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Comparison of standardized versus individualized caloric prescriptions in the nutritional rehabilitation of inpatients with anorexia nervosa

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Abstract

Objective—Sparse research informs how caloric prescriptions should be advanced during nutritional rehabilitation of inpatients with anorexia nervosa (AN). This study compared the impact of a standardized caloric increase approach, in which increases occurred on a predetermined schedule, to an individualized approach, in which increases occurred only following insufficient weight gain, on rate, pattern, and cumulative amount of weight gain and other weight restoration outcomes.

Method—This study followed a natural experiment design comparing AN inpatients consecutively admitted before ($n = 35$) and after ($n = 35$) an institutional change from individualized to standardized caloric prescriptions. Authors examined the impact of prescription plan on weekly weight gain in the first treatment month using multilevel modeling. Within a subsample remaining inpatient through weight restoration ($n = 40$), multiple regressions examined the impact of caloric prescription plan on time to weight restoration, length of hospitalization, maximum caloric prescription, discharge BMI, and incidence of activity restriction and edema.

Results—There were significant interactions between prescription plan and quadratic time on average weekly weight gain ($p = .03$) and linear time on cumulative weekly weight gain ($p < .001$). Under the standardized plan, patients gained in an accelerated curvilinear pattern ($p = .04$) and, therefore, gained cumulatively greater amounts of weight over time ($p < .001$). Additionally, 30% fewer patients required activity restriction under the standardized plan.

Discussion—Standardized caloric prescriptions may confer advantage by facilitating accelerated early weight gain and lower incidence of bed rest without increasing the incidence of refeeding syndrome.

Anorexia Nervosa (AN) is a serious, recalcitrant disorder associated with elevated morbidity and mortality rates (1, 2). Underweight individuals with AN experience a range of alarming physical and psychological symptoms that drastically improve with restoration of body weight to a normative range (3–5). Thus, nutritional rehabilitation, typically through an inpatient eating disorder service, is a necessary first step in treating underweight individuals with AN.

There is no clear empirical evidence to suggest the most effective method of structuring caloric prescriptions during nutritional rehabilitation for inpatients with AN. Inpatient facilities often exercise caution around conducting weight restoration too rapidly, due to concerns about the risk of refeeding syndrome (6, 7). Many follow the consensus-based recommendation that initial caloric prescriptions should be set low (approximately 1,200 kilocalories or kcals/day) and subsequent individualized caloric increases should be conducted gradually to support a slow weight gain of approximately 1.1 to 3.1 lbs. per week (8, 9). Due to the conservative nature of these guidelines, activity restriction, such as medical bed rest, is often necessary during early hospitalization to conserve caloric expenditure and promote continued weight gain.

However, a handful of studies have begun to challenge the “start low, advance slow” approach to initial weight restoration. Studies conducted with samples of adolescents with AN have found that starting patients on the recommended low caloric prescription (~1,200 kcal/day) results in initial weight loss for approximately 83% of patients (10), whereas higher initial caloric prescriptions are associated with more rapid weight gain and shorter hospital stays without increased risk of electrolyte disturbances or refeeding syndrome (10, 11). One study of adolescents examined the effects of a more aggressive approach to refeeding, employing higher initial caloric prescriptions of 1,900 to 2,200 kcal/day (for all but the most medically compromised individuals) and accelerated caloric prescription increases resulting in caloric prescriptions of 2,700 kcal/day by the fifth day of hospitalization (12). Despite challenging the recommendation that caloric prescriptions be started low and increased gradually, this approach was found to be safe and well tolerated. Another large correlational study examined a similarly accelerated approach to refeeding, in which patients were initially prescribed 1,200 to 1,500 kcal/day and prescriptions were advanced to 3,500 to 4,000 kcal/day over nine to eleven days, in a consecutive series of primarily adult AN admissions (13). This more rapid approach was also determined to be safe and well tolerated. In none of these recent studies did rate of weight gain impact the probability of developing hypophosphatemia, which is described as the hallmark of refeeding syndrome (14).

However, there remains no research to guide hospital decisions on how to best structure caloric increases for patients with AN and whether calorie advances should be tailored to individual progress or standardized. Most programs with a conservative approach to nutritional rehabilitation utilize an “individualized” approach, in which caloric prescription is increased through clinical consensus only when a patient fails to gain sufficiently. However, some programs endorsing a more rapid refeeding program have used “standardized” prescriptions. These protocols anticipate increases in metabolic needs by increasing caloric requirements according to a predetermined schedule, independent of an

individual's rate of weight gain. The relative effects of individualized versus standardized caloric increases are unknown, though one study found that standardizing, as opposed to individualizing, food *selection* was associated with more efficient weight gain (15). In the current study, we examined the outcomes from a natural experiment, in which an institutional change occurred on an inpatient eating disorder service in June 2005 that altered the nutritional rehabilitation protocol for all patients with AN from an individualized to a standardized approach to caloric increases. The primary aim of this study was to examine the effect of this change in caloric prescription plan on the rate, pattern, and cumulative amount of patient weight gain in the first four weeks of hospitalization. As a secondary aim, we examined whether prescription plan affected other outcomes of interest to inpatient weight restoration such as time to weight restoration, length of inpatient treatment, maximum caloric prescription, discharge BMI, and incidence of activity restriction and edema. The overall aim of this study was to contribute to the research on effective approaches to nutritional management for inpatients with AN.

Methods

Participants

Research participants were identified through a retrospective chart review. All patients with a diagnosis of AN consecutively admitted to an research-based inpatient eating disorder unit in the Northeast U.S. in the two years following the caloric prescription protocol change (June 2005 to June 2007) who met eligibility criteria (see below) were selected to constitute the sample receiving the standardized caloric prescription plan. We then selected a sample of the same number of eligible inpatients consecutively admitted immediately preceding the June 2005 calorie prescription change to comprise the group receiving individualized caloric increases. All patients provided informed consent for research participation and methods were conducted in accordance with the local institutional review board. Diagnosis of AN, including subtype (AN restricting or binge eating/purging subtype), was established using the Structured Clinical Interview for DSM-IV (SCID-I) (16), excluding the amenorrhea criterion (17). If a patient was admitted to the inpatient unit more than once during the data collection period, only data from the admission involving standardized increases were used in the analyses. Cases were excluded from analysis under the following circumstances: 1) If the patient left the inpatient unit prior to the second week of hospitalization, as no caloric increases were made before the second week ($n = 4$); 2) If a medical illness unrelated to the eating disorder affected a patient's ability to gain weight appropriately ($n = 1$). This methodology resulted in a total sample of 70 patients (35 under the individualized plan, 35 under the standardized plan). As highlighted in Table 1, patient groups were equivalent along demographic and clinical variables at admission.

Due to another institutional change occurring in June 2005 (i.e., the opening of a partial hospitalization service), some participants under the standardized plan did not remain on the inpatient unit for the entirety of treatment (i.e., stepped down to the partial hospitalization program before completing weight restoration); therefore, only a subsample of patients could be selected for secondary analyses examining differences in other outcomes related to the process of weight restoration, as these indices were expected to vary based on level of

care. Of the 35 original participants under the standardized prescription plan, 20 remained on the inpatient unit throughout the entirety of treatment. Therefore, secondary analyses were conducted on a subsample consisting of these patients ($n = 20$), and the same number of participants under the individualized plan ($n = 20$) who were selected for analyses based on age and subtype match with the sample receiving the standardized plan.

Procedures

Inpatient approach to nutritional rehabilitation across prescription plans—

Participants receiving both individualized and standardized caloric prescriptions participated in a structured, behavioral program aimed at restoring weight to 90% of ideal body weight according to the 1959 Metropolitan Life standards (18), which is equivalent to a body mass index (BMI) of 19.5 kg/m^2 . All patients were encouraged to consume 100% of prescribed calories, with privilege level contingent upon program compliance. The first week of hospitalization focused on medical stabilization, during which patients were closely medically monitored and weighed daily. All patients were maintained on a prescription of 1,800 kcal/day during this first week and caloric prescriptions were only increased during this week if a patient demonstrated marked weight loss. At the beginning of the second week of hospitalization, all patients entered a “weight gain” phase, in which they were weighed three times per week and required to gain 0.75 lbs. over their previous highest weight at each weigh-in to maintain their privilege level. Activity restriction, defined on this service as medical bed rest or restriction to the inpatient unit, was prescribed if a patient failed to demonstrate the recommended weight gain at any weigh-in. Activity restriction ceased when a patient’s weight reached 0.75 lbs. over their previous highest weight.

Individualized caloric prescription plan—Under the individualized plan, caloric increases over the initial 1,800 kcal/day occurred only if a patient failed to demonstrate the required 0.75 lbs. weight increase on a weigh-in day. The decision to increase caloric prescription was made through clinical consensus at clinical team meetings that occurred three times per week corresponding with weigh-in days. In the case of insufficient weight gain, caloric prescription was increased by the addition of 400 kcal in food or 350 kcal in liquid supplement (8 ounces Ensure Plus®) at the discretion of the team. In general, calories prescribed in the form of food did not exceed 4,000 kcal/day. Any necessary additional caloric increases over this threshold were made in the form of liquid supplements. Caloric increases continued in this manner until the patient again gained 0.75 lbs. over the previous highest weight. The patient then remained on the current highest caloric prescription until he or she exhibited further evidence of insufficient weight gain or reached 90% of ideal body weight. After reaching 90% of ideal body weight, liquid supplements were typically removed from the caloric prescription and patients were maintained on their highest caloric requirement of solid food, with adjustments made if this prescription proved to be too low or too high a prescription to support weight maintenance.

Standardized caloric prescription plan—Under the standardized plan, caloric increases for all patients were prescribed in a standardized manner according to the schedule outlined in Table 2. Starting on the seventh day of hospitalization, once medical stability was established, patients received scheduled caloric increases in the form of 400 kcal of

food or 350 kcal in liquid supplement approximately every other day independent of weight change, until reaching the maximum scheduled caloric prescription of 3,700 kcal (3,000 kcal food, 700 kcal Ensure Plus®) on day seventeen of hospitalization. The caloric increase schedule outlined in Table 2 was adjusted in the presence of hypophosphatemia, significant edema, or any other clinical indication that increases should be slowed. If a patient reached 90% of ideal body weight before completing all caloric increases, the subsequent scheduled increases were discontinued. For patients who required a prescription higher than 3,700 kcal/day to achieve weight restoration, subsequent caloric increases were prescribed in the form of liquid supplements following weigh-ins at the discretion of the treatment team.

Predictor Variables and Covariates

All variables were obtained retrospectively by chart review. Caloric prescription plan (individualized versus standardized) was the predictor variable for all analyses. Several variables were recorded for examination as covariates due to potential associations with rate of weight gain, including AN subtype, age, duration of illness, admission BMI, and maximum lifetime BMI. All variables other than admission BMI were obtained via patient self-report from the intake summary by nursing and/or research staff. Admission height and weight, measured by nursing staff, was used to calculate admission BMI.

Dependent Variables

Primary dependent variables: Average weekly weight gain and cumulative weekly weight gain—On the inpatient unit, patients were weighed in the morning after voiding, wearing only a hospital gown. Though weight was collected three times per week on the inpatient unit following the second week of hospitalization, in this study we examined weight on a weekly basis. Weekly weights were recorded from the first week of hospitalization until a patient reached 90% of ideal body weight. In this study, we reported both average weekly weight gain (i.e., the amount of weight gained on the particular week of hospitalization), as well as cumulative weekly weight gain (i.e., the total amount of weight gained by the particular week of hospitalization). For patients who completed at least two weeks of inpatient hospitalization, but left the inpatient level of care before reaching weight restoration, weekly weight gain was included for all full weeks of inpatient hospitalization.

Secondary outcome variables examined in a subset of patients—For the subsample of patients who achieved weight restoration on the inpatient unit ($n = 40$), research staff calculated and recorded the number of days from admission until the first weigh-in at which 90% of ideal body weight was achieved (time to weight restoration), total number of inpatient days (length of hospitalization), and highest calorie level prescribed (maximum caloric prescription). Discharge BMI was calculated using height at admission and last weight recorded prior to discharge.

Research staff tallied the number of incidents of prescribed activity restriction for each patient over the course of treatment. Additionally, inpatients were examined daily by medical staff for edema as one measure for monitoring risk of refeeding syndrome. If edema was observed, this information was noted in the inpatient medical chart. Research staff

examined daily progress notes and recorded any notation of edema throughout the weight restoration process as a proxy to risk of refeeding syndrome. As continuous variables, both activity restriction and edema count variables were highly positively skewed. In the case of such extreme skew, in which a large number of observations fall in the most extreme end of the distribution (e.g., 0 incidents of activity restriction or edema), it has been suggested that dichotomization may allow for more appropriate measurement (1). Therefore, incidence of activity restriction and edema were examined categorically (i.e., whether or not a patient was ever prescribed activity restriction throughout treatment; whether or not a patient exhibited edema throughout treatment).

Data Analytic Plan

Primary analyses: Multilevel modeling of weight changes over time—Multilevel modeling was utilized to examine weekly weight gain data for the following reasons: 1) Multilevel modeling allows examination of data at multiple levels of analysis at a time, including at the level of the individual, as well as the level of the observation. This quality allows researchers to not only examine changes in a particular variable over time, but also to examine how different environmental and individual variables affect change in the dependent variable across time; 2) Multilevel modeling is tolerant of missing data and differing numbers of observations over time, due to the use of maximum likelihood analysis methods. This characteristic made multilevel modeling well suited for these data because patients had differing numbers of weight gain observations recorded based on the time at which they had achieved weight restoration, discharged, or stepped down to a less intensive level of care.

Because weight gain observations varied considerably by patient (minimum: 2 observations, maximum: 12 observations) based on amount of time required for weight restoration or when the patient discharged from the inpatient level of care, and therefore missing data varied considerably by week (0% to 99%), the authors chose a cut-off point for the number of weeks of weight gain to examine within the mixed model. We decided upon four weeks for the following reasons: 1) Standardized caloric increases occurred between days seven and seventeen of inpatient hospitalization; therefore, examining the four weeks of treatment allowed an ability to examine the entirety of the time span in which the caloric prescription plans differed; and 2) Between weeks four and five of hospitalization there was a significant increase in the percentage of missing observations (from 13% to 38%) due to numerous individuals reaching weight restoration or transitioning to a lower level of care by week five, therefore week four was determined a sensible cutoff point by which the authors could maintain the integrity of the data.

Multilevel modeling was used to predict the overall rate, pattern, and cumulative amount of weight gain over the first four weeks of treatment. Two models were run to examine these outcomes: 1) A model with weight gained on a given week (average weekly weight gain) entered as the dependent variable; 2) A model with cumulative weight gained by a given week (cumulative weekly weight gain) entered as the dependent variable. Both models included caloric prescription plan, linear and quadratic equations of time (to examine different potential patterns of weight gain across plans), and prescription plan by time

interactions (to account for different potential patterns of weight gain between plans) as independent variables, and included any covariates presumed to be related to rate of weight gain (AN subtype, age, duration of illness, admission BMI, and maximum lifetime BMI) that improved model fit. Simple slope analyses were conducted to examine the nature of any significant interactions.

All continuous covariates were centered to avoid problems related to multicollinearity. Upon initial review, several observations were identified as outliers through examination of the multilevel residuals (Time 1: $n = 9$; Time 2: $n = 2$; Time 3: $n = 2$; Time 4: $n = 1$) and removal of these outliers significantly improved the fit of the models. Therefore, these outliers were removed in all subsequent analyses, resulting in a total of 243 weight observations across 70 participants. Of note, the majority of the outliers were identified at Time 1 (i.e., first week of hospitalization), during which time there was no differentiation in caloric prescription between the two plans. This variability is likely due to vast differences in fluid shifts that occur within the first week of weight restoration based on degree of dehydration prior to admission and diuresis following the initiation of refeeding (20).

Secondary analyses: Regression analyses comparing other outcomes related to weight restoration—To examine differences between prescription plans on other outcomes related to weight restoration within the subset of patients completing treatment on the inpatient unit, we conducted a series of linear regressions in which caloric prescription plan and covariates (AN subtype, age, duration of illness, admission BMI, and maximum lifetime BMI) were entered as predictors, and time to weight restoration, length of hospitalization, maximum caloric prescription, and discharge BMI were entered as dependent variables. Binary logistic regressions were used to examine the effect of caloric prescription plan and covariates on need for activity restriction and incidence of edema. All continuous covariates were centered to avoid multicollinearity.

Results

Primary Analyses: Multilevel Modeling of Weight Changes Over Time

We examined the fit of the models using information criteria including Akaike's Information Criterion (AIC), Schwarz's Bayesian Criterion (BIC), and -2 Restricted Log Likelihood. Of the covariates tested, only two (AN subtype and maximum lifetime BMI) improved the models and therefore were included in the analyses. Table 3 details the models examining weight changes over time.

Average weekly weight gain—The information criteria for this model were as follows: AIC = 943.17, BIC = 960.22, and -2 Restricted Log Likelihood = 933.17. There was a significant linear relationship between time and weekly weight gain ($p < .001$), indicating that, across prescription plans, patients gained at a higher rate each consecutive week over the first four weeks of weight restoration.

A significant interaction was noted between prescription plan and quadratic time ($p = .03$). Analysis of simple slopes revealed that for individuals receiving the standardized caloric prescription plan there was a significant linear relationship of time to weekly rate of weight

gain, $b = .65$, $SE = .17$, $p < .001$, and a significant quadratic relationship of time to weekly rate of weight gain, $b = .74$, $SE = .35$, $p = .04$. For individuals receiving the individualized caloric prescription plan, a trend was noted for a linear relationship of time on weekly rate of weight gain, $b = .28$, $SE = .15$, $p = .06$, but not for the quadratic relationship of time, $b = -.31$, $SE = .32$, $p = .33$. As highlighted in Figure 1, the results suggests a curvilinear relationship between rate of weight gain and time for individuals receiving standardized caloric increases, with average weekly weight gain increasing to a peak in the third week of inpatient hospitalization (weight gain of approximately 4.5 lbs. during this week) before stabilizing. On the other hand, weekly weight gain trended towards increasing in a linear fashion for individuals receiving individualized caloric increases.

Cumulative weekly weight gain—The information criteria for this model were as follows: AIC = 926.52, BIC = 947.96, and -2 Restricted Log Likelihood = 916.52. There was a significant linear relationship between time and cumulative weight gain ($p < .001$), indicating that, across prescription plans, patients' cumulative amount of weight gain increased over time in a relatively consistent manner.

A significant interaction was noted between prescription plan and linear time ($p < .001$). Analysis of simple slopes again revealed that, though patients under both plans accumulated total weight gain in a linear fashion over time, individuals receiving the standardized plan gained at a faster rate within the first four weeks of treatment (i.e., more cumulative weight over time), $b = 4.21$, $SE = .17$, $p < .001$, compared to those receiving individualized increases, $b = 3.33$, $SE = .15$, $p < .001$. As highlighted in Figure 2, the results suggest that, over the course of the four weeks of treatment, individuals receiving standardized treatment increasingly gained a greater cumulative amount of weight than those in the standardized group. This more rapid rate of weight gain resulted in a maximum difference of approximately two pounds more weight gained in the standardized group compared to the individualized group after four weeks of treatment.

Secondary Analyses: Regression Analyses Comparing Other Outcomes Related to Weight Restoration

Medical providers did not note any cases of refeeding syndrome requiring transfer to medical care under either caloric prescription plan. Caloric prescription plan did not significantly affect time to weight restoration ($\beta = 0.05$, $SE = 3.24$, $p = .63$), length of hospitalization ($\beta = 0.11$, $SE = 0.03$, $p = .50$), maximum caloric prescription ($\beta = 0.16$, $SE = 135.53$, $p = .23$), or discharge BMI ($\beta = -0.03$, $SE = 0.25$, $p = .85$), or chance of edema, $Wald \chi^2(1) = 1.12$, $p = .27$. However, caloric prescription plan was significantly associated with lower incidence of activity restriction, $Wald \chi^2(1) = 4.59$, $p = .03$. While 95% of the patients ($n = 19$) receiving individualized caloric increases required activity restriction over the course of weight restoration, only 65% ($n = 13$) of those receiving standardized increases required activity restriction.

In terms of covariates, admission BMI significantly predicted time to weight restoration ($\beta = -0.79$, $SE = 1.09$, $p < .001$), maximum caloric prescription ($\beta = -0.73$, $SE = 45.74$, $p < .001$), length of hospitalization ($\beta = -0.58$, $SE = 0.01$, $p = .002$), and incidence of activity

restriction ($Wald \chi^2 (1) = 5.38, SE = .68, p = .02$). Individuals admitted at lower BMIs required more time, higher caloric prescriptions, and more frequent activity restriction to assist with weight restoration and, as a result, had longer hospitalizations. Highest lifetime BMI predicted maximum caloric prescription ($\beta = 0.33, SE = 22.36, p = .02$) and risk of edema ($Wald \chi^2 (1) = 4.07, SE = .40, p = .04$). Patients with higher lifetime maximum BMIs required higher caloric prescriptions to reach weight restoration and were at greater risk of developing edema.

Discussion

In this study, we compared the effects of individualized and standardized management of caloric prescription increases on outcomes for individuals with AN undergoing weight restoration on an inpatient eating disorder unit. The primary aim of this study was to examine the effects of these different caloric prescription plans on the rate, pattern, and cumulative amount of weekly weight gain during the first four weeks of inpatient treatment. Results indicated that caloric prescription did not affect average rate of weight gain, but did affect the pattern of early weight gain. Consequently, caloric prescription affected the cumulative amount of weight gain over the first four weeks of inpatient treatment. Patients receiving standardized increases gained weight in a curvilinear pattern, with rate of weight gain increasing weekly until reaching a maximum of approximately 4.5 lbs./week in the third week of hospitalization, at which point rate of weight gain began to stabilize. The standardized prescription plan was predicated on “stacking” caloric increases within the second and third week of treatment, thus it is unsurprising that rate of weight gain increased over these weeks and reached a peak following the final caloric increase on day seventeen of treatment. Patients receiving individualized increases, on the other hand, gained in a fairly uniform manner, trending towards a very gradual increase in rate of weekly weight gain to a maximum of approximately 3.5 lbs./week in the fourth week of hospitalization. As a result of the more accelerated curvilinear pattern of weight gain, patients receiving the standardized plan gained a greater cumulative amount of weight over time, ultimately gaining two pounds more than those under the individualized plan by the end of the fourth week of treatment.

There are important implications related to this difference in the early pattern and cumulative amount of weight between plans. Changes in managed care over the past thirty years have drastically altered the inpatient treatment of eating disorders. Currently, the average length of inpatient treatment for AN approved by insurance carriers is approximately 21 to 24 days, (21, 22). This brief length of stay is concerning when considering findings that insufficient weight restoration during inpatient treatment places individuals with AN at increased risk of relapse (23). Thus, a caloric prescription plan that promotes a more rapid weight gain within the first four weeks of inpatient treatment, such as the standardized caloric prescription plan utilized in this study, may be better suited to compensate for the limitations imposed by managed care. In this study, individuals receiving standardized caloric increases gained only a modest amount more weight over the first month of treatment compared to those receiving individualized increases (i.e., approximately two pounds more); however, there is evidence that even small differences in weight restoration can impact vulnerability to relapse from AN (23). Thus, these findings suggest

the utility of continuing to investigate the clinical implications of utilizing standardized caloric increases during early weight restoration.

As a secondary aim of this study, we examined the effects of the different caloric prescription plans on a number of other outcome variables of interest in weight restoration. Results indicated that time to weight restoration, length of hospitalization, maximum caloric prescription, and discharge BMI did not vary as a function of caloric prescription plan. While these negative findings could be considered to contradict the idea that standardized caloric increase plans support more accelerated weight gain, the context of the study environment is important to consider when interpreting these results. This study used clinical data from a state-funded inpatient research facility, which, unlike the average “real-world” eating disorder service, was unlimited by insurance restrictions and, thereby, able to keep patients in hospital until they achieved weight restoration and initial weight maintenance. In this sample, the average time to weight restoration was 41 days, which was nearly four weeks beyond the final standardized caloric increase. After the standardized increases were completed on the seventeenth day of inpatient treatment, the prescription plans did not differ in the method of subsequent caloric increases; under both plans, caloric increases were individualized after this point. Thus, the impact of the standardized increases on rate and amount of weight gain was diluted over the full hospital stay. However, for the average inpatient eating disorder service in which average length of stay is three to four weeks, the findings pertaining early weight response are of critical importance, whereas results pertaining to longer-term inpatient variables may be less relevant.

Although laboratory data examining important indices related to refeeding syndrome (e.g., hypophosphatemia, hypomagnesemia, and hypokalemia) were not available for review, there were no differences in the rate of edema and no severe cases of refeeding syndrome that required transfer to medical units in either group, providing some early indication that the standardized increases could be conducted without major physiological consequences. Importantly, the data demonstrated that the use of a standardized caloric increase plan eliminated the need for activity restriction for approximately one third of patients. While 95% of patients required activity restriction under the individualized plan, only 65% required activity restriction under the standardized plan. This reduction in need for activity restriction offers a distinct advantage of the standardized caloric prescription plan, as activity restriction is often experienced by patients as punitive and by staff as burdensome to enforce as it requires a higher level of nursing observation and is more costly. While certain programs restrict activity level in a uniform manner, those programs for which activity level is contingent upon weight progression stand to benefit from the reduced need for activity restriction associated with standardized caloric increases.

There were other findings from this study that, though not the primary focus of investigation, offer insight into clinical variables associated with different experiences of weight restoration among individuals with AN. Unsurprisingly, lower admission BMI was significantly associated with longer length of time, higher caloric requirements, and greater necessity of activity restriction in order to reach weight restoration, as well as longer length of inpatient treatment. This suggests the utility of encouraging patients present for inpatient treatment before BMI drops too low, in order to promote a less burdensome process of

weight restoration. Additionally, higher lifetime maximum BMI was significantly associated with higher caloric requirements to reach weight restoration and greater chance of developing edema. This is likely reflective of the effects of weight suppression (i.e., the difference between lifetime highest weight and current weight), which was highly correlated with maximum lifetime BMI in this sample ($r = .88, p < .001$). Previous studies have found higher weight suppression to be associated with greater clinical severity, faster rate of weight gain, and greater overall weight gain among individuals with AN (24, 25). The current study adds to the growing literature suggesting that weight suppression affects clinical and weight gain outcomes among individuals with eating disorders.

There are several additional limitations to this study. The study is based on a retrospective chart review; therefore, patients were not randomized to their respective caloric prescription plans. A randomized, controlled trial comparing the relative efficacy and safety of standardized and individualized caloric prescription plans would be helpful in more definitely establishing the effects of different caloric increase plans on weight-related outcomes. The research team also did not have access to information regarding the incidence of hypophosphatemia, hypomagnesaemia, and hypokalemia, which are important to the assessment of refeeding risk. However, several recent publications suggest that admission BMI, rather than rate of refeeding, is most closely linked to risk of hypophosphatemia (11, 13). Nonetheless, future work should examine these laboratory parameters among individuals receiving standardized increases. Finally, this study was conducted with adult patients on a research-based inpatient unit; therefore, it is possible that the results may not generalize to adolescent samples or other treatment settings. Related, on both the caloric plans described in this paper, patients were held stable for the first week of treatment on 1,800 kcal/day before caloric increases commenced. Such a stabilization period may not be feasible on a unit with stricter time limitations. Further research is needed to determine the effects of standardized caloric prescriptions among diverse clinical populations and inpatient environments.

The results of this research, along with other recent studies (12, 13), challenge the traditional perspective that has discouraged rapid advancement of caloric prescriptions during nutritional rehabilitation of AN. Though caloric prescriptions under the standardized plan were increased rapidly ($> 1,000$ kcal increase within ten days), there were no cases of refeeding syndrome that required transfer to medical care, and there were advantages associated with this approach. Standardized caloric increases resulted in a more accelerated pattern of early weight gain, greater cumulative weight gain over the first month of inpatient treatment, and reduced need for aversive consequences associated with insufficient weight gain, such as bed rest and other activity restriction. Thus, despite historical concerns, this study adds to the recent literature that suggests that more aggressive refeeding programs may be well tolerated and perhaps advantageous and indicates a need for further studies examining standardized approaches to caloric increases.

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Figure 1.

Average weekly rate of weight gain by caloric prescription plan over the first four weeks of nutritional rehabilitation for inpatients with anorexia nervosa (n = 70)

Note: Error bars represent standard error of the mean

Figure 2.

Cumulative weekly weight gain by caloric prescription plan over the first four weeks of nutritional rehabilitation for inpatients with anorexia nervosa (n = 70)

Note: Error bars represent standard error of the mean

Comparison of demographic and clinical variables between AN patients receiving individualized (n = 35) and standardized (n = 35) caloric prescription plans

Table 1

Dependent Variable	Individualized caloric prescription plan group (n = 35) Mean (SD)	Standardized caloric prescription plan group (n = 35) Mean (SD)	df	t / χ^2	p	Cohen's d
Age (years)	24.51 (7.51)	26.34 (6.46)	68	1.09	0.28	0.26
Length of illness (years)	8.28 (7.30)	7.16 (6.40)	68	-0.68	0.50	0.16
Admission BMI (kg/m ²)	15.84 (1.39)	15.97 (2.00)	68	0.32	0.75	0.08
Highest lifetime BMI (kg/m ²)	22.19 (3.37)	22.86 (2.89)	68	0.89	0.38	0.21
AN subtype (% restricting subtype)	48.57%	25.71%	1	3.92	0.08	-----

Note: BMI = Body mass index; AN = anorexia nervosa

Table 2

Caloric increase schedule for the standardized caloric prescription plan

Days since admission	Food prescription (kcal)	Liquid supplement (Ensure Plus ®) prescription (kcal)	Total prescription (kcal)
0	1800	0	1800
7	2200	0	2200
9	2200	350	2550
12	2600	350	2950
15	2600	700	3300
17	3000	700	3700

Note: kcal = kilocalorie

Table 3

Multilevel regression model predicting weekly weight gain over the first four weeks of inpatient weight restoration for AN patients receiving standardized (n = 35) versus individualized (n = 35) caloric prescription plans

Dependent variable	Independent variables	Estimate	SE	df	t	p
Average weekly weight gain	Intercept	2.86	0.22	54.11	15.37	<.001**
	Time (linear)	0.28	0.15	94.12	1.88	<.001**
	Time (quadratic)	-0.31	0.32	152.09	-0.97	0.37
	Caloric prescription plan	0.44	0.26	59.64	1.69	0.10
	Highest lifetime BMI	0.02	0.04	52.10	0.60	0.55
	AN subtype	0.45	0.26	52.65	-1.72	0.09
	Caloric prescription plan * Time (linear)	0.37	0.22	101.12	1.62	0.11
	Caloric prescription plan * Time (quadratic)	1.05	0.48	155.28	2.20	0.03*
Cumulative weekly weight gain	Intercept	8.74	0.86	51.66	10.20	<.001**
	Time (linear)	3.33	0.15	93.73	22.71	<.001**
	Time (quadratic)	-0.30	0.30	129.76	-1.01	0.313
	Caloric prescription plan	0.73	1.01	52.39	0.73	0.470
	Highest lifetime BMI	0.01	0.16	51.27	0.08	0.93
	AN subtype	-1.46	1.08	51.24	-1.36	0.18
	Caloric prescription plan * Time (linear)	0.88	0.22	98.28	3.94	<.001**
	Caloric prescription plan * Time (quadratic)	0.07	0.44	127.63	0.16	0.87

* p < .05,

** p < .001

Note: kcal = kilocalorie; AN = anorexia nervosa