HHS Public Access

Author manuscript

Appetite. Author manuscript; available in PMC 2020 August 01.

Published in final edited form as:

Appetite. 2019 August 01; 139: 35–41. doi:10.1016/j.appet.2019.04.008.

Fat Preference and Fat Intake in Individuals with and without Anorexia Nervosa

Janet E. Schebendach, PhD, RD[1,2], **Blair Uniacke, MD**[1,2], **B. Timothy Walsh, MD**[1,2], **Laurel E.S. Mayer, MD**[1,2], **Evelyn Attia, MD**[1,2], and **Joanna Steinglass, MD**[1,2]

[1]Department of Psychiatry, Columbia University Irving Medical Center, NY, NY

[2]Department of Psychiatry, New York State Psychiatric Institute, NY, NY

Abstract

Fat restriction is a characteristic eating behavior among individuals with anorexia nervosa (AN), and laboratory meal studies demonstrate restricted fat intake among low-weight patients. The Geiselman Food Preference Questionnaire-I© (FPQ) is a validated self-report measure that yields a fat preference score (FPS). Prior research reported that patients with AN had a significantly lower FPS than did healthy control (HC) participants. The goal of the current study was to compare self-reported fat preference (FPS) to fat intake (multi-item meal (MIM) study) in low-weight ANs and HCs. Specific aims were 1) to determine if the FPS differed between ANs and HCs; 2) to determine if fat and energy intakes differed between ANs and HCs; and 3) to determine if the FPS was associated with fat and energy intakes in ANs and HCs. Forty-four female AN inpatients and 48 female HCs completed the FPQ and participated in a MIM study. Compared to HCs, ANs consumed less energy (469.1 ± 397.7 vs. 856.4 ± 346.8 kcal, $p<0.001$), less fat (16.4 ± 20.4 vs. 36.7 ± 18.9 g, $p<0.001$), and a smaller percentage of calories from fat (22.9 ± 13.8 vs. 36.6 ± 8.0%, $p<0.001$) at the MIM. Compared to HCs, ANs also had a lower FPS (79.7 ± 27.4 vs. 102.3 ± 18.9, $p<0.001$). The FPS was significantly and positively correlated with caloric intake ($r=0.481$, $p<0.01$), total fat ($r=0.453$, $p<0.01$), and the percentage of calories from fat ($r=0.37$, $p<0.05$) in ANs as well as in HCs (kcal: $r=0.583$, $p<0.001$; fat: $r=0.621$, $p<0.001$; % fat kcal: $r=0.601$, $p<0.001$). The FPS is related to objective measures of energy and fat intake in patients with AN as well as in healthy individuals.

Corresponding author: J. Schebendach PhD, RD, New York State Psychiatric Institute, 1051 Riverside Drive, Unit 98, New York, NY 10032, js2202@cumc.columbia.edu,Tele: 646-774-8014, Fax: 646-774-5854.

Statement of Authorship

Conception and study design: Schebendach, Uniacke, Steinglass, Walsh, Mayer, Attia,

Acquisition of data: Schebendach, Steinglass

Analysis and interpretation of data: Schebendach, Steinglass, Walsh, Mayer

Drafting of manuscript: Schebendach, Uniacke, Walsh, Steinglass

Critical revision of manuscript for intellectual content: Schebendach, Uniacke, Mayer, Walsh, Attia, Steinglass

Final approval of submitted manuscript: Schebendach, Uniacke, Mayer, Attia, Walsh, Steinglass.

Conflict of Interest

J. Steinglass receives royalties from UpToDate. Other co-authors have no conflict of interest, financial or otherwise, related to this study or the submitted manuscript.

Keywords

Anorexia nervosa; Geiselman Food Preference Questionnaire-I©; fat preference score (FPS); multi-item meal (MIM); fat intake; energy intake; Eating Disorder Examination Questionnaire (EDE-Q)

INTRODUCTION

Anorexia nervosa (AN) is a serious psychiatric illness associated with significant morbidity (American Association, 2013) and a mortality rate that is among the highest for psychiatric illnesses (Arcelus, Mitchell, Wales, & Nielsen, 2011). AN is characterized by low body weight and malnutrition (American Association, 2013). Specialized treatment programs are largely successful at nutritional rehabilitation and weight restoration (Attia & Walsh, 2009); however, risk of relapse is high within the first year following treatment (Khalsa, Portnoff, McCurdy-McKinnon D, Feusner, 2017). Thus, sustaining improvement in dietary intake is difficult for many individuals with this disorder.

Dietary fat restriction is a characteristic eating behavior that contributes to the energy deficit in individuals with AN (Walsh, 2011). This behavior has been observed and quantified during laboratory meal studies (Hadigan et al., 2000; Mayer, Schebendach, Bodell, Shingleton, & Walsh, 2012). Meal studies are, however, expensive and labor intensive, both in preparation and deliverance (Sysko, Steinglass, Schebendach, Mayer, & Walsh, 2018), so while these studies are informative in research settings, their utility in clinical settings is limited.

The Geiselman Food Preference Questionnaire-I© (FPQ) is an easily completed and quickly scored self-report measure that yields a fat preference score (FPS) (Geiselman et al., 1998). The FPQ was initially validated in adult males who completed both the FPQ and a multi-item laboratory meal study. Results indicated that the FPS was significantly and positively correlated with energy (r=0.70, p<0.003) and fat intake (r=0.86, p<0.003) at the laboratory meal.

In a prior study, we reported that patients with AN had significantly lower FPSs than did healthy individuals (Schebendach et al., 2017); however, scores were not compared to food intake in these participants. The primary goal of the current study was to compare self-reported fat preference (FPS) to observed and measured food intake (laboratory MIM study) among low-weight patients with AN and healthy control participants (HCs).

The present study included meal study data from two previously published studies (Foerde, Steinglass, Shohamy, & Walsh, 2015; Steinglass et al., 2018) and one ongoing study conducted at the New York State Psychiatric Institute (NYSPI). FPQ data from 3 AN participants and 10 HCs were previously reported (Schebendach et al., 2017).

The specific aims were 1) to determine if the FPS differed between ANs and HCs, and 2) to determine if fat intake differed between ANs and HCs; these aims have been addressed in prior studies and the current study serves to replicate and extend those findings. Specific aim

3, to determine if the FPS was associated with energy (kcal) and fat intakes in ANs and HCs, has not, to our knowledge, been demonstrated in females with and without AN.

The Eating Disorder Examination Questionnaire (EDE-Q) (Fairburn CG, 2008) is administered during routine assessment of patients and healthy controls at the NYSPI Eating Disorders Research Unit. The EDE-Q scores include a global score and four subscale scores (Restraint, Eating Concern, Weight Concern, Shape Concern). Assuming that EDE-Q scores relate in some way to food intake in AN, we secondarily investigated 1) the relation between EDE-Q global and subscale scores and MIM intake in AN and HC participants, and 2) the relation between EDE-Q global and subscale scores and the FPS in AN and HC participants.

MATERIALS AND METHODS

Participants

Patients were females between the ages of 16 and 48 years who met the criteria for AN according to the *Diagnostic and Statistical Manual of Mental Disorders, 5th Edition* (DSM-5) (American Association, 2013) at the time of admission. Diagnosis of AN subtype was made by the Eating Disorder Assessment for DSM-5 (Glasofer DR, 2016) or the Eating Disorder Examination (Fairburn CG, 2008). All were hospitalized at the NYSPI for inpatient treatment that included weight restoration to a BMI approximately equal to 20 kg/m^2. Healthy normal weight controls were females between the ages of 16 and 48 years with a BMI of 18–25 kg/m^2 and no past or present psychiatric illness, including any history of an eating disorder. Additional exclusion criteria for HCs were significant medical illness and current psychotropic medications. All studies were approved by the NYSPI Institutional Review Board. Written informed consent was obtained prior to participation.

Geiselman Food Preference Questionnaire-I© (FPQ)

Participants completed the FPQ within the first week of hospital admission (for AN) or at the time of screening (for HC). The FPQ assesses preference from three high fat food groups (high fat/high sugar, high fat/high complex carbohydrate, high fat/high protein) and three low fat food groups (low fat/high sugar, low fat/high complex carbohydrate, low fat/high protein). High fat foods contain > 45% fat calories and low fat foods contain < 20% fat calories. Twelve foods are included in each of the six food groups, for a total of 72 foods listed in intermixed order on the questionnaire. Respondents are asked to rate how much they like each of the 72 foods on a 9-point Likert scale (1 = *dislike extremely*, 5 = *neutral*, 9 = *like extremely*; no rating is assigned to foods endorsed as "*don't know/never tasted before*"). The FPQ was scored according to the method of Geiselman (Geiselman et al., 1998) to yield a fat preference score (FPS). A FPS > 100 indicates high fat preference and a FPS < 100 indicates low fat preference. In addition to the FPS, completed FPQs were reviewed to determine the total number of rated foods (i.e., food rated between 1 and 9), the total number of unrated foods (i.e., "*don't know/never tasted before*"), and the total number of disliked foods (i.e., food rated < 5). The FPQ and meal study were not completed on the same day.

Laboratory Meal Study (Sysko et al., 2018)

Laboratory MIM studies were conducted on the Biological Studies Unit at the NYSPI. Participants ate a standardized breakfast of ~300 kcal at ~8 am on the morning of the study. Thereafter, participants refrained from eating and drinking, water excepted, until the test meal at ~1 pm. Patients with AN completed the MIM study within the first week of hospitalization.

The MIM included a range of foods of varying energy and fat content, including items like grilled chicken, fried chicken, macaroni and cheese, tuna, American cheese, turkey breast, pickles, French fries, tossed salad, Oreo® cookies, chocolate candy (M&Ms® or Hershey® bar), vanilla ice cream, donuts or Munchkins®, popcorn, fresh fruit salad, whole wheat bread, white bread, butter, mustard, mayonnaise, ketchup, Italian salad dressing, salt, pepper, bottled water, Diet Coke®, and Snapple® iced tea (specific foods available varied slightly across studies). Participants had up to 60 minutes to complete the meal; they were instructed: “This is your lunch for the day. Eat as much or as little as you would like.” Participants were alone in the room during the meal study but were continuously monitored via a one-way, closed circuit TV.

Food and beverage items were weighed before and after the meal on a Sartorius 8200 electronic balance (readability 0.1g). Nutrient analysis software (University of Minnesota Nutrition Data System for Research, Regents of the University of Minnesota, Nutrition Coordinating Center, version 2009) was used to determine intakes of energy (kcal), carbohydrate (g), protein (g), fat (g), and weight (in g) of consumed foods and beverages; Atwater factors (4 kcal/g of carbohydrate, 4 kcal/g of protein, 9 kcal/g fat) were applied to determine the percentage of energy provided by each macronutrient. Intake data were also analyzed for energy density and diet variety. The diet energy density score (DEDS) is defined as caloric intake (kcal) divided by the total weight (in g) of food and beverages consumed; the diet variety score (DVS) is defined as the number of unique calorie-containing foods and beverages consumed divided by the total number of calorie-containing foods and beverages served (Schebendach et al., 2008).

Eating Disorder Examination Questionnaire (Fairburn CG, 2008)

The Eating Disorders Examination Questionnaire (EDE-Q) was administered to patients during the first week of hospitalization and to HCs at the screening visit. The EDE-Q is a 36-item self-report measure of eating disorder symptoms. The EDE-Q scores four symptom subscales on a scale of 0–6: Restraint, Eating Concern, Shape Concern, and Weight Concern. The subscale scores are averaged to obtain the EDE-Q global score. The EDE-Q has established community norms for adolescents (Carter, Stewart, & Fairburn, 2001) and adults (Mond, Hay, Rodgers, & Owen, 2006).

Statistical Analysis

The independent samples *t* test was used to compare clinical characteristics, EDE-Q scores, FPQ measures, and MIM nutrient intakes between AN and HC participants, and between patients with AN restricting (AN-R) and AN binge eating/purging (AN-BP) subtypes. A chi-

square test of independence was also calculated to compare low fat preference (FPS < 100) and high fat preference (FPS > 100) in the AN and HC groups.

A significant difference in age was found between the AN and HC groups. To determine if age difference impacted results, linear regression models were constructed with age and FPS entered as independent variables, and energy (kcal), carbohydrate (g), protein (g), fat (g), the percentage of kcal from carbohydrate, protein and fat, DEDS, and DVS entered as dependent variables within the participant groups.

Pearson correlation coefficients were calculated within the AN and HC groups to determine associations between: 1) the FPS and nutrient intake; 2) the FPS and diet energy density (DEDS); 3) the number of disliked foods on the FPQ and diet variety (DVS); 4) EDE-Q scores and nutrient intake, DEDS, and DVS; and 5) EDE-Q scores and the FPS.

In the AN group, two multiple linear regressions were conducted. In model 1, the independent variables were the FPS and EDE-Q Restraint score, and the dependent variable was energy (kcal) intake at the MIM. In model 2, the independent variables were the FPS and EDE-Q Restraint score, and the dependent variable was fat (g) intake at the MIM.

Analyses were performed using IBM SPSS® Statistics 24 for WINDOWS software. Means +/− SDs are reported; *t* tests were 2-tailed. Statistical significance was set at $p < 0.05$. Effect size was calculated using Cohen's *d*.

RESULTS

Forty-four patients with AN and 48 HCs were included in the study. Three additional patients with AN that had an energy intake greater than three SD above the mean were deemed outliers, reflecting that these patients had likely engaged in binge eating; these data were removed from the data set and subsequent statistical analyses. Of the 44 patients, 23 met criteria for AN-R, and 21 met criteria for AN-BP.

Clinical characteristics are presented in Table 1. As expected, mean BMI was significantly lower in ANs than HCs, but did not differ between AN subtypes. Although patients with AN were older than HCs, linear regression analyses indicated that age was not significantly related to study findings (data not shown).

Fat preference scores (FPS) and food group hedonic ratings are presented in Table 2. A significant difference in the FPS was found between participant groups, with ANs having a lower mean score and HCs having a higher mean score. The mean hedonic ratings of the three high fat food groups were significantly lower in patients vs. HCs. A hedonic rating < 5 indicates a disliked food and a rating > 5 indicates a liked food. Among ANs, all three high fat food groups were rated < 5 (disliked); in HCs, all three high fat food groups were rated > 5 (liked). The mean hedonic rating of the three low fat food groups was also significantly lower in patients, and only one low fat food group (low fat/high sugar) was similarly rated and liked by both AN and HC participants. The participant groups hedonically rated a similar number of food items on the FPQ; however, the number of disliked foods (hedonic rating < 5) in patients was almost double that of HCs. AN subtypes did not differ on fat

preference scores, food group hedonic ratings, the number of foods rated, and the number of disliked foods.

Participants were categorized as having a preference for low fat foods (FPS < 100) vs. high fat foods (FPS > 100) according to the method of Geiselman (Geiselman et al., 1998). Within the AN group, 84.1% preferred low fat foods and 15.9% preferred high fat foods; within the HC group, 35.4% preferred low fat foods and 64.6% preferred high fat foods. Among study participants, preference for high fat vs. low fat foods was significantly associated with diagnostic group ($X^2(1) = 20.471$, $p < 0.001$).

Total energy, macronutrient intake, the percentage of energy provided by macronutrients, DEDS, and DVS at the meal are presented in Table 3. Compared with the HC group, the AN group consumed significantly less energy and fewer grams of carbohydrate, protein, and fat. The AN group consumed a significantly higher percentage of kcal from carbohydrate and a significantly lower percentage of kcal from fat than did the HC group; however, no significant between-group difference in the percentage of kcal derived from protein was observed. The between-group difference in both the mean DEDS and DVS was significant, with lower scores observed the AN group and higher scores in the HC group. No significant differences in nutrient intake were found between the AN subtypes.

Associations between fat preference (FPS) and nutrient intake (MIM) were examined. In both the AN (Table 4) and HC (Table 5) groups, the FPS was significantly and positively correlated with energy, energy density (DEDS), total carbohydrate, protein, and fat intakes, and the percentage of energy from fat at the MIM.

One may presume that people eat a greater variety of foods when they like more foods, and eat less variety when they like fewer foods; therefore, the number of disliked foods (hedonic rating < 5) on the FPQ was compared to the DVS at the meal. As expected, ANs endorsed a significantly greater number of disliked foods on the FPQ than did HCs (Table 2). Likewise, ANs had a significantly lower DVS at the meal than did HCs (Table 3). In both the AN (Table 4) and HC (Table 5) groups, the DVS (meal) and the number of disliked foods (FPQ) were significantly and negatively correlated, meaning that individuals who self-reported a greater number of disliked foods also consumed less variety at the MIM study.

Significant differences in EDE-Q scores (global and subscales) were found between the AN and HC groups (Table 1). Within the AN group (Table 4), kcal intake was significantly and negatively correlated with the global score and two subscale scores (Restraint and Weight Concern), and total fat (g) intake and the percentage of kcal from fat, were significantly and negatively correlated with the global score and three subscale scores (Restraint, Weight Concern, Shape Concern). In the HC group (where the range of scores was narrow), no significant associations were found between EDE-Q measures and MIM intake (Table 5).

Among patients with AN, the FPS, EDE-Q global score, and EDE-Q Restraint score were significantly correlated with kcal, fat, and percentage of kcal from fat at the MIM (Table 4). The EDE-Q global score is the average of the subscale scores. Because two subscale scores (Eating Concern and Shape Concern) failed to significantly correlate with kcal intake, and one subscale score (Eating Concern) failed to significantly correlate with fat (g) intake, the

Restraint subscale score, rather than the global score, was selected as an independent variable in both regression models. Since no significant correlations were found between the FPS and any EDE-Q measure in the AN group (Eating Concern: $r = 0.013$; Restraint: $r = -0.044$; Weight Concern: $r = 0.007$; Shape Concern: $r = -0.033$), both the FPS and Restraint score were entered as independent variables in the two regression models.

In model 1, constructed to predict kcal intake from the FPS and Restraint score, a significant regression equation was found ($F(2,41)=10.532$, $p<0.001$; $R^2=0.339$) with the FPS being a significant positive predictor (*Beta*= 0.466, $t=3.67$, $p=0.001$) and the Restraint score a significant negative predictor (*Beta*= −0.329, $t=2.592$, $p=0.013$) of kcal intake at the MIM. In model 2, constructed to predict fat intake from the FPS and Restraint score, a significant regression equation was also found ($F(2,41)=9.44$, $p<0.001$; $R^2=0.315$) with the FPS being a significant positive predictor (*Beta*= 0.438, $t=3.39$, $p=0.002$) and the Restraint score a significant negative predictor (*Beta*= −0.332, $t=-2.567$, $p=0.014$) of fat intake at the MIM.

DISCUSSION

The current study compared self-reported fat preference (FPS) to observed and measured fat intake (MIM study) in low-weight female patients with AN and healthy individuals. Fat preference and fat intake differed between the AN and HC groups, and fat preference was associated with fat intake in both the AN and HC groups.

In the current study, patients with AN consumed fewer kcal and a lower percentage of fat kcal at the MIM than did HCs (22.9% vs. 36.6%, respectively). Using a similar meal paradigm, Mayer (Mayer et al. 2012) also reported that 18 low-weight AN patients consumed fewer kcal and a lower percentage of kcal from fat than did 14 HCs (18% vs.38%, respectively). Likewise, a 1-day observed and estimated food intake study conducted by Hadigan (Hadigan et al., 2000) reported that 30 low-weight patients with AN consumed fewer kcal and a lower percentage of fat kcal compared to 28 healthy individuals (17.6% vs. 28.4%, respectively). Although absolute nutrient intakes differed across these studies, patients with AN consistently consumed fewer kcal and a lower percentage of kcal from fat compared to healthy individuals

The utility of the FPQ has been demonstrated in studies of healthy (King et al., 2018) and obese (McVay et al., 2014; Yancy Jr et al., 2013) individuals; however, self-reported fat preference on the FPQ was compared to measured food intake in only one study of nine healthy adult males (Geiselman et al., 1998). The current study compared self-reported fat preference (FPS) to fat intake (MIMS) in large samples of healthy females and low-weight patients with AN. Despite differences in sample size, gender, and weight status of participants, both Geiselman's study (Geiselman et al., 1998) and the current study had similar findings: self-reported fat preference (FPS) was significantly and positively associated with kcal intake and the percentage of kcal from fat consumed during a laboratory MIM study.

Diet energy density is substantially influenced by fat consumption (Rolls, 2009). Assuming that greater fat preference results in greater fat intake and a higher DEDS, correlations

between the FPS and DEDS were determined. As expected, a significant positive association between the FPS and DEDS were found in both participant groups. Prior studies suggest that decreased energy density is associated with poor clinical outcome in weight-restored patients with AN (Schebendach et al., 2008; Schebendach et al., 2012). Calculation of diet energy density requires nutrient analysis of dietary intake, which is a labor intensive process. Results of the current study suggest that the FPS may be a useful metric for the assessment of diet energy density in patients with AN, as well as healthy individuals.

Greater variety in the diet is associated with greater food intake (McCrory, Burke, & Roberts, 2012), whereas restricted diet variety is likely to result in less food intake and possible weight loss (Raynor, 2012). Clinical observation suggests that patients with AN eat a relatively limited variety of foods (Schebendach et al., 2011). Research findings suggest that limited diet variety is associated with poor clinical outcome in weight-restored patients with AN (Schebendach et al., 2008; Schebendach et al., 2012). In both the current study and Mayer study (Mayer et al., 2012), AN patients chose less variety at the MIM study than did healthy normal-weight participants. In the current study, participants who selected less variety at the meal also reported a greater number of disliked foods on the FPQ, suggesting that the FPQ may be a useful metric for the assessment of diet variety in individuals with and without AN.

In the current study, the FPS and the EDE-Q global and EDE-Q Restraint scores were associated with energy and fat intakes at the MIM in patients with AN. That the FPS and EDE-Q measures failed to correlate with each other suggests that the Geiselman FPQ and the EDE-Q capture different aspects of eating behavior in patients with AN. For example, the restraint subscale asks more generalized questions about restraint (“Have you been deliberately trying to limit the amount of food you eat…”), food avoidance (“Have you tried to exclude from your diet any foods that you like…”), and dietary rules (“Have you tried to follow definite rules regarding your eating, for example, a calorie limit…” In contrast, the FPQ simply asks the respondent to indicate, at this moment, how much they like or dislike specific high fat and low fat foods. It is possible that the EDE-Q identifies clinical issues (restraint, eating concern, weight concern, shape concern) that impact food choice, while the FPQ identifies the specifics of food choice. An alternative interpretation of the non-significant finding between EDEQ scores and FPS is that while lower fat preference may be a factor that distinguishes people with vs. without AN, fat preference may not be related to severity among those with AN.

Study Limitations

The current study provides novel information about the relation between self-reported fat preference and laboratory meal intake in individuals with and without AN; however, several limitations must be considered in the interpretation of these findings. First, the Geiselman FPQ-I© was validated in healthy adult males (Geiselman et al., 1998) and we studied exclusively females. Second, this study was conducted in low-weight patients with AN and it is unknown whether this relationship extends to weight-restored patients, or individuals with other DSM-5 eating disorder diagnoses, i.e., atypical AN, bulimia nervosa, and binge eating disorder. Third, three patients with AN were under the age of 18 years; further study

is needed to determine if the FPQ is useful in adolescents with and without an eating disorder. Fourth, this study was performed in an inpatient AN population undergoing meal based behavioral refeeding. Replication in an outpatient population would be useful to generalizing results e.g. applicability in outpatient laboratory meal studies. Finally, the FPQ includes several foods (i.e., leeks, parsnips, red snapper) that were endorsed as “don’t know, never tasted before” by individuals in both participant groups. A revised version of the questionnaire that includes fewer regional and more “generic” food items is now available.

Conclusion

Persistent avoidance of dietary fat is a characteristic eating behavior among individuals with AN. Although structured treatment programs are largely successful at restoring weight and getting patients to eat during treatment, restricted intake often recurs after the patient returns to the home environment. Laboratory meals document objective abnormalities in the eating behavior of patients with AN. The Geiselman Food Preference Questionnaire-I© is a quickly administered and easily scored self-report measure that may be a good and flexible way to capture eating behavior. Results of this study indicate that the fat preference score is associated with observed and measured intake of kcal, fat, and percentage of kcal from fat, as well diet energy density and diet variety, in low-weight females with AN. Further study is needed to determine if this relationship is maintained after weight restoration, and if it extends to individuals with other DSM-5 eating disorder diagnoses.

Acknowledgements

Authors acknowledge and thank the patients and staff of the Eating Disorders Research Unit, and the Biological Studies Unit at the New York State Psychiatric Institute, Columbia University Irving Medical Center.

Funding/Support:

National Institute of Mental Health (RO1MH105452), 2015, PI: J. Steinglass National Institute of Mental Health (RO1 MH079397), 2008, PI: B.T. Walsh The Irving Institute for Clinical and Translational Research at Columbia University Medical Center, 2015, PI:J. Steinglass

The Hilda and Preston Davis Foundation, PI: J. Steinglass

The National Eating Disorders Association (NEDA) Feeding Hope Fund, PI:J.Steinglass

Abbreviations:

AN	Anorexia Nervosa
PFQ	Geiselman Food Preference Questionnaire-I©
FPS	fat preference score
EDE-Q	Eating Disorders Examination-Questionnaire
MIM	multi-item meal study

REFERENCES

American Psychiatric Association, A. P. (2013). Diagnostic and Statistical Manual of Mental Disorders (5th ed.). Washington, D.C. : APA Press

Arcelus J, Mitchell AJ, Wales J, & Nielsen S (2011). Mortality rates in patients with anorexia nervosa and other eating disorders. A meta-analysis of 36 studies. Arch Gen Psychiatry, 68(7), 724–731. doi:10.1001/archgenpsychiatry.2011.74 [PubMed: 21727255]

Attia E, & Walsh B (2009). Behavioral management for anorexia nervosa. New Eng J Med, 360(5), 500–506. [PubMed: 19179317]

Carter JC, Stewart DA, & Fairburn CG (2001). Eating disorder examination questionnaire: norms for young adolescent girls. Behav Res Ther, 39(5), 625–632. [PubMed: 11341255]

Fairburn CG, Cooper Z, & O'Connor M. (2008). Eating Disorder Examination (16.OD) In CG F (Ed.), Cognitive Behavior Therapy and Eating Disorders. New York: Guilford Press.

Foerde K, Steinglass JE, Shohamy D, & Walsh BT (2015). Neural mechanisms supporting maladaptive food choices in anorexia nervosa. Nat Neurosci, 18(11), 1571–1573. doi:10.1038/nn.4136 [PubMed: 26457555]

Geiselman PJ, Anderson AM, Dowdy ML, West DB, Redmann SM, & Smith SR (1998). Reliability and validity of a macronutrient self-selection paradigm and a food preference questionnaire. Physiol Behav. 1998 3;63(5):919–28. [PubMed: 9618017]

Glasofer DR, Sysko R, & Walsh BT (2016). Use of the Eating Disorder Assessment for DSM-5 In Attia E, Walsh BT, Glasofer DR, Sysko R (Ed.), Handbook of Assessment and Treatment of Eating Disorders. Virginia: American Psychiatric Association.

Hadigan CM, Anderson EJ, Miller KK, Hubbard JL, Herzog DB, Klibanski A, & Grinspoon SK (2000). Assessment of macronutrient and micronutrient intake in women with anorexia nervosa. Int J Eat Disord, 28(3), 284–292. [PubMed: 10942914]

Khalsa SS, Portnoff LC, Mc-Curdy-McKinnon D, & Feusner JD (2017). What happens after treatment? A systematic review of relapse, remission, and recovery in anorexia nervosa. J Eat Disord, 6 14; 5:20 Doi 10.1186/s40337-017-0145-3. [PubMed: 28630708]

King JL, Fearnbach SN, Ramakrishnapillai S, Shankpal P, Geiselman PJ, Martin CK, Murray KB, Hicks JL, McClernon FJ, Apolzan JW, & Carmichael OT (2018). Perceptual characterization of the macronutrient picture system (MaPS) for food image fMRI. Front Psychol, 9, 17. doi:10.3389/fpsyg.2018.00017 [PubMed: 29434559]

Mayer LES, Schebendach J, Bodell LP, Shingleton RM, & Walsh BT (2012). Eating behavior in anorexia nervosa: Before and after treatment. International Journal of Eating Disorders, 45(2), 290–293. doi:10.1002/eat.20924 [PubMed: 21495053]

McCrory MA, Burke A, & Roberts SB (2012). Dietary (sensory) variety and energy balance. Physiol Behav, 107(4), 576–583. doi:10.1016/j.physbeh.2012.06.012 [PubMed: 22728429]

McVay MA, Voils CI, Coffman CJ, Geiselman PJ, Kolotkin RL, Mayer SB, Smith VA, Gaillard L, Turner MJ, & Yancy WS Jr. (2014). Factors associated with choice of a low-fat or low-carbohydrate diet during a behavioral weight loss intervention. Appetite. 2014 8 19;83C:117–124. doi: 10.1016/j.appet.2014.08.023.

Mond JM, Hay PJ, Rodgers B, & Owen C (2006). Eating Disorder Examination Questionnaire (EDE-Q): norms for young adult women. Behav Res Ther, 44(1), 53–62. doi:10.1016/j.brat.2004.12.003 [PubMed: 16301014]

Raynor HA (2012). Can limiting dietary variety assist with reducing energy intake and weight loss? Physiol Behav, 106(3), 356–361. doi:10.1016/j.physbeh.2012.03.012 [PubMed: 22450259]

Rolls BJ (2009). The relationship between dietary energy density and energy intake. Physiol Behav, 97(5), 609–615. doi:10.1016/j.physbeh.2009.03.011 [PubMed: 19303887]

Schebendach JE, Call CC, Attia E, Devlin MJ, Timothy Walsh B, & Mayer LE (2017). The effect of acute weight restoration on dietary fat preference in hospitalized patients with anorexia nervosa. Int J Eat Disord, 50(2), 148–151. doi:10.1002/eat.22620 [PubMed: 27610952]

Schebendach JE, Mayer LE, Devlin MJ, Attia E, Contento IR, Wolf RL, & Walsh BT (2008). Dietary energy density and diet variety as predictors of outcome in anorexia nervosa. Am J Clin Nutr, 87(4), 810–816. [PubMed: 18400701]

Schebendach JE, Mayer LE, Devlin MJ, Attia E, Contento IR, Wolf RL, & Walsh BT (2011). Food choice and diet variety in weight-restored patients with anorexia nervosa. J Am Diet Assoc, 111(5), 732–736. [PubMed: 21515121]

Schebendach JE, Mayer LE, Devlin MJ, Attia E, & Walsh BT (2012). Diet energy density and diet variety as risk factors for relapse in anorexia nervosa: A replication. int J Eat Disord, 45, 79–84. [PubMed: 21448937]

Steinglass JE, Glasofer DR, Walsh E, Guzman G, Peterson CB, Walsh BT, Attia E, & Wonderlich SA (2018). Targeting habits in anorexia nervosa: a proof-of-concept randomized trial. Psychol Med, 48(15), 2584–2591. doi:10.1017/s003329171800020x [PubMed: 29455696]

Sysko R, Steinglass J, Schebendach J, Mayer LES, & Walsh BT (2018). Rigor and reproducibility via laboratory studies of eating behavior: A focused update and conceptual review. Int J Eat Disord. doi:10.1002/eat.22900

Walsh BT (2011). The importance of eating behavior in eating disorders. Physiol Behav, 104(4), 525–529. doi:10.1016/j.physbeh.2011.05.007 [PubMed: 21570418]

Yancy WS Jr, Coffman CJ, Geiselman PJ, Kolotkin RL, Almirall D, Oddone EZ, Mayer SB, Gaillard LA, Turner M, Smith VA, & Voils CI (2013). Considering patient diet preference to optimize weight loss: Design considerations of a randomized trial investigating the impact of choice. Contemporary Clinical Trials, 35(1), 106–116. doi:10.1016/j.cct.2013.03.002 [PubMed: 23506974]

Table 1.

Comparison of clinical characteristics in patients with anorexia nervosa (AN) and healthy control (HC) participants

	AN (n = 44)	HC (n = 48)	*t*	*df*	*p*[1]	*Cohen's d*[2]	AN-R (n=23)	AN-BP (n=21)	*t*	*df*	*p*[1]	*Cohen's d*[2]
Age (years)	29.31 (8.47)	25.68 (5.31)	2.437	71.167	0.017	0.513	28.82 (8.72)	29.85 (8.36)	−0.399	42	0.692	−0.120
BMI (kg/m^2)	16.53 (2.89)	21.34 (1.63)	−9.705	66.699	< 0.001	−2.048	16.12 (2.98)	16.98 (2.78)	−0.989	42	0.328	−0.299
EDE-Q Restraint	4.29 (1.75)	0.32 (0.72)	13.952	6.227	< 0.001	0.828	3.77 (1.93)	4.87 (1.34)	−2.204	39.357	0.033	−0.660
EDE-Q Eating Concerns	3.55 (1.58)	0.08 (0.32)	14.247	46.313	< 0.001	0.834	2.98 (1.72)	4.18 (1.15)	−2.728	38.671	0.01	−0.816
EDE-Q Shape Concerns[3]	4.66 (1.58)	0.31 (0.47)	17.360	48.712	< 0.001	0.881	4.23 (1.76)	5.16 (1.19)	−2.059	38.852	0.046	−0.621
EDE-Q Weight Concerns	4.48 (1.69)	0.28 (0.49)	15.811	49.841	< 0.001	0.859	3.92 (1.84)	5.09 (1.28)	−2.458	39.392	0.018	−0.736
EDE-Q Global	4.26 (1.53)	0.48 (1.64)	11.387	89.962	< 0.001	0.764	3.74 (1.70)	4.82 (1.10)	−2.525	38.081	0.016	−0.754

EDE-Q: Eating Disorder Examination Questionnaire

All values expressed as mean +/− standard deviation (SD)

1. Independent samples *t* test: AN vs. HC; AN-R vs. AN-BP

2. Cohen's *d*: small effect = 0.2; medium effect = 0.5; large effect = 0.8

3. EDE- Q Shape Concerns: value missing for 1 AN participant (n=43)

Table 2.

Comparison of Geiselman Food Preference Questionnaire-I© (FPQ) food group hedonic ratings and fat preferences scores in patients with anorexia nervosa (AN) and healthy control (HC) participants

Hedonic Ratings[1] and Fat Preference Scores[2]	AN (n = 44)	HC (n = 48)	*t*	*df*	*P*[3]	*Cohen's d*[4]	AN-R (n=23)	AN-BP (n=21)	*t*	*df*	*P*[3]	*Cohen's d*[4]
High fat/High sugar	4.89 (2.28)	6.05 (1.44)	−2.869	71.55	0.005	−0.604	5.12 (2.32)	4.65 (2.26)	0.688	42	0.495	0.206
High fat/ High complex carbohydrate	3.79 (1.75)	5.51 (1.27)	−5.356	77.925	<0.001	−1.125	3.73 (1.65)	3.85 (1.90)	0.351	42	0.830	−0.065
High fat/High protein	3.69 (1.79)	7.12 (7.37)	−3.001	90	0.003	−0.638	3.70 (1.90)	3.68 (1.71)	0.035	42	0.972	0.010
Mean hedonic rating of High fat groups	4.13 (1.71)	5.89 (1.22)	−5.624	77.075	<0.001	−1.182	4.19 (1.80)	4.06 (1.65)	0.232	42	0.817	0.070
Low fat/High sugar	5.79 (1.64)	5.98 (1.28)	−0.646	90	0.520	−0.134	5.97 (1.59)	5.58 (1.70)	0.78	42	0.440	0.234
Low fat/ High complex carbohydrate	4.99 (1.31)	5.92 (1.13)	−3.623	90	<0.001	−0.753	5.24 (1.15)	4.72 (1.45)	1.313	42	0.196	0.394
Low fat/High protein	4.46 (1.75)	5.44 (1.19)	−3.103	75.116	0.003	−0.652	4.53 (1.82)	4.39 (1.71)	0.256	42	0.799	0.077
Mean hedonic rating of Low fat groups	5.11 (1.27)	5.81 (0.95)	−2.976	90	0.004	−0.617	5.29 (1.15)	4.92 (1.39)	0.979	42	0.333	0.294
Fat preference score	79.76 (27.48)	102.33 (18.96)	−4.543	75.544	<0.001	−0.955	77.46 (27.24)	82.29 (28.20)	−0.578	42	0.566	−0.174
# Foods rated (max. 72)[5]	67.63 (4.41)	66.52 (4.76)	1.134	87	0.260	0.241	67.82 (4.82)	67.43 (4.04)	0.286	41	0.776	0.087
# Disliked foods (hedonic rating <5)[5]	31.30 (15.8)	17.63 (11.96)	4.621	87	<0.001	0.975	31.09 (17.60)	31.52 (14.09)	−0.089	41	0.930	−0.026

All values expressed as mean +/− standard deviation (SD)

1. Hedonic rating: 9-point Likert scale with 1 = dislike extremely, 5 = neutral, 9 = like extremely

2. Fat preference score: > 100 indicates preference for high fat foods, < 100 indicates preference for low fat foods

3. Independent samples *t* test

4. Cohen's *d*: small effect = 0.2; medium effect = 0.5; large effect = 0.8

5. Values for the # foods rated and the # disliked foods missing for 1 AN and 2 HC participants

Table 3.

Comparison of nutrient intake at the multi-item meal study in patients with anorexia nervosa (AN) and healthy control (HC) participants

Multi-Item Meal Intake	AN (n = 44)	HC (n = 48)	*t*	*df*	*P*[1]	*Cohen's d*[2]	AN-R (n=23)	AN-BP (n=21)	*t*	*df*	*P*[1]	*Cohen's d*[2]
Energy (kcal)	469.16 (397.71)	856.40 (346.89)	−4.987	90	<0.001	−1.037	543.22 (477.64)	388.04 (275.51)	1.303	42	0.200	0.397
Carbohydrate (g)	58.40 (45.17)	93.97 (37.10)	−4.115	89	<0.001	−0.860	64.44 (50.36)	51.79 (38.83)	0.926	42	0.360	0.281
Protein (g)[3]	22.06 (17.06)	39.45 (15.18)	−5.141	89	<0.001	−1.076	25.18 (17.59)	18.65 (16.19)	1.278	42	0.208	0.386
Fat (g)	16.45 (20.43)	36.74 (18.90)	−4.949	90	<0.001	−1.031	20.54 (25.97)	11.97 (10.71)	1.452	29.832	0.157	0.431
% kcal Carbohydrate[3]	52.09 (20.69)	43.85 (6.60)	2.524	51.162	0.015	0.536	48.22 (16.99)	56.34 (23.81)	−1.310	42	0.197	−0.392
% kcal Protein[3]	20.41 (13.46)	19.41 (6.07)	0.451	58.934	0.654	0.095	22.43 (13.52)	18.20 (13.37)	1.042	42	0.303	0.314
% kcal Fat	22.95 (13.81)	36.68(8.03)	−5.757	67.817	<0.001	−1.214	24.99 (13.77)	20.72 (13.85)	1.023	42	0.312	0.308
Diet Energy Density (DEDS)[4]	0.607 (0.509)	0.978 (0.293)	−4.232	67.433	<0.001	−0.892	0.647 (0.542)	0.563 (0.480)	0.537	42	0.594	0.162
Diet Variety (DVS)[5]	5.80 (3.46)	8.96 (2.66)	−4.934	90	<0.001	−1.023	6.39 (3.94)	5.14 (2.79)	1.201	42	0.236	0.365

All values expressed as mean +/− standard deviation (SD)

[1] Independent samples *t* test

[2] Cohen's *d*: small effect = 0.2; medium effect = 0.5; large effect = 0.8

[3] Values for carbohydrate (g and %) and protein (g and %) missing for 1 HC participant (n=47)

[4] DEDS: energy intake (kcal) divided by the gram weight of all food/beverage items consumed

[5] DVS: the number of energy-containing food/beverage items consumed divided the number of energy-containing food and beverage items served.

Table 4

Pearson correlations of the Geiselman Food Preference Questionnaire-I© fat preference score and Eating Disorder Examination Questionnaire (EDE-Q) measures with multi-Item meal intake in patients with anorexia nervosa (n=44)

Multi-Item Meal Intake	Fat Preference Score	EDE-Q Eating Concern	EDE-Q Restraint	EDE-Q Weight Concern	EDE-Q Shape Concern	EDE-Q Global Score
Energy (kcal)	0.481 **	− 0.249	− 0.350 *	− 0.302 *	− 0.269	− 0.327 *
Carbohydrate (g)	0.453 **	− 0.175	− 0.297	− 0.223	− 0.150	− 0.244
Protein (g)	0.361 *	− 0.310 *	− 0.306 *	− 0.232	− 0.233	− 0.298 *
Fat (g)	0.453 **	− 0.256	− 0.351 *	− 0.347 *	− 0.351 *	− 0.359 *
% kcal Carbohydrate	− 0.060	0.138	0.103	0.102	0.162	0.126
% kcal Protein	− 0.165	− 0.223	− 0.046	0.022	0.036	− 0.047
% kcal Fat	0.370 *	− 0.295	− 0.359 *	− 0.335 *	− 0.377 *	− 0.372 *
Diet Energy Density Score (DEDS)	0.436 **	− 0.195	− 0.346 *	− 0.262	− 0.311 *	− 0.305 *
Diet Variety Score (DVS)[2]		− 0.336 *	− 0.323 *	− 0.324 *	− 0.350 *	− 0.371 *

1. Data are missing for 1 AN for the EDE-Q Shape Concern

2. DVS at the meal was negatively correlated with the number of disliked foods on the FPQ ($r = -0.453$, $p < 0.01$)

* $p < 0.05$,

** $p < 0.01$

Table 5

Pearson correlations of the Geiselman Food Preference Questionnaire-I© fat preference score and Eating Disorder Examination Questionnaire (EDE-Q) measures with multi-Item meal intake in healthy control participants (n=48)

Multi-Item Meal Intake	Fat Preference Score	EDE-Q Eating Concern	EDE-Q Restraint	EDE-Q Weight Concern	EDE-Q Shape Concern	EDE-Q Global Score
Energy (kcal)	0.583 ***	0.126	0.197	0.146	− 0.003	0.021
Carbohydrate (g)[1]	0.469 **	0.173	0.237	0.162	0.015	0.056
Protein (g)[1]	0.447 **	0.039	0.060	0.158	− 0.006	− 0.034
Fat (g)	0.621 ***	0.081	0.157	0.091	− 0.039	0.006
% kcal Carbohydrate[1]	− 0.414 **	0.151	0.173	0.043	0.043	0.089
% kcal Protein[1]	− 0.364 *	− 0.087	− 0.160	− 0.017	− 0.027	− 0.097
% kcal Fat	0.601 ***	− 0.064	− 0.032	− 0.050	− 0.038	− 0.004
Diet Energy Density Score (DEDS)	0.531 ***	0.008	0.005	− 0.040	− 0.123	− 0.057
Diet Variety Score (DVS)[2]		− 0.256	− 0.136	0.041	0.016	0.032

1. n = 47 for carbohydrate (g and %) and protein (g and %)

2. DVS at the meal was negatively correlated with the number of disliked foods on the FPQ ($r = -0.390$, $p < 0.01$)

* $p < 0.05$,

** $p < 0.01$,

*** $p < 0.001$