HHS Public Access

Author manuscript

Alcohol Clin Exp Res. Author manuscript; available in PMC 2016 September 01.

Published in final edited form as:

Alcohol Clin Exp Res. 2015 September ; 39(9): 1740–1748. doi:10.1111/acer.12829.

Bulimic Behaviors and Early Substance Use: Findings from a Cotwin-Control Study

Melissa A. Munn-Chernoff, Ph.D.[1,2], **Julia D. Grant, Ph.D.**[1,2], **Kathleen K. Bucholz, Ph.D.**[1,2], **Arpana Agrawal, Ph.D.**[1,2], **Michael T. Lynskey, Ph.D.**[3], **Pamela A. F. Madden, Ph.D.**[1,2], **Andrew C. Heath, D.Phil.**[1,2], and **Alexis E. Duncan, Ph.D., M.P.H.**[1,2,4]

[1]Department of Psychiatry, Washington University School of Medicine, St. Louis, MO, USA

[2]Midwest Alcoholism Research Center, Washington University School of Medicine, St. Louis, MO, USA

[3]Institute of Psychiatry, Psychology & Neuroscience, Kings College London, London, UK

[4]George Warren Brown School of Social Work, Washington University, St. Louis, MO, USA

Abstract

Background—Bulimic behaviors (i.e., binge eating and compensatory behaviors) and substance use frequently co-occur. However, the etiology underlying this association is poorly understood. This study evaluated the association between bulimic behaviors and early substance use, controlling for genetic and shared environmental factors.

Methods—Participants were 3540 young adult women from the Missouri Adolescent Female Twin Study. A telephone adaptation of the Semi-Structured Assessment for the Genetics of Alcoholism interview assessed DSM-IV bulimic behaviors, substance use, and other psychological characteristics. Lifetime bulimic behaviors were examined in twin pairs concordant and discordant for early substance use. Logistic regressions were adjusted for the non-independence of twin data, zygosity, age, body mass index, early menarche (onset before age 12), and early sex (first consensual sexual intercourse before age 15).

Results—In the entire study population, women who reported early use of alcohol or nicotine were more likely to engage in bulimic behaviors after adjusting for covariates. In 53 pairs of monozygotic twins discordant for alcohol experimentation before age 15, the twin who reported early alcohol experimentation had 3.21 (95% confidence interval=1.54–6.67) times higher odds of reporting bulimic behaviors than the cotwin who did not report early alcohol experimentation, even after adjustment for covariates.

Conclusions—Findings suggest that early alcohol experimentation may contribute to the development of bulimic behaviors via mechanisms extending beyond shared vulnerability, including individual-specific environmental experiences or causal pathways.

Correspondence to: Melissa A. Munn-Chernoff, Ph.D., Department of Psychiatry, University of North Carolina at Chapel Hill, Chapel Hill, NC 27599, Phone: 984-974-3788, Fax: 984-974-3781, melissa_chernoff@med.unc.edu.

The authors do not have any conflicts of interest to report.

Keywords

cotwin-control design; early substance use; eating disorders; bulimia; sexual intercourse

INTRODUCTION

Early substance use has been associated with a higher risk for substance use disorders (SUDs) (Grant and Dawson 1997; Robins and Przybeck 1985), yet the extent to which early substance use is related to other forms of psychopathology more prevalent in women, such as eating disorders, is uncertain. Findings from the few existing reports are inconsistent. One study (Tomeo et al. 1999) reported that experimenting with cigarettes was associated with engaging in weight control behaviors in early- or mid-adolescence, while another (Zaider et al. 2002) found that alcohol, cigarette, and illicit substance use in late adolescence was not associated with incident eating disorder symptoms. Clinically, women with eating disorders are more likely to use alcohol and drugs and to meet criteria for SUDs than women without eating disorders. This is particularly true for those who engage in binge eating (i.e., eating a large amount of food in a short period of time and having a sense of loss of control) and compensatory behaviors (e.g., self-induced vomiting) (Dansky et al. 2000; Gadalla and Piran 2007). Importantly, comorbid eating disorders and SUDs are associated with many negative outcomes (Dansky et al. 2000); women with bulimia nervosa (hence engaging in binge eating and compensatory behaviors; herein referred to as bulimic behaviors) and alcohol dependence are also more likely to have other drug dependence, major depression, suicidality, and engage in unsafe sex than women with only bulimia nervosa or alcohol dependence (Duncan et al. 2006). Understanding the relation between bulimic behaviors and early substance use is critical to elucidate female correlates of substance use involvement, an often underrepresented area of research.

It has been hypothesized that bulimic behaviors and substance use co-occur because of a shared etiology (Wolfe and Maisto 2000). While classical twin studies suggest that bulimic behaviors are associated with problem substance use and SUDs via shared genetic and environmental mechanisms (Baker and Munn-Chernoff 2014), it is unknown whether after accounting for this shared familial liability, there is a residual link between bulimic behaviors and substance use involvement. Such a residual association might reflect individual-specific influences than contribute to both bulimic behaviors and substance use. One study design that can parse familial and individual-specific influences is the cotwin-control method, which examines differences on an outcome (e.g., bulimic behaviors) between members within a twin pair discordant for an exposure (e.g., early substance use). Identical or monozygotic (MZ) twins are generally examined as they share 100% of their genes identical-by-descent and are presumed to share 100% of their familial environments. Therefore, in an MZ twin pair discordant for exposure, any residual increase in likelihood of an outcome in the exposed versus unexposed twin is attributed to individual-specific environmental factors that influence both exposure and outcome. By contrast, fraternal or dizygotic (DZ) twins have roughly 50% of their genes identical-by-descent and 100% of their shared environment in common. Thus, residual associations in discordant DZ twin pairs could be attributable to genetic and/or non-genetic individual-specific environmental

factors. Although only discordant MZ twins contribute to determining the presence of individual-specific influences (Agrawal et al. 2004; Kendler et al. 1993), a comparison of the association between exposure and outcome in MZ versus DZ pairs discordant for exposure can provide clues regarding the relative role of genetic and familial environmental influences.

In the addiction literature, discordance for early exposure to specific substances has been examined for its relationship with use and misuse of other substances, as well as other behavioral and psychopathological outcomes, while accounting for shared familial factors. Early substance use is often linked to a host of individual-specific environmental influences (e.g., peer affiliations; Fergusson et al. 1995) that may result in onsets of other maladaptive behaviors. In addition, there is mounting evidence that early and repeated exposure to substances may result in brain-related alterations that have lasting consequences (Jacobus and Tapert 2013). The most consistent finding emerging from this study design indicates that, even in MZ twin pairs, early onset cannabis use (typically, prior to age 17) is associated with an increased likelihood of subsequent experimentation and problems with other illicit drugs (Agrawal et al. 2004; Lynskey et al. 2003, 2006). A less consistent finding has linked early onset alcohol use to later alcohol dependence. For instance, while an early study by Prescott and Kendler (1999) reported that this association was entirely attributable to shared familial liabilities, others (Grant et al. 2006) found that relative to their non-early regular drinker cotwins, twins who drank alcohol regularly before age 17 were significantly more likely to meet criteria for alcohol and other drug abuse/dependence.

A similar discordant paradigm has also been used to examine the comorbidity between cannabis involvement and major depression, as well as suicidal thoughts and behaviors (Grant et al. 2012; Lynskey et al. 2004). Results have suggested that even after accounting for familial liabilities, suicide attempts are more common in twins exposed to cannabis at an early age relative to their unexposed cotwins (Lynskey et al. 2004). However, only one study has used discordant twins to test possible associations between bulimic behaviors and substance use. Bulik and colleagues (2000) reported no significant difference in the odds ratio (OR) for alcohol dependence between MZ cotwins with bulimia nervosa, versus those without, suggesting that this association is entirely attributable to shared familial liabilities and that individual-specific environmental factors unique to exposed twins may not be a contributor. Although this latter study yielded important insights into possible mechanisms contributing to the association between bulimic behaviors and SUDs, inferences were limited by the small sample size (n=10–20), narrow range of substance involvement evaluated, and focus on bulimia nervosa diagnosis rather than bulimic behaviors, which are thought to be the key link between the eating disorder-SUD comorbidity (Gadalla and Piran 2007). Additionally, the authors examined whether alcohol dependence was associated with bulimia nervosa but did not examine whether this relationship extended to early onset of alcohol and other substance use, which typically occurs prior to or concurrent with bulimic behaviors. Disentangling the role of shared familial liabilities from individual-specific influences on early substance use and bulimic behaviors would not only articulate how these behaviors might be coupled during adolescence but also inform prevention and treatment of both behaviors in women.

We examined the association between bulimic behaviors and early substance use (i.e., alcohol, nicotine, and cannabis) in a cross-sectional sample of young adult female twins. We used the cotwin-control method to control for genetic and familial environmental factors common to both twins that might contribute to this association. Any observed differences between discordant, particularly MZ, twins would suggest that: (1) individual-specific environmental factors not shared between members of a twin pair likely contribute to the association between bulimic behaviors and early substance use, or (2) the early substance use and bulimic behaviors association may be due to confounding via a third unmeasured variable. In light of Problem Behavior Theory (Jessor and Jessor 1977), which posits that early substance use, early sexual activity -- and more recently, poor dietary practices (Jessor 1998) -- share similar etiologic mechanisms, we also examined the association between bulimic behaviors and early consensual sexual intercourse to assess whether any observed associations were specific to substance use or were an indicator of early risky behaviors more broadly.

MATERIALS AND METHODS

Participants

Participants were 3540 young adult women (3034 European American (EA) and 506 African American (AA)) from the first full-length follow-up assessment of the Missouri Adolescent Female Twin Study (MOAFTS) (Heath et al. 2002; Waldron et al. 2013). The MOAFTS is a population-based longitudinal survey of female twins born between July 1st 1975 and June 30th 1985 in Missouri to a mother who was a state resident and is demographically representative of the Missouri population. Nearly 15% of twins self-identifying as AA and almost all remaining twins self-identifying as being of European descent. Twins were initially recruited using a cohort sequential sampling design, with ascertainment of successive 6-month cohorts of 13, 15, 17, and 19 year old twin pairs over a two year period and continued recruitment of 13 year olds over an additional two years. A baseline interview was conducted with twins in 1995 (median age=15). The first full-length young adult follow-up interview (Wave 4) was conducted about six years after the baseline assessment (median age=22). Since all members of the target cohort were at least 18 years old and study participation was no longer contingent upon parental consent, all individuals from the original sampling frame were invited to participate in Wave 4, even if they had not participated at baseline, unless the twin herself had refused future contact or parents had refused all future contact with family members. Despite the longitudinal design of the MOAFTS, we included cross-sectional data from Wave 4 only because (a) some twins who participated at baseline did not complete the Wave 4 assessment (n=151 twin pairs); (b) a new cohort of individuals who did not participate at baseline completed the Wave 4 assessment (n=424 twin pairs) (Waldron, 2013); and (c) the baseline assessment did not query bulimic behaviors and only the older adolescents were asked about cannabis use and consensual sexual intercourse. Out of 1999 EA and 370 AA twin pairs originally identified from birth records, a total of 1517 (76%; 853 MZ, 664 DZ) EA and 253 (68%; 111 MZ, 142 DZ) AA complete twin pairs completed the Wave 4 assessment and were therefore included in this study. Zygosity was assigned based on standard questions (Nichols and Bilbro 1966) that have shown approximately 95% agreement with genotyping methods (Eaves et al.

1989). The protocol was approved by the Washington University School of Medicine Institutional Review Board, and all twins gave verbal informed consent before study participation.

Measures

A telephone interview using an adaptation of the Semi-Structured Assessment for the Genetics of Alcoholism (SSAGA) (Bucholz et al. 1994) assessed DSM-IV lifetime criteria for psychopathology, including eating disorder symptoms and diagnoses; substance use, abuse, and dependence; and sexual intercourse. The SSAGA has demonstrated good validity and reliability for SUDs (Bucholz et al. 1994); however, psychometric properties of the eating disorders assessment have not been evaluated.

Bulimic Behaviors—Women were coded positive for lifetime bulimic behaviors if they reported ever engaging in binge eating or compensatory behaviors. Individuals were coded positive for binge eating if they answered yes to both questions: “Has there ever been a time in your life when you went on eating binges – eating a large amount of food in a short period of time, usually less than 2 hours?” and “During these binges, were you afraid you could not stop eating or that your eating was out of control?” Women were coded positive for compensatory behaviors if they endorsed any of the following questions, “In order to lose weight or prevent weight gain (or to make up for your eating binge), did you ever: make yourself vomit; take laxatives; diet strictly; fast- that is, not eat anything at all; exercise vigorously for a long time; or take water pills or diuretics?”, where each compensatory behavior was queried separately. Questions were asked about compensatory behaviors regardless of the twin’s response to the binge eating questions, as there is evidence suggesting that a large proportion of clinically significant eating pathology is missed by following skip rules (Swanson et al. 2014). More information about the eating disorder assessment can be found elsewhere (Duncan et al. 2007).

Early Substance Use—Age 15 was used as the cut-off to define early use based on findings on conduct disorder suggesting that this age cut-off may be capturing more deviant behavior than earlier age cutoffs (Robins 1966). We examined eight early substance use variables. Early alcohol use was defined two ways: (1) ever having a full drink of alcohol before age 15, and (2) having an alcoholic drink on at least six separate days or drinking at least one drink each week for eight weeks in a row before age 16 (early regular alcohol use). Early nicotine use was defined three ways: (1) ever smoking before age 15; and among those who tried nicotine, (2) smoking at least once per week for at least two months in a row before age 16 (early regular nicotine use), and (3) smoking daily or nearly every day for at least two months in a row before age 16 (early daily nicotine use). Early cannabis experimentation was defined by whether the individual ever used cannabis before age 15. Two additional variables were created: (1) ever using nicotine and/or cannabis before age 15 (any early nicotine or cannabis experimentation), and (2) ever using alcohol, nicotine, or cannabis before age 15 (any early substance experimentation). Twins were divided into four groups based on whether one or both cotwins reported early substance use for between-family comparisons: 1) Concordant Unexposed (i.e., twin and cotwin do not report early substance use); 2) Discordant Unexposed (i.e., twin does not report early substance but

cotwin does); 3) Discordant Exposed (i.e., twin reports early substance use but cotwin does not); and 4) Concordant Exposed (i.e., twin and cotwin report early substance use).

Early Sex—Early sex was defined as having engaged in consensual sexual intercourse before age 15 and was examined two ways. First, early sex was included as a covariate because it has been associated with substance use (Zimmer-Gembeck and Helfand 2008). Second, it was evaluated for an association with bulimic behaviors to assess whether any observed associations were specific to substance use or instead represents a general indicator of early risky behaviors.

Additional Covariates—Covariates included age and body mass index (BMI) (from Wave 4 assessment), as well as early menarche (menarche before age 12, based on distribution of our data and published evidence (Anderson et al. 2003)). Menarche was included as a covariate because it has been shown to be associated with bulimic behaviors and substance use (Dick et al. 2000; Zehr et al. 2007).

Statistical analyses

Data preparation and preliminary analyses were conducted in SAS (SAS Institute 1999). Logistic regressions were conducted in STATA (StataCorp 2005) using a robust variance estimator to adjust for the non-independence of twin data.

To investigate whether genetic and shared environmental influences partly explain associations between bulimic behaviors and early substance use or early sex, we computed the prevalence of bulimic behaviors for concordantly unexposed or exposed and discordant MZ and DZ twin pairs, where the exposure was early risky behaviors. If the exposed twin from discordant pairs was less likely to report bulimic behaviors than the concordantly exposed twins, then the role of familial influences would be suggested (i.e., a protective effect from an unexposed cotwin). Under this model, one would also expect higher rates of bulimic behaviors in the unexposed members of the discordant pairs, relative to members of concordant unexposed pairs (i.e., increased risk associated with having an exposed cotwin).

Additionally, MZ twin pairs discordant for each exposure variable were examined to determine whether early risky behaviors were associated with bulimic behaviors after accounting for genetic and shared environmental influences. Since members of an MZ twin pair share 100% of their genetic makeup and their shared environment, any observed differences between these discordant twins (i.e., an MZ OR significantly greater than 1) is due to individual-specific environmental factors. As detailed elsewhere (Agrawal et al. 2004; Grant et al. 2012), the association between bulimic behaviors and early risky behaviors could result from (1) correlated familial factors that contribute to both phenotypes (expected discordant MZ OR=1); (2) a third unmeasured individual-specific factor that contributes to both phenotypes but is not shared by members of the twin pair (expected discordant MZ OR>1); or (3) a combination of the two (expected discordant MZ OR>1 but less than discordant DZ and general population OR). Conditional logistic regression analyses examined whether the twin who reported the early risky behavior had higher odds of engaging in bulimic behaviors than her cotwin who did not engage in the early risky behavior, after accounting for genetic and shared environmental effects. Although the

zygosity-by-exposure group interaction was not significant (*p*-values>.05), allowing us to combine MZ and DZ twins into one group for analyses, we also examined discordant MZ twin pairs separately for completeness.

Given the large number of tests performed, we used a Bonferroni correction to adjust the *p*-value based on the number of risky behaviors examined (i.e., alcohol, nicotine, cannabis, and sexual intercourse). Thus, the adjusted *p*-value is .013 (.05/4). For all analyses, we tested for racial/ethnic differences in bulimic behaviors for each risky behavior group. Since results were non-significant (*p*>.05), we have reported combined analyses for EA and AA women.

RESULTS

Descriptive statistics

In the full sample of 3540 twins, nicotine use had the lowest age of onset (mean (sd)=14.39 (3.52) years), followed by alcohol (16.99 (2.78) years) and cannabis (19.28 (3.45) years). The mean age at first sex was 16.85 (2.68) years. Significant differences in mean BMI (*p*=.001), BMI categories (omnibus *p*=.01), early menarche (*p*=.02), early sex (*p*<.0001), and all eating disorder symptoms (*p*≤.01) were detected between women who reported substance experimentation before age 15 and those who did not, with higher means and percentages among women reporting early substance experimentation (Table 1). A very high proportion (90%) of those reporting any early substance experimentation reported first nicotine use before age 15 (Table 1). There were moderate tetrachoric correlations among the early substance use variables, as well as between these variables and early sex (.25–.36).

Individual-based associations between exposure groups and outcome

Results of logistic regression analyses using MZ and DZ twins within the general study population (i.e., not taking into account cotwin exposure status) are presented in Table 2. There was a significant association between bulimic behaviors and all early substance use variables in Model 1, with 5 of 8 remaining significant after adjusting for relevant covariates (Model 3). The strongest association was with early regular alcohol use. There was also a significant association between bulimic behaviors and early sex after adjusting for zygosity (Model 1), but not for other relevant covariates (Model 3).

Taking into account respondent and cotwin exposure history, the prevalence of bulimic behaviors was generally similar and highest in the concordant exposed and exposed twins from discordant pairs, followed by unexposed twins from discordant pairs and then concordant unexposed twins (Table 3; Table S1). This pattern is consistent with a model in which the likelihood of engaging in bulimic behaviors increases as exposure to early risky behaviors increases and was the same whether we included MZ and DZ twins together or separately.

In general, among MZ and DZ twin pairs and for all risky behaviors, after controlling for relevant covariates, concordant unexposed twins had the lowest odds for bulimic behaviors, followed by discordant unexposed twins, with discordant exposed twins and concordant exposed twins having the highest risk and not differing from each other (Table S2; Model

3). This pattern of results indicates that both the respondent's own risk and her cotwin's exposure status (i.e., familial influences) are associated with the development of bulimic behaviors.

Conditional logistic regression analyses

Finally, we examined within-pair differences in bulimic behaviors among twin pairs discordant for early risky behaviors after adjusting for age, BMI, early menarche, and other early risky behaviors. Among both MZ and DZ twins (Table 4), the cotwin who used alcohol for the first time before age 15 had significantly higher odds of reporting bulimic behaviors compared with her twin sister who was not an early alcohol experimenter (Model 3 OR, 95% confidence interval=1.93, 1.22–3.05). Similarly, the cotwin who reported any substance experimentation (i.e., alcohol, nicotine, or cannabis) before age 15 had significantly higher odds of engaging in bulimic behaviors than her twin sister who did not report any early substance experimentation (Model 3: 1.62, 1.15–2.28). Although results also provided some evidence for higher odds of bulimic behaviors among cotwins who reported early regular alcohol use (Model 1: 2.64, 1.32–5.28; Model 2: 2.85, 1.39–5.83) or early nicotine experimentation (Model 2: 1.53, 1.10–2.15) than their non-early using cotwins, the findings did not remain significant after additional adjustment for other early risky behaviors (Model 3).

Since discordant MZ twins alone provide the best estimate of individual-specific environmental effects, we also examined associations between bulimic behaviors and early risky behaviors in this subgroup (Table 5). Even after adjusting for covariates, the MZ cotwin who used alcohol for the first time before age 15 had 3.21 (1.54–6.67; Model 3) higher odds of bulimic behaviors than her MZ cotwin who did not report early alcohol experimentation, suggesting that early alcohol experimentation may contribute to the development of bulimic behaviors via factors common to bulimic behaviors and early alcohol use but unshared by members of a twin pair. Whether including MZ and DZ discordant twins together or MZ discordant twins alone, no other significant differences were observed between bulimic behaviors and early risky behaviors ($p \geq .013$).

DISCUSSION

We examined the association between bulimic behaviors and early use of alcohol, nicotine, and cannabis in young adult women after controlling for genetic and shared environmental factors common to both cotwins. To test the specificity of findings, we also examined whether there was an association between bulimic behaviors and early sex. There was evidence for individual-specific environmental factors (or an unmeasured confounding variable) contributing to the association between bulimic behaviors and alcohol experimentation before age 15 and between bulimic behaviors and any substance experimentation before age 15. This residual association could also indicate a causal link between early alcohol use and bulimic behaviors, although we would need longitudinal data preceding the onset of both behaviors and extending into adulthood to demonstrate support for this hypothesis. Despite the MOAFTS being a longitudinal cohort, data on bulimic

behaviors was not collected at baseline, thus limiting our ability to draw such causal inferences.

After accounting for genetic and shared environmental factors, as well as relevant covariates (age, BMI, early menarche, and early sex), bulimic behaviors were increased among women who experimented with alcohol or any substance before age 15 but not among those with early nicotine or cannabis experimentation. Notably, the association between bulimic behaviors and any early substance experimentation may be driven by the significant association with alcohol, as evidenced by a lack of association between bulimic behaviors and any early nicotine/cannabis experimentation. These results corroborate findings from one study (Krahn et al. 1996) showing an association between dieting and ever using alcohol in adolescence, but not others (Tomeo et al. 1999; Zaider et al. 2002), investigating associations between eating disorder symptoms and early substance use. Furthermore, one investigation using discordant twins to examine the association between eating disorders and substance use did not find higher rates of alcohol dependence in cotwins who had bulimia nervosa compared with their cotwins who did not (Bulik et al. 2000), which is similar to our findings regarding early regular drinking. Taken together, it is possible that the association between bulimic behaviors and alcohol use differs depending on level of alcohol involvement. Early alcohol initiation may have a causal effect on bulimic behaviors by predisposing individuals to misuse food, thereby representing an initial vulnerability factor. Bulimic behaviors and heavier/problematic use of alcohol may then constitute correlated risks, as has been identified with classical twin studies, the previous cotwin-control study on alcohol dependence (Bulik et al. 2000), and our findings on early regular alcohol use.

It is hypothesized that personality traits, such as impulsivity or novelty seeking, underlie the relationship between bulimic behaviors and alcohol use (Wolfe and Maisto 2000) since they are separately associated with bulimic behaviors and substance use (Dick et al. 2010; Pearson et al. 2014). However, our findings suggest that early alcohol experimentation, but not early experimentation with other substances or early sex, is associated with bulimic behaviors. If impulsivity or novelty seeking were important, we would have expected to observe similar, if not stronger, associations with nicotine and cannabis as well as early sexual intercourse, all of which have been linked to disinhibition (Lynskey et al. 1998). Similarly, if peers, who are likely to experiment with more than just one substance, influenced the association between bulimic behaviors and early alcohol experimentation, we would have expected the twin who reported early nicotine or early cannabis experimentation to also have significantly higher rates of bulimic behaviors than her cotwin who did not report early experimentation. However, this was not the case. Finally, because we did not see a similar association between bulimic behaviors and early sex, the observed relationship is unlikely to represent early transitions to precocious behaviors in general (Fergusson et al. 1994).

Our findings are most robust for alcohol, especially its first use. One reason for this substance specificity may be the route of administration (i.e., ingestive), as both food and alcohol are dietary in nature; thus, these behaviors may more exclusively complement or substitute for each other. Substances with a similar route of administration are more likely to be co-used (Agrawal and Lynskey 2009) and may invoke similar pathways of reward. Both

food and alcohol have caloric implications, in contrast to smoking, which is associated with weight management (White 2012). The substance specificity could also be due to food and alcohol activating similar neuronal responses in sucrose taste receptors (Lemon et al. 2004). Indeed, research has shown that alcohol-preferring rats tend to consume higher concentrations of sucrose than non-alcohol-preferring animals and that the link between the consumption of sweet foods, which are common among individuals who binge eat, and alcohol intake may be at least partly genetic (Kampov-Polevoy et al. 1999). A final possibility for the specificity might be that epigenetic mechanisms (i.e., factors that regulate gene expression independent of DNA sequence) influence the association between bulimic behaviors and early alcohol experimentation. Although highly speculative, one putative gene is neuropeptide Y (NPY), given its involvement in food and alcohol consumption (Bailer and Kaye 2003; Thiele et al. 1998). It is possible that exposure to alcohol early in adolescence influences NPY expression, which then impacts binge eating or that events occurring earlier in life, such as childhood abuse, alter NPY expression (Feder et al. 2009), which then influences both binge eating and early alcohol intake. However, considerably more research is needed to articulate the pathophysiology underlying the link between bulimic behaviors and early alcohol use.

Our study was unique because, by including twins discordant for early substance use, we controlled for a shared familial liability that may contribute to the bulimic behaviors-substance use association. Still, there were some limitations. First, individuals may not have been through the risk period for bulimic behaviors at the time of assessment. Although this is less true for EA women, since the peak onset is 16–18 years old (Stice et al. 1998), the average ages of onset for bulimia nervosa and binge eating in AA women have been reported to be approximately 21 and 23 years old, respectively (Taylor et al. 2007). Second, due to differences in the wording of questions between the eating disorder and substance use sections in the diagnostic interview, ages of onset for bulimic behaviors are less clear than ages of onset for substance use, and in general, were contemporaneous. This lack of temporal resolution further limited our ability to examine potential causal hypotheses of early substance use and early sex on bulimic behaviors.

Findings suggest that after controlling for genetic and shared environmental factors, female twins who report alcohol experimentation before age 15 were significantly more likely to report bulimic behaviors than their twin sisters who did not use alcohol early. Although the precise mechanism(s) contributing to the association between bulimic behaviors and early alcohol experimentation are unknown, these results highlight the importance of screening for eating problems and substance use in early adolescence since interventions targeting early substance use prevention may have the additional benefit of reducing unhealthy dieting practices, including bulimic behaviors.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

This work is supported by NIH grants: R01 DA023668, R21 AA021235 (AA); and R01 HD049022, R01 AA009022, R01 AA017915, R01 AA021492, R37 AA007728, P50 AA011988, K05 AA017688, T32 AA007580 (ACH).

References

Agrawal A, Lynskey MT. Tobacco and cannabis co-occurrence: does route of administration matter? Drug Alcohol Depend. 2009; 99:240–247. [PubMed: 18926646]

Agrawal A, Neale MC, Prescott CA, Kendler KS. A twin study of early cannabis use and subsequent use and abuse/dependence of other illicit drugs. Psychol Med. 2004; 34:1227–1237. [PubMed: 15697049]

Anderson SE, Dallal GE, Must A. Relative weight and race influence average age at menarche: results from two nationally representative surveys of US girls studied 25 years apart. Pediatrics. 2003; 111:844–850. [PubMed: 12671122]

Bailer UF, Kaye WH. A review of neuropeptide and neuroendocrine dysregulation in anorexia and bulimia nervosa. Curr Drug Targets CNS Neurol Disord. 2003; 2:53–59. [PubMed: 12769812]

Baker, JH.; Munn-Chernoff, MA. Genetic vulnerability to eating disorders and substance use disorders. In: Brewerton, TD.; Dennis, AB., editors. Eating Disorders, Addictions and Substance Use Disorders. Springer-Verlag; Berlin Heidelberg: 2014. p. 91-106.

Bucholz KK, Cadoret R, Cloninger CR, Dinwiddie SH, Hesselbrock VM, Nurnberger JI, Reich T, Schmidt I, Schuckit MA. A new, semistructured psychiatric interview for use in genetic-linkage studies: a report on the reliability of the SSAGA. J Stud Alcohol. 1994; 55:149–158. [PubMed: 8189735]

Bulik CM, Wade TD, Kendler KS. Characteristics of monozygotic twins discordant for bulimia nervosa. Int J Eat Disord. 2000; 29:1–10.

Dansky BS, Brewerton TD, Kilpatrick DG. Comorbidity of bulimia nervosa and alcohol use disorders: results from the National Women's Study. Int J Eat Disord. 2000; 27:180–190. [PubMed: 10657891]

Dick DM, Rose RJ, Viken RJ, Kaprio J. Pubertal timing and substance use: associations between and within families across late adolescence. Dev Psychol. 2000; 36:180–189. [PubMed: 10749075]

Dick DM, Smith G, Olausson P, Mitchell SH, Leeman RF, O'Malley SS, Sher K. Understanding the construct of impulsivity and its relationship to alcohol use disorders. Addict Biol. 2010; 15:217–226. [PubMed: 20148781]

Duncan AE, Bucholz KK, Neuman RJ, Agrawal A, Madden PA, Heath AC. Clustering of eating disorder symptoms in a general population female twin sample: a latent class analysis. Psychol Med. 2007; 37:1097–1107. [PubMed: 17472759]

Duncan AE, Neuman RJ, Kramer JR, Kuperman S, Hesselbrock VM, Bucholz KK. Lifetime psychiatric comorbidity of alcohol dependence and bulimia nervosa in women. Drug Alcohol Depend. 2006; 84:122–132. [PubMed: 16455211]

Eaves, LJ.; Eysenck, HJ.; Martin, NG. Genes, culture and personality: an empirical approach. Academic Press; London: 1989.

Feder A, Nestler EJ, Charney DS. Psychobiology and molecular genetics of resilience. Nat Rev Neurosci. 2009; 10:446–457. [PubMed: 19455174]

Fergusson DM, Horwood LJ, Lynskey MT. The comorbidities of adolescent problem behaviors: a latent class model. J Abnorm Child Psychol. 1994; 22:339–354. [PubMed: 8064037]

Fergusson DM, Lynskey MT, Horwood LJ. The role of peer affiliations, social, family and individual factors in continuities in cigarette smoking between childhood and adolescence. Addiction. 1995; 90:647–659. [PubMed: 7795501]

Gadalla T, Piran N. Co-occurrence of eating disorders and alcohol use disorders in women: a meta analysis. Arch Womens Ment Health. 2007; 10:133–140. [PubMed: 17533558]

Grant BF, Dawson DA. Age at onset of alcohol use and its association with DSM-IV alcohol abuse and dependence: results from the National Longitudinal Alcohol Epidemiologic Survey. J Subst Abuse. 1997; 9:103–110. [PubMed: 9494942]

Grant JD, Scherrer JF, Lynskey MT, Agrawal A, Duncan AE, Haber JR, Heath AC, Bucholz KK. Associations of alcohol, nicotine, cannabis, and drug use/dependence with educational attainment: evidence from cotwin-control analyses. Alcohol Clin Exp Res. 2012; 36:1412–1420. [PubMed: 22587016]

Grant JD, Scherrer JF, Lynskey MT, Lyons MJ, Eisen SA, Tsuang MT, True WR, Bucholz KK. Adolescent alcohol use is a risk factor for adult alcohol and drug dependence: evidence from a twin design. Psychol Med. 2006; 36:109–118. [PubMed: 16194286]

Heath AC, Howells W, Bucholz KK, Glowinski AL, Nelson EC, Madden PA. Ascertainment of a mid-western US female adolescent twin cohort for alcohol studies: assessment of sample representativeness using birth record data. Twin Res. 2002; 5:107–112. [PubMed: 11931688]

Jacobus J, Tapert SF. Neurotoxic effects of alcohol in adolescence. Annu Rev Clin Psychol. 2013; 9:703–721. [PubMed: 23245341]

Jessor, R. New perspectives on adolescent risk behavior in New perspectives on adolescent risk behavior. Jessor, R., editor. Cambridge University Press; New York: 1998. p. 1-10.

Jessor, R.; Jessor, SL. Problem behavior and psychosocial development: a longitudinal study of youth. Academic Press; New York: 1977.

Kampov-Polevoy AB, Garbutt JC, Janowsky DS. Association between preference for sweets and excessive alcohol intake: a review of animal and human studies. Alcohol Alcohol. 1999; 34:386–395. [PubMed: 10414615]

Kendler KS, Neale MC, MacLean CJ, Heath AC, Eaves LJ, Kessler RC. Smoking and major depression. A causal analysis. Arch Gen Psychiatry. 1993; 50:36–43. [PubMed: 8422220]

Krahn D, Piper D, King M, Olson L, Kurth C, Moberg DP. Dieting in sixth grade predicts alcohol use in ninth grade. J Subst Abuse. 1996; 8:293–301. [PubMed: 8934435]

Lemon CH, Brasser SM, Smith DV. Alcohol activates a sucrose-responsive gustatory neural pathway. J Neurophysiol. 2004; 92:536–544. [PubMed: 14985409]

Lynskey MT, Fergusson DM, Horwood LJ. The origins of the correlations between tobacco, alcohol, and cannabis use during adolescence. J Child Psychol Psychiatry. 1998; 39:995–1005. [PubMed: 9804032]

Lynskey MT, Glowinski AL, Todorov AA, Bucholz KK, Madden PA, Nelson EC, Statham DJ, Martin NG, Heath AC. Major depressive disorder, suicidal ideation, and suicide attempt in twins discordant for cannabis dependence and early-onset cannabis use. Arch Gen Psychiatry. 2004; 61:1026–1032. [PubMed: 15466676]

Lynskey MT, Heath AC, Bucholz KK, Slutske WS, Madden PA, Nelson EC, Statham DJ, Martin NG. Escalation of drug use in early-onset cannabis users vs co-twin controls. JAMA. 2003; 289:427–433. [PubMed: 12533121]

Lynskey MT, Vink JM, Boomsma DI. Early onset cannabis use and progression to other drug use in a sample of Dutch twins. Behav Genet. 2006; 36:195–200. [PubMed: 16402286]

Nichols RC, Bilbro WC Jr. The diagnosis of twin zygosity. Acta Genet Stat Med. 1966; 16:265–275. [PubMed: 4959152]

Pearson CM, Riley EN, Davis HA, Smith GT. Two pathways toward impulsive action: an integrative risk model for bulimic behavior in youth. J Child Psychol Psychiatry. 2014; 55:852–864. [PubMed: 24673546]

Prescott CA, Kendler KS. Age at first drink and risk for alcoholism: a noncausal association. Alcohol Clin Exp Res. 1999; 23:101–107. [PubMed: 10029209]

Robins, LN. Deviant Children Grown Up. The Williams & Wilkins Company; Baltimore: 1966.

Robins LN, Przybeck TR. Age of onset of drug use as a factor in drug and other disorders. NIDA Res Monogr. 1985; 56:178–192. [PubMed: 3929100]

SAS User's Guide [computer program] Version 82. Cary, NC: SAS Institute, Inc; 1999.

Stata Statistical Software [computer program] Release 9. College Station, TX: StataCorp LP; 2005.

Stice E, Killen JD, Hayward C, Taylor CB. Age of onset for binge eating and purging during late adolescence: a 4-year survival analysis. J Abnorm Psychol. 1998; 107:671–675. [PubMed: 9830254]

Swanson SA, Brown TA, Crosby RD, Keel PK. What are we missing? The costs versus benefits of skip rule designs. Int J Methods Psychiatr Res. 2014; 23:474–485. [PubMed: 24030679]

Taylor JY, Caldwell CH, Baser RE, Faison N, Jackson JS. Prevalence of eating disorders among Blacks in the National Survey of American Life. Int J Eat Disord. 2007; 40(Suppl):S10–S14. [PubMed: 17879287]

Thiele TE, Marsh DJ, Ste ML, Bernstein IL, Palmiter RD. Ethanol consumption and resistance are inversely related to neuropeptide Y levels. Nature. 1998; 396:366–369. [PubMed: 9845072]

Tomeo CA, Field AE, Berkey CS, Colditz GA, Frazier AL. Weight concerns, weight control behaviors, and smoking initiation. Pediatrics. 1999; 104:918–924. [PubMed: 10506235]

Waldron M, Bucholz KK, Lynskey MT, Madden PA, Heath AC. Alcoholism and timing of separation in parents: findings in a midwestern birth cohort. J Stud Alcohol Drugs. 2013; 74:337–348. [PubMed: 23384382]

White MA. Smoking for weight control and its associations with eating disorder symptomatology. Compr Psychiatry. 2012; 53:403–407. [PubMed: 21741037]

Wolfe WL, Maisto SA. The relationship between eating disorders and substance use: moving beyond co-prevalence research. Clin Psychol Rev. 2000; 20:617–631. [PubMed: 10860169]

Zaider TI, Johnson JG, Cockell SJ. Psychiatric disorders associated with the onset and persistence of bulimia nervosa and binge eating disorder during adolescence. J Youth Adolesc. 2002; 31:319–329.

Zehr JL, Culbert KM, Sisk CL, Klump KL. An association of early puberty with disordered eating and anxiety in a population of undergraduate women and men. Horm Behav. 2007; 52:427–435. [PubMed: 17707381]

Zimmer-Gembeck MJ, Helfand M. Ten years of longitudinal research on US adolescent sexual behavior: developmental correlates of sexual intercourse, and the importance of age, gender and ethnic background. Dev Rev. 2008; 28:153–224.

Table 1

Sample characteristics (results shown as n (percentages) unless otherwise indicated).

	Any Early Substance Experimentation (*n*=1393–1403)	No Early Substance Experimentation (*n*=2118–2134)	*p*
Sample Characteristics			
Age (mean (sd))	21.73 (0.09)	21.52 (0.08)	.07
Monozygotic	740 (53.46)	1178 (55.20)	.40
BMI (mean (sd))	24.63 (0.20)	23.87 (0.14)	**.001**
BMI Categories			**.01**
Underweight	75 (5.37)	157 (7.38)	
Normal Weight	851 (60.92)	1344 (63.19)	
Overweight	255 (18.25)	373 (17.54)	
Obese	216 (15.46)	253 (11.89)	
Early Menarche[a]	305 (21.82)	390 (18.41)	**.02**
Early Sex[b]	264 (18.95)	57 (2.67)	**<.0001**
Eating Disorder Symptoms			
Binge Eating	51 (3.66)	46 (2.17)	**.01**
Compensatory Behaviors	370 (26.45)	369 (17.30)	**<.0001**
Purging Behaviors	166 (11.87)	146 (6.84)	**<.0001**
Non-purging Behaviors	321 (22.94)	325 (15.23)	**<.0001**
Bulimic Behaviors	382 (27.40)	385 (18.19)	**<.0001**
Substance Use History			
Early Alcohol Experimentation[c]	527 (37.59)	---	---
Early Regular Alcohol Use[d]	144 (10.30)	---	---
Early Nicotine Experimentation[e]	1257 (89.59)	---	---
Early Regular Nicotine Use[f]	407 (29.11)	---	---
Early Daily Nicotine Use[g]	297 (21.20)	---	---
Early Cannabis Experimentation[h]	242 (17.29)	---	---
Any Early Nicotine/Cannabis Experimentation[i]	1281 (91.30)	---	---

Note. sd = standard deviation; BMI = body mass index. Statistically significant effects are bolded.

[a] Age of onset of menarche before age 12.

[b] First consensual sexual intercourse before age 15.

[c] Ever having a full drink of alcohol before age 15.

[d] Having an alcoholic drink on at least six separate days or dinking at least one drink each week for eight weeks in a row before age 16.

[e] Ever smoking before age 15.

[f] Smoking at least once per week for at least two months in a row before age 16.

[g] Smoking daily or nearly every day for at least two months in a row before age 16.

[h] Ever using cannabis before age 15.

[i] Ever using nicotine or cannabis before age 15.

Table 2

Individual-based associations between bulimic behaviors and early risky behaviors.

	N (in twins)	Model 1[1]	Model 2[2]	Model 3[3]
Early Alcohol Experimentation	3532	**1.86 (1.50– 2.31)***	**1.91 (1.54– 2.38)***	**1.57 (1.23– 2.01)***
Early Regular Alcohol Use	3518	**2.27 (1.60– 3.23)***	**2.48 (1.73– 3.56)***	**1.91 (1.30– 2.80)***
Early Nicotine Experimentation	3526	**1.61 (1.35– 1.91)***	**1.58 (1.33– 1.88)***	**1.37 (1.13– 1.66)***
Early Regular Nicotine Use	3510	**1.64 (1.29– 2.07)***	**1.65 (1.30– 2.10)***	1.32 (1.01– 1.72)*
Early Daily Nicotine Use	3518	**1.56 (1.19– 2.03)***	**1.56 (1.19– 2.05)***	1.18 (0.87– 1.60)
Early Cannabis Experimentation	3526	**1.78 (1.33– 2.38)***	**1.77 (1.32– 2.38)***	1.16 (0.84– 1.61)
Any Early Nicotine/Cannabis Experimentation	3538	**1.61 (1.35– 1.91)***	**1.58 (1.33– 1.88)***	**1.38 (1.14– 1.68)***
Any Early Substance Experimentation	3534	**1.70 (1.43– 2.01)***	**1.68 (1.42– 2.00)***	**1.65 (1.38– 1.97)***
Early Sex	3508	**1.58 (1.22– 2.05)***	1.39 (1.07– 1.81)*	1.01 (0.75– 1.35)

Note. 95% confidence intervals are presented in parentheses. Statistically significant effects that survive Bonferroni correction ($p<.013$) are bolded.

*Significant before Bonferroni correction ($p<.05$).

[1]Adjusted for zygosity.

[2]Adjusted for zygosity, age, BMI, and early menarche.

[3]Adjusted for zygosity, age, BMI, early menarche, and other early risky behaviors (three out of four early alcohol experimentation, early nicotine experimentation, early cannabis experimentation, early sex- excluding the early risky behavior that was used as the exposure variable).

Table 3

Bulimic behaviors by concordant/discordant exposure of early risky behaviors in the total sample (ns and percentages [in parentheses] are given).

	N (in twins)	Bulimic Behaviors
Early Alcohol Experimentation		
Concordant Unexposed	2718	536 (19.87)
Discordant Unexposed	288	64 (22.30)
Discordant Exposed	288	96 (33.45)
Concordant Exposed	238	70 (29.79)
Early Regular Alcohol Use		
Concordant Unexposed	3236	674 (20.98)
Discordant Unexposed	116	28 (24.14)
Discordant Exposed	116	46 (40.35)
Concordant Exposed	50	16 (32.00)
Early Nicotine Experimentation		
Concordant Unexposed	1830	327 (18.04)
Discordant Unexposed	439	97 (22.20)
Discordant Exposed	439	127 (29.06)
Concordant Exposed	818	213 (26.20)
Early Regular Nicotine Use		
Concordant Unexposed	2872	582 (20.43)
Discordant Unexposed	202	47 (23.38)
Discordant Exposed	202	55 (27.50)
Concordant Exposed	234	75 (32.05)
Early Daily Nicotine Use		
Concordant Unexposed	3026	617 (20.55)
Discordant Unexposed	181	54 (30.00)
Discordant Exposed	181	54 (30.17)
Concordant Exposed	130	37 (28.46)
Early Cannabis Experimentation		
Concordant Unexposed	3144	648 (20.76)
Discordant Unexposed	142	40 (28.17)
Discordant Exposed	142	51 (35.92)
Concordant Exposed	98	26 (26.53)
Any Early Nicotine/Cannabis Experimentation		
Concordant Unexposed	1818	323 (17.97)
Discordant Unexposed	440	98 (22.37)
Discordant Exposed	440	127 (29.00)
Concordant Exposed	840	218 (26.11)
Any Early Substance Experimentation		
Concordant Unexposed	1678	290 (17.44)
Discordant Unexposed	454	95 (21.02)

	N (in twins)	Bulimic Behaviors
Discordant Exposed	454	128 (28.38)
Concordant Exposed	948	253 (26.86)
Early Sex		
Concordant Unexposed	2994	611 (20.57)
Discordant Unexposed	193	52 (27.08)
Discordant Exposed	193	57 (29.69)
Concordant Exposed	128	38 (29.92)

Table 4

Within-pair contrasts for monozygotic and dizygotic twin pairs discordant for early risky behaviors.

	N (in pairs)	Model 1[1]	Model 2[2]	Model 3[3]
Early Alcohol Experimentation	288	**1.89 (1.26– 2.83)***	**2.08 (1.36– 3.17)***	**1.93 (1.22– 3.05)***
Early Regular Alcohol Use	116	**2.64 (1.32– 5.28)***	**2.85 (1.39– 5.83)***	2.54 (1.22– 5.29)*
Early Nicotine Experimentation	439	1.51 (1.09– 2.10)*	**1.53 (1.10– 2.15)***	1.38 (0.97– 1.95)
Early Regular Nicotine Use	202	1.31 (0.78– 2.18)	1.32 (0.77– 2.25)	1.16 (0.67– 2.02)
Early Daily Nicotine Use	181	1.00 (0.59– 1.68)	0.99 (0.58– 1.71)	0.86 (0.49– 1.52)
Early Cannabis Experimentation	142	1.55 (0.88– 2.72)	1.49 (0.84– 2.64)	1.00 (0.53– 1.89)
Any Early Nicotine/Cannabis Experimentation	440	1.48 (1.07– 2.04)*	1.49 (1.07– 2.08)*	1.34 (0.95– 1.89)
Any Early Substance Experimentation	454	**1.59 (1.14– 2.22)***	**1.62 (1.15– 2.28)***	**1.62 (1.15– 2.28)***
Early Sex	193	1.17 (0.71– 1.92)	1.16 (0.70– 1.91)	0.94 (0.55– 1.61)

Note. In all comparisons, the non-early using cotwin is the referent group. 95% confidence intervals are presented in parentheses. Statistically significant effects that survive Bonferroni correction ($p<.013$) are bolded.

*Significant before Bonferroni correction ($p<.05$).

[1]Unadjusted model.

[2]Adjusted for age, BMI, and early menarche.

[3]Adjusted for age, BMI, early menarche, and other early risky behaviors (three out of four early alcohol experimentation, early nicotine experimentation, early cannabis experimentation, early sex- excluding the early risky behavior that was used as the exposure variable).

Table 5

Within-pair contrasts for monozygotic twin pairs discordant for early risky behaviors.

	N (in pairs)	Model 1[1]	Model 2[2]	Model 3[3]
Early Alcohol Experimentation	135	**2.62 (1.38– 5.00)***	**3.24 (1.63– 6.43)***	**3.21 (1.54– 6.67)***
Early Regular Alcohol Use	53	1.25 (0.49– 3.17)	1.55 (0.58– 4.12)	1.55 (0.58– 4.19)
Early Nicotine Experimentation	191	1.54 (0.92– 2.58)	1.61 (0.95– 2.74)	1.42 (0.82– 2.49)
Early Regular Nicotine Use	95	1.07 (0.52– 2.22)	1.03 (0.48– 2.21)	0.79 (0.35– 1.77)
Early Daily Nicotine Use	85	0.73 (0.34– 1.60)	0.66 (0.29– 1.47)	0.49 (0.20– 1.18)
Early Cannabis Experimentation	67	1.55 (0.67– 3.59)	1.42 (0.60– 3.35)	0.71 (0.26– 1.92)
Any Early Nicotine/Cannabis Experimentation	193	1.46 (0.89– 2.41)	1.51 (0.91– 2.53)	1.30 (0.76– 2.22)
Any Early Substance Experimentation	198	1.81 (1.06– 3.08)*	1.90 (1.10– 3.30)*	1.92 (1.10– 3.33)*
Early Sex	84	1.31 (0.64– 2.69)	1.30 (0.62– 2.74)	1.15 (0.51– 2.61)

Note. In all comparisons, the non-early using cotwin is the referent group. 95% confidence intervals are presented in parentheses. Statistically significant effects that survive Bonferroni correction ($p<.013$) are bolded.

*Significant before Bonferroni correction ($p<.05$).

[1]Unadjusted model.

[2]Adjusted for age, BMI, and early menarche.

[3]Adjusted for age, BMI, early menarche, and other early risky behaviors (three out of four early alcohol experimentation, early nicotine experimentation, early cannabis experimentation, early sex- excluding the early risky behavior that was used as the exposure variable).