Features Associated With Excessive Exercise in Women with Eating Disorders

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ABSTRACT

Objective: Excessive exercise and motor restlessness are observed in a substantial number of patients with eating disorders. This trait has been studied extensively among animal models of activity anorexia nervosa (AN) and may hold particular interest as an endophenotype for AN. We explored features associated with excessive exercise across subtypes of eating disorders.

Method: Participants were female probands and affected female relatives from the multi-site international Price Foundation Genetic Studies with diagnoses of AN, bulimia nervosa (BN), and both AN and BN or eating disorder not otherwise specified (ED-NOS) ($N = 1{,}857$). Excessive exercise was defined based on responses to the Structured Interview for Anorexic and Bulimic Disorders (SIAB).

Results: Among the eating disorder diagnostic groups, excessive exercise was most common among the purging subtype of AN. Individuals who reported excessive exercise also reported lower minimum BMI, younger age at interview, higher scores on anxiety, perfectionism, and eating disorder symptom measures, more obsessions and compulsions, and greater persistence.

Conclusion: Excessive exercise may be associated particularly with the purging subtype of AN as well as with a constellation of anxious/obsessional temperament and personality characteristics among women with eating disorders. © 2006 by Wiley Periodicals, Inc.

Keywords: anorexia nervosa; activity; exercise; anxiety

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Introduction

Despite the high prevalence of excessive exercise in eating disorders, little research has examined the diagnostic and temperamental correlates of these behaviors in individuals with eating pathology. The lack of empirical data is surprising, given that the presence of excessive exercise among patients with anorexia nervosa (AN) has been found to be associated with longer inpatient treatment[1] and a shorter time to relapse.[2] Understanding the diagnostic and personality profiles that commonly accompany

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these deleterious behaviors would therefore inform treatment efforts and possibly theories regarding the etiology of the exercise behaviors and the eating disorder itself.

Few studies have examined the prevalence of excessive exercise across eating disorder diagnostic categories. A retrospective study of hospital records[1] failed to find a significant difference in the proportion of excessive exercisers between groups with AN and those with bulimia nervosa (BN) or eating disorder not otherwise specified (EDNOS). However, the measurement of exercise in the study was problematic, as participants were only asked to recall exercise behavior in the 6 months before their admission and exercise status was established using a median split difference in the study sample. In their study with adult inpatients, Davis et al.[3] found that compared with patients with BN, a significantly greater proportion of patients with AN were excessive exercisers during the acute phase of their disorder. No study to date has examined differential rates of excessive exercise across subtypes of AN (i.e., restrictor, binge/purge, or purge only) or BN (purging and non-purging). Given significant differences in other behavioral and personality characteristics across these subgroups (e.g., see Klump et al.[4]), it is important to determine whether excessive exercise shows stronger associations with some eating disorder subtypes than others.

Although there have been numerous studies of exercise and excessive activity in eating disorders, there is no consensus on what constitutes excessive exercise with definitions varying in frequency of hours, definitions of unhealthy preoccupation with exercise, and discomfort experienced when unable to exercise—or exercise "craving." In addition, as pointed out by Adkins and Keel,[5] little research has been carried out to support whether the excessive or compulsive dimension of exercising is related to eating disorders.

A greater body of work has examined personality and psychopathological correlates of exercise behaviors in individuals with eating disorders. However, findings have been inconsistent. Bamber et al.[6] found that individuals with eating disorders and "secondary exercise dependence" [defined as excessive exercise behavior associated with an eating disorder[7]] had significantly higher scores on impulsiveness and addictiveness as compared with those with exercise dependence only. Other investigators have found anxious and depressive traits to be more closely associated with excessive exercise than impulsivity. In a retrospective case series study involving outpatients with AN and BN, Penas-Lledo et al.[8] found higher levels of anxiety and depression (based on scores on SCL-90-R) among those who were identified as exercising excessively. The authors claimed that exercise might serve to reduce anxiety and stress in individuals with AN. In a similar study with adolescent inpatients with AN, Holtkamp et al.[9] found that anxiety significantly predicted variance in exercise levels. These investigators proposed that anxiety symptoms in combination with food restriction contributed to increased levels of physical activity and that physical activity served an anxiolytic function.

In summary, relatively little is known about the diagnostic and personality correlates of excessive exercise in individuals with eating disorders. These behaviors may be associated with anxious traits, but studies are too few and inconsistent to derive definitive conclusions. Consequently, the aims of the current study were to use a large and well-characterized sample of women with eating disorders to explore (1) the prevalence of excessive exercise across diagnostic subtypes of eating disorders; and (2) the relation between excessive exercise and clinical variables, including perfectionism, temperament, anxiety, depression, and obsessions and compulsions.

Method

Participants

Participants were from the multi-site international Price Foundation Genetic Study of AN,[10] of BN,[11] and of AN Trios[12] studies. These studies constitute an effort to identify susceptibility loci influencing risk for eating disorders. Probands and affected relatives were assessed for psychological and personality features that have been shown to be associated with, and may underlie vulnerability to, eating disorders.

Informed consent was obtained from all study participants, and all sites received approval from their local Institutional Review Boards.

AN Study. Probands met modified criteria for the Diagnostic and Statistical Manual of Mental Disorders (DSM-IV; criterion D not required[13]) for AN. Affected male and female biological relatives of probands were required to have a lifetime history of AN, BN, or ED-NOS. All were recruited from seven sites in North America and Europe ($n = 431$). The complete details of the methods are described in Kaye et al.[10]

BN Study. Probands from the BN study were required to meet modified DSM-IV criteria (bingeing and vomiting

for a period of ≥6 months was required) for a lifetime diagnosis of BN. All affected relatives were required to have a lifetime history of AN, BN, or EDNOS. The total number of participants was 750. Complete methods are described in Kaye et al.[11]

AN Trios Study. Female and male probands affected with AN and their parents were recruited from 9 sites in North America and Europe. Additional affected relatives, if available, were also assessed. The total number of affected participants was 749. Complete methods are described in Reba et al.[12]

Individuals from these three studies with any combination of AN, BN, or EDNOS were included in this study. Participants were classified as EDNOS if their only diagnosis was EDNOS. Individuals were excluded from the analyses if they did not have a valid response for the Structured Interview for Anorexic and Bulimic Disorders (SIAB) item regarding exercise ($n = 13$) or for age of onset of ED ($n = 8$). Males were also excluded from the analyses, as the frequency of males with these diagnoses was too low for meaningful comparison ($n = 52$). The resulting sample size was 1,857.

Assessments and Measures

Demographic and Clinical Variables. Data relative to current age, ED duration, current, and minimum and maximum body mass index (BMI) were obtained.

Eating Disorder Diagnoses. Lifetime histories of eating disorders and the presence or absence of eating disorder behaviors (e.g., purging, exercising, dieting) in probands and affected relatives were assessed with the SIAB[14] and an expanded version of Module H of the Structured Clinical Interview for DSM-IV Axis I Disorders (SCID).[15] The SIAB is a semi-structured clinical interview designed to gather detailed information on weight and eating history to establish eating disorder diagnoses as defined by DSM-IV and International Classification of Diseases-10 (ICD-10). The training procedures for the SIAB and SCID have been described in detail elsewhere.[11]

Personality and Symptom Assessments. Temperament and character dimensions were measured with the Temperament and Character Inventory (TCI).[16] Perfectionism was measured by the Frost Multidimensional Perfectionism Scale (MPS).[17] Participants also completed the State-Trait Anxiety Inventory (STAI Form Y-1),[18] the Yale–Brown Obsessive Compulsive Scale (Y-BOCS),[19] and the Yale–Brown–Cornell Eating Disorder Scale (YBC-EDS).[20] All assessments were administered in all three studies.

Excessive Exercise. Participants were divided into exercise groups based on their response to the SIAB question "How much exercise did you engage in?", which was asked within the context of questions related to behavior at its worst. Interviewers were trained to endorse excessive exercise when any of the following were reported by the participant: (1) severe interference with important activities; (2) exercising more than 3 h/day and distress if unable to exercise; (3) frequent exercise at inappropriate times and places and little or no attempt to suppress the behavior; and (4) exercising despite more serious injury, illness or medical complication. Participants endorsing any of the above were categorized as excessive exercisers ($N = 721$). The rest were categorized as no/regular exercisers ($N = 1{,}136$).

Statistical Analyses

Logistic regression analyses were conducted using the GENMOD procedure of SAS version 9.1[21] correcting for the relatedness of individuals in our study with Generalized Estimating Equations (GEE).[22–24] GEE is a statistical approach based on a regression technique used to investigate correlated data, such as panel studies and the affected relative-pair data used in the current study. In the current study, biologically related family members comprised each cluster in the GEE analyses. However, because the current study included family members of varying relatedness (i.e., first-degree, second-degree, and third-degree relatives, as well as unrelated controls), the GEE analyses were conducted in two steps. First, models were fit to the data via the GEE method for probands and their siblings only using the exchangeable working correlation matrix to obtain an estimate of the familial correlation among these first-degree relatives. Second, models were refit to the entire data set of relatives, using familial correlations estimated from the probands and siblings as the user-defined working correlation matrix. The model parameters and statistics from these models were then used as the final solution. This approach to the analyses can be considered conservative, as the proband/sibling correlations are likely overestimates of the expected correlations among clusters of unrelated individuals and second-degree and third-degree relatives. Such overestimation is likely to result in fewer, rather than more, significant findings.

The prevalence of excessive exercise in the eating disorder diagnostic subgroups is presented in Table 1. Logistic regression analysis was applied, as described above, predicting exercise group from ED subtype. Age and proband status (whether the participant was a proband or the relative of a proband) were entered into the model as covariates.

The perfectionism scales, TCI measures, STAI trait anxiety, BDI, worst YBC-EDS scales, Y-BOCS scales, BMI measures, age at interview, menarche, and duration of ED were compared in the two exercise groups using logistic regression analysis (see Table 2), with ED sub-

TABLE 1. Description of diagnostic categories and prevalence of excessive exercise across diagnostic groups

	Description of Diagnostic Category	No/Regular Exercisers	Excessive Exercisers
RAN ($N = 521$)	AN with restrictive eating (no purging and no bingeing behavior)	59.7% (311)	40.3% (210)
PAN ($N = 336$)	AN with purging (no bingeing behavior)	45.5% (153)	54.5% (183)
BAN ($N = 182$)	AN with bingeing and purging/restricting	62.6% (114)	37.4% (68)
PBN ($N = 296$)	BN with purging behavior	79.8% (237)	20.2% (60)
NPBN ($N = 25$)	BN with bingeing (no purging behavior)	76.0% (19)	24.0% (6)
ANBN ($N = 400$)	Lifetime diagnosis of AN and BN	56.5% (226)	43.5% (174)
EDNOS ($N = 96$)	Lifetime diagnosis of EDNOS	79.2% (76)	20.8% (20)

Note: AN = anorexia nervosa; BN = bulimia nervosa; RAN = restricting type AN; PAN = purging only type AN; BAN = bingeing with or without purging type AN; PBN = purging type BN; NPBN = non-purging type BN; ANBN = lifetime diagnosis of both full syndromal AN and BN; EDNOS = eating disorder not otherwise specified.

TABLE 2. Means, standard deviations, and results of logistic regression for demographic, course of illness, psychological, and personality variables associated with excessive exercise across ED subtypes

Variable[a]	No or Regular Exercise ($N = 1137$) Mean (SD)	Excessive Exercise ($N = 721$) Mean (SD)	χ^2 (p-value)	OR (95% CI)
Current BMI	19.85 (3.33)	19.00 (3.10)	1.6 (0.21)	---
Maximum BMI	22.68 (3.33)	22.14 (2.96)	1.3 (0.25)	---
Minimum BMI	15.95 (2.85)	14.52 (2.59)	36.1 (<0.001)	0.62 (0.53, 0.72)
Age at interview	27.99 (9.51)	26.29 (7.68)	17.9 (<0.001)	0.80 (0.72, 0.89)
ED duration[b]	9.41 (8.04)	9.27 (6.93)	0.8 (0.38)	---
Menarche	13.65 (6.52)	14.19 (8.97)	0.8 (0.36)	---
State–Trait Anxiety Inventory—Form Y				
Trait anxiety	49.55 (13.41)	53.95 (13.85)	21.0 (<0.001)	1.27 (1.15, 1.41)
Temperament and Character Inventory				
Harm avoidance	20.04 (7.78)	21.57 (7.68)	3.7 (0.06)	---
Novelty seeking	18.86 (7.21)	17.31 (7.20)	8.3 (0.004)	0.86 (0.77, 0.95)
Reward dependence	16.74 (3.91)	16.57 (3.90)	0.7 (0.41)	---
Persistence	5.52 (2.05)	6.07 (1.91)	20.1 (<0.001)	1.26 (1.14, 1.40)
Cooperativeness	33.71 (6.11)	34.35 (5.95)	3.5 (0.06)	---
Self-directedness	26.60 (9.33)	25.72 (9.45)	1.3 (0.27)	---
Self-transcendence	14.63 (6.80)	14.64 (6.46)	0.3 (0.56)	---
Multidimensional Perfectionism Scale				
Concern over mistakes	30.83 (9.51)	33.97 (9.05)	25.5 (<0.001)	1.30 (1.17, 1.44)
Doubts about actions	12.45 (4.02)	13.51 (3.97)	13.9 (<0.001)	1.22 (1.10, 1.35)
Personal standards	26.25 (6.32)	28.25 (5.53)	27.3 (<0.001)	1.31 (1.18, 1.45)
Organization	23.66 (5.66)	24.93 (5.34)	13.9 (<0.001)	1.21 (1.09, 1.34)
Parental criticism	10.52 (4.70)	11.67 (4.83)	20.0 (<0.001)	1.26 (1.14, 1.40)
Parental expectations	14.11 (5.74)	15.30 (5.86)	13.6 (<0.001)	1.21 (1.09, 1.34)
YBC-EDS				
Worst ritual	10.97 (3.72)	13.36 (2.36)	138.0 (<0.001)	2.36 (2.02, 2.76)
Worst preoccupation	11.70 (3.22)	13.33 (2.30)	78.9 (<0.001)	1.72 (1.51, 1.94)
Worst motivation to change	17.13 (5.86)	18.48 (5.49)	6.1 (<0.013)	1.13 (1.03, 1.25)
YBOCS				
Obsessions	5.54 (5.96)	8.23 (6.29)	48.9 (<0.001)	1.45 (1.31, 1.60)
Compulsions	6.16 (6.26)	8.97 (6.64)	51.2 (<0.001)	1.45 (1.31, 1.60)

Note: BMI = body mass index; ED, eating disorder; SD = standard deviation; OR = odds ratio; CI = confidence interval; YBC-EDS = Yale–Brown–Cornell Eating Disorder Scale; Y-BOCS = Yale–Brown Obsessive Compulsive Scale.

[a] ED subtype, proband status, and age at interview were entered as covariates in the model.

[b] A reduced sample was used for ED duration. Individuals from the AN ARP study were removed because the information needed to calculate ED duration was not available. In addition, age was not entered as a covariate in the model because age was used to compute duration for those individuals not fully recovered at time of interview.

type, age, and proband status entered as covariates. Interactions between the covariates and the predictor of interest were not significant so were removed from analyses. All measures were standardized before the regression analyses. The χ^2 and p values are listed in Table 2. A large number of clinical variables, including subscales of per-

fectionism, and temperament, anxiety, obsessions, and compulsions, were found to be significantly associated with excessive exercise.

Results

Description of Samples

Our sample consisted of 1,857 females who met lifetime criteria for (1) restricting type AN (RAN; $N = 521$); (2) purging only type AN (PAN; $N = 336$); (3) bingeing with or without purging type AN (BAN; $N = 182$); (4) purging type BN (PBN; $N = 297$); (5) non-purging type BN (NPBN; $N = 25$); (6) lifetime diagnosis of both full syndromal AN and BN (ANBN; $N = 400$); or (7) EDNOS ($N = 96$) (see **Table 1**). To be categorized as RAN, probands had AN with restrictive eating and no purging or bingeing behavior. The category of PAN included those individuals who had AN with purging behavior and no bingeing behavior and those having AN with bingeing with or without compensatory behaviors were categorized as BAN. Those who met criteria for BN with purging behavior were classified as PBN, whereas those who had BN with bingeing and no purging behavior were NPBN. Individuals with a lifetime diagnosis of both AN and BN were categorized as ANBN and those having subthreshold AN or BN or meeting criteria for binge eating disorder, or purging disorder[11] for more details) were classified as EDNOS. The prevalence of excessive exercise was high across the entire sample (39%). Results of the logistic regression analyses with post hoc tests for pairwise comparisons across ED subtypes examining excessive exercise across eating disorder subtypes indicated that there were significantly more excessive exercisers in the PAN group (54%). The PBN group had the fewest excessive exercisers (20%) and differed significantly from the RAN, PAN, BAN, and ANBN groups.

Demographics. **Table 2** presents demographic features of the sample as well as means and standard deviations for the variables of interest. Individuals categorized as excessive exercisers were significantly younger at the time of interview ($\overline{X} = 26.34$ years; $SD = 7.75$) than those classified as nonexcessive exercisers ($\overline{X} = 27.90$ years; $SD = 9.51$). In addition, participants in the excessive exercise group had a significantly lower lifetime minimum as well as current BMI than those in the nonexcessive exercise group. There were no differences in maximum BMI, age at menarche, or duration of illness between the two groups.

Psychological and Personality Variables

Results of the logistic regression analyses for the psychological and personality variables are presented in **Table 2**. Excessive exercise was associated with significantly higher scores on the anxiety measure, persistence, and perfectionism, and lower scores for novelty seeking. Excessive exercise was also associated with greater severity of eating disorder symptoms, as measured by worst ritual, worst preoccupation and worst motivation to change in the YBC-EDS. Similarly, higher obsessions and compulsions (YBOCS) were associated with excessive exercise.

Conclusion

We examined diagnostic, personality, and psychological variables associated with excessive exercise in the largest and most diagnostically diverse cohort of female eating disorder patients studied to date. Among the eating disorder subtypes, individuals with PAN were more likely to be excessive exercisers than individuals in any other category. Previous studies have reported differences in excessive exercise among individuals with AN and BN in the acute phase of their disorder,[3] and our results support this finding; however, ours is the first study to examine exercise behavior across subtypes of AN, BN, and EDNOS. In their analysis of retrospective hospital records, Brewerton et al.[25] found a nonsignificantly higher proportion of "compulsive exercisers" among individuals with AN when compared with individuals with BN. The generalizability of our results is limited by the fact that we do not have information about the time frame of the exercise behavior, especially in relation to other behaviors, such as purging and severity of illness.

The preponderance of excessive exercise in the group of individuals with PAN is interesting, given previous research showing that this subgroup is particularly prone to anxious and harm avoidant traits.[4] Findings from the current study suggest that excessive exercise is also associated with a younger age at time of interview, and higher rates of anxious/obsessional and perfectionistic traits. The relation between exercise and age at interview may be explained by ease of access to exercise behaviors as a weight control mechanism at younger ages (in contrast to access to laxatives or purgatives) and the inverse relationship between exercise and age (i.e., individuals tend to exercise less as they become older).[26] We found significantly

higher levels of trait anxiety, depression, and obsessions and perfectionism among individuals in the excessive exercise group. In a study with adolescent patients with AN, Davis et al.[27] found that, compared with controls, patients reported engaging in more exercise during the year before the onset of their illness. Thus, it may be that individuals who are particularly prone to anxious obsessionality are more likely to engage in "extra" eating disorder behaviors (e.g., purging and excessive exercise) that are driven by their fear, anxiety, and obsessive preoccupation with weight gain. An alternative explanation may be that exercise served to reduce or manage anxiety as postulated by Holtkamp et al.[9] or to counteract prominent eating and weight related obsessions. From a genetic perspective, a common allele or neural pathway may influence susceptibility to both exercise and anxiety. The importance of these additional eating disorder behaviors and anxious/obsessional traits should not be underemphasized, as they clearly place this subgroup of patients at increased risk for serious complications (e.g., low BMI; see Table 2).[28] Targeting the excessive anxiety and obsessionality experienced by these patients may therefore help alleviate their drive to engage in these behaviors and enhance their treatments above and beyond the standard levels of care.

The rather homogeneous diagnostic and personality profile of the excessive exercising patients also has implications for the etiology of eating disorders. Efforts to map susceptibility loci for these disorders have emphasized the need to examine more clearly defined phenotypes that might delineate subgroups of eating disorder patients with specific genetic diatheses that are distinct from those of other eating disorder patients.[29] Given that the broad diagnostic categories for eating disorders are most likely heterogeneous with regard to susceptibility genes, identification of homogeneous subgroups of patients across the eating disorder categories on the basis of certain endophenotypes or intermediate phenotypes may assist in the search for risk loci.

Genetic and neurobiological data further suggest that this phenotype might prove fruitful for molecular genetic research. The heritability and biological underpinnings of perfectionism, anxiety and temperamental categories have been discussed at length (e.g., see Jonnal et al.[30] and Micallef and Blin[31]); however, the drive to engage in physical activity has also been found to be biologically driven.[32] For example, recent studies have shown the peroxisome proliferator-activated receptor (PPAR) gamma to be involved in lipid metabolism and in the control of energy expenditure. Casper[33] pointed out that several studies have implicated the noradrenergic transporter gene promoter region, the agouti-related peptide gene (*AGRP*) and multiple serotonin receptor genes as possibly associated with the impact of activity, hunger, and arousal in AN. Researchers have also used findings from animal studies on hyperactivity to implicate the role of leptin in the treatment of hyperactivity among patients with AN.[34,35]

In their study with a small sample of patients with AN, Favaro et al.[36] found significantly higher tryptophan to large, neutral amino acids (TRP-to-LNAA) ratios among those who exercised excessively. These investigators postulated that exercise helped to counteract the reduction of TRP/LNAA and serotonin synthesis, potentially functioning as a form of "self medication" to balance the levels of TRP/LNAA in the body. These findings suggest that physical activity and weight regulation may, in fact, represent endophenotypes for eating pathology that contribute to its etiology, particularly the etiology of eating disorders characterized by high perfectionism, anxiety, ritualistic behaviors, obsessiveness, and purging behaviors.

The limitations of the study were that group membership was determined by retrospective reports of exercise behavior. Given the age range of our participants, and the fact that both actively ill and recovered individuals were included, accuracy of memory may have differed across participants. In addition, our exercise assessment was not extensive and we were unable to determine the duration of excessive exercise and the relation between the time frame of the excessive exercise and other eating disorder behaviors. As is true of other studies, these findings are limited in their applicability and may not hold true for samples of women with eating disorders from the general population. Future research should use more contemporaneous and comprehensive measures of excessive and compulsive exercise along with greater diversity in obtained samples to confirm our findings.

Despite these limitations, this is the first study to obtain information from a large cohort of participants, enabling a comprehensive analysis of several variables across subtypes of AN and BN. Moreover, we examined the association between excessive exercise and a number of demographic, personality, and clinical variables unlike previous studies. In summary, the results of this study point to a number of personality and clinical variables that are associated with excessive exercise among female patients with eating disorders and support findings from some of the smaller sample studies. In light of

the findings that excessive exercise may be resistant to change,[3] there might be added value to specific treatment focus on these accompanying personality and clinical variables. In addition, it is worth noting that variables such as worst rituals, obsessions, and perfectionism are significantly associated with excessive exercise, which may make it more difficult to treat such patients and also lead to poorer outcome. Studies comparing actively ill with recovered individuals have indicated that anxiety and certain temperamental traits persist beyond recovery.[37,38] Based on our sample, individuals with a diagnosis of PAN have a higher likelihood of exercising excessively and are therefore more likely to have the associated clinical and personality variables. These results suggest that excessive exercise may be a central strategy that contributes to maintenance of low BMI in patients with AN. The coupling of excessive exercise with additional purging methods, although common in our sample, is particularly worrisome clinically—especially in light of the fact that low BMIs are associated with increased risk for poorer outcome in patients with AN.[28] In addition, given the emerging focus on the genetics of physical activity and exercise in both animal and human studies,[32,33] we believe that exploring the genetic basis of exercise among patients with ED may be a productive endeavor.

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