36)	9.47 (0.43) *
Race/ethnicity				
White non-Hispanic	73	4.76 (0.38)	7.90 (0.36)	10.29 (0.44)
Hispanic	16	5.13 (0.45)	6.94 (0.65)	9.81 (1.06)
Other minority	11	5.64 (0.90)	8.73 (1.06)	10.73 (1.23)
Marital status				
Married/living together	57	5.09 (0.42)	7.79 (0.41)	10.07 (0.51)
Single/divorced/widowed	43	4.70 (0.42)	7.91 (0.47)	10.52 (0.60)
Body mass index				
Overweight	32	5.29 (0.56)	7.94 (0.59)	10.97 (0.65)
Obese class 1	48	4.63 (0.41)	7.71 (0.41)	10.40 (0.53)
Obese class 2	20	5.05 (0.68)	8.00 (0.74)	8.80 (1.00)
Legend: * p<0.05 at baseline from t-tests or linear regression				

Table 1: Baseline associations with eating inventory scales.

Eating behaviors and weight loss

The walnut-enriched reduced-energy diet group and the standard reduced-energy-density diet group began the study with few significant differences in weight or eating behaviors. At baseline, internal locus of hunger was higher in the subjects assigned to the walnut-enriched reduced-energy diet than in those assigned to the standard reduced-energy-density diet (2.1 *vs.* 1.4, p = 0.04, Table 2). The only other difference observed between the two diet arms throughout the study was in external locus of hunger at 6 months, where again those assigned to the walnut-enriched reduced energy diet arm had higher levels (1.3 *vs.* 0.08, p = 0.04).

However, after 6 months of weight loss intervention, large differences were observed within each arm in all of the scales and most of the subscales (Table 2). Restraint increased from 10.26 to 15.73, disinhibition decreased from 7.84 to 5.60, and hunger also decreased from 4.92 to 2.95 (p<0.0001 for each). Flexible and rigid restraint subscales increased in both groups; internal and external disinhibition decreased, and emotional and situational susceptibility to disinhibition also decreased. All subscales were different at 6 months compared to baseline in subjects assigned to the walnut-enriched reduced-energy diet. In those assigned to the standard reduced-energy-density diet, the only subscales that did not achieve a statistically significant change over the course of the intervention were habitual susceptibility to disinhibition and internal locus of hunger. Both of these subscales showed nominal changes (p=0.06 for each).

The correlation analysis for change in the EI scales showed that restraint was inversely correlated with weight change and increased with weight loss. Changes in disinhibition and hunger were significantly correlated (rho=0.49, Table 3). Disinhibition also declined with more physical activity (Table 3).

Parameters	Standard Reduced-Energy-Density Diet		Walnut-Enriched Reduced-Energy Diet	
	Base	6 Mo	Base	6 Mo
	(n=51)	(n=47)	(n=49)	(n=47)
Restraint Score	9.8 (0.6)	15.6 (0.4) *	10.8 (0.5)	15.9 (0.4) *
Flexible Restraint	3.0 (0.2)	4.8 (0.2) *	3.3 (0.2)	5.0 (0.2) *
Rigid Restraint	2.9 (0.3)	5.1 (0.2) *	3.2 (0.2)	5.3 (0.2) *
Disinhibition Score	7.7 (0.4)	5.4(0.5) *	8.0(0.4)	5.8(0.4) *
Internal	3.1 (0.3)	2.1(0.2) *	3.2(0.3)	2.1(0.3) *
External	3.0 (0.2)	1.7 (0.2) *	3.0 (0.2)	1.9 (0.2) *
Habitual Susceptibility	1.5 (0.2)	1.0 (0.1)	1.4 (0.1)	1.0 (0.1) *
Emotional Susceptibility	1.4 (0.2)	1.0 (0.2) *	1.7 (0.2)	1.0 (0.2) *
Situational Susceptibility	2.6 (0.2)	1.5 (0.2) *	2.6 (0.2)	1.7 (0.2) *
Hunger Score	4.4 (0.4)	2.5 (0.3) *	5.4 (0.4)	3.4 (0.4) *
Internal Locus	1.4 (0.2)	0.7 (0.2)	2.1 (0.2) †	1.0 (0.2) *
External Locus	1.8 (0.2)	0.8 (0.1) *	2.0 (0.2)	1.3 (0.2) *†

Legend: * p<0.05 within group over time, paired t test

† p<0.05 between groups at the given time, two-sample t test

Table 2: Scales and subscales by diet group and time period.

Parameters	Restraint Change	Disinhibition Change	Hunger Change	Physical Activity Change	% Weight Change	Age	College Graduate	Male Sex
Restraint Change	1	-0.16	-0.17	0.13	-0.21 *	-0.16	0.16	0.27 *
Disinhibition Change		1	0.49 *	-0.22 *	0.17	0.14	-0.09	-0.07
Hunger Change			1	- 0.05	0.003	0.2	-0.22 *	-0.11
Physical Activity Change				1	-0.16	-0.05	0.08	-0.05
% Weight Change					1	-0.29 *	0.03	-0.13

Age						1	-0.22 *	0.005
White Non-Hispanic							-0.07	-0.07
College Graduate							1	0.08
Male Sex								1
Legend: * p<0.05								

Table 3: Spearman correlation matrix for changes in eating inventory scales.

Eating behaviors and personal characteristics

In our cohort of mixed gender (21% male), mixed race/ethnicity (27% minority), adults aged 27-74 years, we observed no significant associations between sex, age, education, race/ethnicity, marital status, or BMI with the hunger or disinhibition scales (Table 1). However, sex, age, and education were all significantly associated with the restraint scale. At baseline, women reported significantly higher restraint than men (10.76 *vs.* 8.43, p=0.02), younger subjects reported lower restraint than older subjects (p=0.007 in a continuous regression model) and college graduates reported lower restraint than those who had not graduated from college (9.47 *vs.*12.00, p=0.004).

The correlation analysis (Table 3) for change in the EI scales also revealed that men showed a larger increase in restraint than women (7.74 *vs.* 4.78, p=0.02). Change in hunger was related to education, as college graduates reported a greater decrease on their hunger scale compared to non-college graduates that was of marginal significance (2.19 *vs.* 0.79, p=0.06).

Discussion

Gaining a better understanding of the factors that influence eating behavior changes is important to the development of effective weight loss programs and meaningful expectations of them. This study, which examined two dietary strategies in a weight loss intervention over a 6-month period, provided an opportunity to explore the relationship between weight loss program strategies and eating behaviors as well as personal characteristic correlates with weight loss success. Both dietary strategies showed comparable weight loss and comparable changes in eating behaviors, suggesting that specific diet type had no significant correlation with the eating behaviors of restraint, disinhibition and hunger in the context of a behavioral weight loss intervention. The results also allowed for examination of the eating behaviors as they relate to weight loss and personal characteristics of participants. Overall, restraint was the eating behavior with the most significant correlations. It was the only eating behavior significantly correlated with weight loss and also the eating behavior significantly correlated with the most personal characteristics; at baseline being higher in females, lower in younger individuals and lower in college graduates; and over the course of the weight loss programs increasing significantly for males but not females.

Results from this study agree with previously reported findings, as over the course of the intervention, restraint increased, disinhibition decreased and hunger decreased [5,6,12]. However, in regard to weight change specifically, increased restraint was the only behavior significantly correlated with weight loss. Most studies have agreed with this finding of the key significance of restraint [5,12,13]. Many such studies, however, also identify elements of disinhibition [5,12,13] as having some significance in addition to hunger [6]. As suggested by other studies, these findings support the concept that restraint may be a key eating behavior to target in interventions focused on weight loss specifically.

When examining changes in the subscales, all subscales achieved significant changes in both arms except for two subscales in the standard reduced-energy-density diet arm within the disinhibition and hunger (but not restraint) categories, specifically, habitual susceptibility and internal locus of hunger. It is clear that the main difference between the two diet groups was the prescribed consumption of walnuts in the walnut-enriched reduced-energy diet arm. Perhaps the inclusion of a goal to consume a specific food (walnuts) was connected to the decrease in habitual disinhibition in the walnut-enriched reduced-energy diet arm by providing a daily habit of consuming walnuts that somehow counteracted the behavior of habitual disinhibition. Furthermore, understanding that walnuts may promote satiety, it is possible that this specific diet component related to the significant changes in internal locus of hunger, which is driven by physiological cues within the body. However, despite the different findings of significant changes in these subscales, the standard reduced-energy-density diet arm still achieved comparable weight loss and overall eating behavior changes as the walnut-enriched reduced-energy diet arm. Thus, it is important to emphasize that restraint was the behavior specifically correlated with weight loss and that in both arms, restraint and its subscales of flexible and rigid restraint increased significantly.

Another finding was that disinhibition was correlated with both hunger and physical activity, decreasing with decreased hunger and increased physical activity. Other studies have shown that higher disinhibition is associated with binge eating [12] and that disinhibition is linked to hunger [4]. Disinhibition has also been connected to weight loss in other studies, identified as significant in weight gain [4,16,18], and disinhibition has been specifically suggested as a target for interventions to prevent weight regain [16,24]. Weight loss and eating behaviors have been studied in relation to correlates of exercise behavior and it was found that while short term weight loss was associated with eating behaviors, long term weight loss was associated with increases in certain exercise behaviors such as exercise self-efficacy and motivation [13]. To our knowledge, the relationship between exercise itself and eating behaviors has not been examined as it has in this study, specifically examining the correlation between an increase in exercise (as prescribed in the weight loss programs) and changes in eating behaviors. According to our study, physical activity was not significantly correlated to weight loss; however, increased physical activity was significantly correlated to decreased disinhibition. This relationship between physical activity and disinhibition highlights the value of including physical activity in efforts to curb disinhibited eating habits, and knowing the possible role of disinhibition in weight

gain, the need to further explore the role of exercise in weight maintenance after weight loss program participation.

Overall, restraint was shown to be the eating behavior with the most significant correlation with the personal characteristics examined. When examining these correlates, the findings regarding gender support those from previous studies. Females reported significantly higher restraint at baseline, which has been noted in other studies as well [4]. It was also found that males had more significant increases in restraint throughout the program compared to females. Other studies have variable findings regarding restraint and gender. For example, it has been suggested that only disinhibition (and not restraint) is correlated with BMI in females, but both restraint and disinhibition are correlated to BMI in males [4]. It has also been suggested that greater increases in restraint are associated with more significant weight loss [12] but also that dietary restraint may only be specifically beneficial in preventing weight gain in individuals with high disinhibition [17]. Our findings in conjunction with the variable findings of other studies regarding eating behaviors and gender reveal a need to further examine eating behaviors in the context of gender so as to better understand how weight loss programs could be tailored to these characteristics.

Lastly, restraint was also associated with age and education, as younger and college educated individuals reported significantly lower restraint at baseline. Despite reporting significantly lower restraint, college graduates also showed a significant decrease in hunger over the duration of the intervention. To our knowledge, there have been few studies exploring the relationships between eating behaviors and personal characteristics of weight loss program participants in this way. It is a simple task to collect these personal characteristics from weight loss program participants. Knowing that increased restraint is often correlated with weight loss, it may be relevant to specifically target weight loss programs to increasing restraint in these groups that had significantly lower restraint at baseline. These findings highlight the value of collecting such information and the need for future studies to further examine how personal characteristics relate to eating behaviors so as to better tailor weight loss intervention strategies to individual participants.

There are some strengths and limitations to this study. One strength is that it included both men and women and also attempted to identify other personal characteristics of participants. As other studies have not focused on sex or have focused on women specifically, this helped to provide more data on eating behaviors as they relate to both sexes. Furthermore, this study had good follow-up with participants and few missing data as most participants in both groups completed the EI questionnaires, ultimately reducing ambiguity of the results.

A limitation of this study was that the interventions were multifaceted, making it difficult to specifically isolate the effects of different aspects of the intervention such as the diet type *vs.* behavioral counseling. It is also important to acknowledge that the two intervention arms relied on self-reported dietary intake. However, it was possible to measure markers of walnut consumption and measurements suggested that individuals assigned to the walnut-consuming arm did eat walnuts [22], and in general, the overall successful weight loss in both arms suggested participants did adhere to some aspects of their diet plans.

Conclusion

Findings from this study suggest that restraint is the eating behavior significantly correlated with weight loss and also significantly correlated with a number of personal characteristics: at baseline, restraint was higher in females, lower in younger individuals and lower in college graduates; and over the course of the weight loss intervention it increased significantly for males but not females. Other interesting findings were that disinhibition is significantly correlated with physical activity and hunger, decreasing with increased activity and decreasing with decreased hunger. College graduates also experienced a significant decrease in hunger.

In conclusion, we suggest that future studies further explore the aspects of weight loss programs, such as dietary strategies, as well as personal characteristics of participants, such as sex, age and education, in order to better understand how weight loss interventions can be tailored to individual participants. Further exploration of these topics may help reveal whether or not other strategies are significantly correlated with eating behavior changes as well as the relationship between personal characteristics and weight loss. As of now, as further supported by our findings, restraint remains an especially important behavior to consider in weight loss programs as it is significantly correlated to weight loss.

Informed Consent

Written informed consent for data collection was obtained from all subjects at the point of recruitment and before any data collection.

Ethical Considerations

All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation.

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Clinical Trial Number

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Conflict of Interest

The authors declare no conflict of interest.

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