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Season of Birth and Disordered Eating in a Population-Based Sample of Young U.S. Females

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Abstract

Objective—We used data from a population-based study of 9,039 adolescent and young adult females, followed prospectively since 1996 as part of the Growing Up Today Study (GUTS), to examine the relationship between season of birth and disordered eating in the U.S.

Methods—We tested whether the distribution of birth season and month differed for participants who had ever reported both underweight and dieting/weight concern symptoms ($n=134$) or both frequent bingeing and purging symptoms ($n = 77$) compared to other GUTS participants.

Results—The two disordered-eating groups had relative birth peaks in the fall and relative birth troughs in the summer compared to other GUTS participants, but only the fall peak was consistently statistically significant.

Discussion—It appears that U.S. females born in the fall are more likely to develop disordered eating and that age relative to the rest of their school-year cohort may account for some of this phenomenon.

A number of studies^{1–12} have examined the relationship between season of birth (SoB) and eating disorders, as described in a recent review by Winje et al.¹³ The studies^{1·4·5·7·9·11·12} that compare season of birth for individuals with anorexia nervosa (AN) and population-based controls suggest that there is an upward SoB bias in the spring months for individuals with AN in non-equatorial locations in both the Northern and Southern hemispheres, especially for early-onset and restrictive subtypes of AN.¹³ The few studies^{3·10·12} that compare season of birth for individuals with bulimia nervosa (BN) and population-based controls have had less consistent findings. One study³ found an upward SoB bias with a peak in July for individuals with BN who were born in or before 1963 but not in or after 1964, and an upward SoB bias in the spring months for individuals with BN who had previously had AN. In contrast, a second study¹⁰, conducted in the U.S., found an upward SoB bias in the fall months for individuals with BN, and a third study¹² did find any significant SoB biases for individuals with BN.

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Several additional studies^{14–17} have examined the relationship between season of birth and disordered eating, rather than clinical eating disorders. Most of the disordered eating studies group birth dates into intervals of four months or longer, instead of into months or three-month seasons as was done in the previously-cited eating disorder studies. One disordered eating study¹⁴ found a significant association between measures of restriction and body dissatisfaction and being born in warmer months. However, another study¹⁵ did not replicate this association, and, in general, these studies^{14–17} did not find significant associations between season of birth and numerous other measures of disordered eating, such as bulimia/binge eating and weight preoccupation. However, the total disordered eating score was elevated (albeit not significantly) in the last third of the year in both disordered eating studies conducted in the U.S.^{16,17}

Various geophysical, biological, and/or sociological explanations have been proposed for the spring SoB bias for AN (see Winje et al.¹³). A number of these explanations center on the role of temperature and sunlight at various time points ranging from conception to birth. Although some studies have found significant associations between greater restraint and higher temperatures at conception^{5,6} or birth^{14,18}, other studies have not observed any significant associations between various measures of disordered eating and temperature at birth¹⁵ or conception¹⁷.

Alternatively, a possible explanation for the potential fall SoB bias for BN¹⁰ and for the last-third SoB trend for disordered eating^{16,17} in the U.S. is that there are age cutoffs for school-year entry that typically occur in the late summer or early fall in the U.S.. Therefore, individuals born in the fall are usually the oldest children in their school-year cohort. Since season of birth is confounded with age relative to school-year cohort (henceforth referred to as “relative age”), and since relative age has been associated with a wide variety of educational, behavioral, and psychological and psychiatric outcomes^{19–26}, it is possible that relative age may account for at least some of the observed relationship between season of birth and disordered eating.

Unfortunately, the three studies^{10,16,17} that examined the relationship between season of birth and eating disorders / disordered eating in population-based samples in the U.S. did not examine the effects of relative age. Therefore, to fill this void, we used data from a population-based prospective study of adolescent and young adult U.S. females (the Growing Up Today Study (GUTS)), who have been followed since 1996, to examine the relationship between season of birth and disordered eating and to explore the relationship between relative age and disordered eating. Among these females we tested whether the proportion of births in each season and month differed for participants who had ever reported AN-like symptoms (being underweight and dieting/having weight concerns) or for participants who had ever reported BN-like symptoms (bingeing and purging frequently) during the study, compared to other GUTS participants. We also performed exploratory analysis examining whether relative age might explain some of the effect of season of birth on underweight and dieting/weight concern symptoms or on frequent bingeing and purging symptoms.

METHODS

Sample

GUTS was established in 1996 by recruiting children of women participating in the Nurses' Health Study II, an ongoing study that was established in 1989 and consists of 116,608 female nurses who were 25 to 43 years of age at enrollment. Additional details about the cohort have been reported previously.²⁷ Using data from the Nurses' Health Study II, we identified mothers who had children who were 9 to 14 years of age. We wrote a detailed

letter to the mothers, explaining the purpose of GUTS and seeking parental consent to enroll their children. Children whose mothers gave consent to invite them to participate were mailed an invitation letter and a questionnaire. Additional details have been reported previously.²⁸ Approximately 68% of the females ($n=9,039$) returned completed questionnaires, thereby assenting to participate in the GUTS cohort. From Fall 1996 to Fall 2003, GUTS participants received a questionnaire assessing a variety of factors every 12 to 24 months. The participants were children and adolescents (9–15 years of age) at baseline and became older adolescents and adults (16–23 years of age) during the course of the study. The study was approved by the Human Subjects Committee at Brigham and Women's Hospital, and the analyses presented herein were approved by the institutional review boards at Brigham and Women's Hospital and Children's Hospital Boston, both in Boston, Massachusetts.

Predictor Measures

The questionnaires included questions that made it possible to determine the birth month, birth season, and relative age for the GUTS females. Participants reported their exact date of birth on each questionnaire, but only information on birth year and birth month were available for our analysis for reasons of confidentiality. Regarding birth year, all females in our analyses were born between 1980–1987. Regarding birth month, we grouped birth months into birth seasons based on the following divisions, which represent the traditional seasonal divisions in the U.S.: Winter (December, January, February), Spring (March, April, May), Summer (June, July, August), and Fall (September, October, November). Also, in the 1999 survey, participants were asked “What grade/school level will you most likely be in next fall (fall of 2000)?” Responses ranged from 7th grade to a senior in college. When combined with the information on participants' birth month and year, these responses allowed us to determine participants' approximate relative age, specifically the approximate number of months difference between their date of birth and the median date of birth for all GUTS females in the relevant school year. Birth month and birth year was available for all GUTS females, but relative age could be calculated for only 78.8% of the GUTS females either because they were working rather than in school at the time of the 1999 questionnaire (0.1%) or because information on their school level was missing (21.2%).

Although there are other predictor variables (e.g., ethnicity, geographical region) that may interact with season of birth and/or relative age in their effect on disordered eating outcomes, we did not include any predictor variables other than season of birth or relative age in our analyses because of limited statistical power.

Outcome Measures

The questionnaires also included a number of questions relevant to disordered eating, which were used to determine membership in three disordered-eating groups (see below). Participants' body mass index (weight in kilograms divided by height in meters squared; BMI) was calculated using self-reported weight and height. For our analyses, women (females 18 years of age or older) were classified as underweight if their self-reported BMI was less than or equal to 17.5.²⁹ Girls (females younger than 18 years of age) were classified as underweight based on the international BMI cutoff³⁰ (calculated using the lmsGrowth³¹ add-in for Microsoft Excel) corresponding to the -1.7 Z-score of age- and sex-specific BMI values; the -1.7 Z-score was chosen because it corresponds to a BMI of 17.5 at 18 years of age. Weight concern was assessed with 4 questions adapted from the McKnight Risk Factor Survey (MRFS)³² that asked participants how often or much (“never”, “a little”, “sometimes”, “a lot”, or “always/totally”) they had felt fat, thought about wanting to be thinner, worried about having fat on their body, or worried about gaining 2 pounds, in the past year. For our analyses, females who on average responded to these

questions with “a lot” or “always/totally” were classified as having high weight concern. Weight control behaviors (dieting and purging) were assessed with questions adapted from the Youth Risk Behavior Surveillance System questionnaire³³. Dieting was assessed by asking participants how often during the past year they dieted to lose weight or to keep from gaining weight. For our analyses, females who reported that they had dieted to lose or maintain weight with any frequency other than “never” were classified as dieting. Purging was assessed by asking participants two questions: how often during the past year (“never”, “less than monthly”, “1–3 times a month”, “once per week”, “2–6 times per week”, “daily”) they made themselves throw up to lose or maintain weight, and how often during the past year they took laxatives to lose or maintain weight. For our analyses, females who reported that they vomited or used laxatives to lose or maintain weight “once per week”, “2–6 times per week”, or “daily” were classified as purging frequently. Binge eating was assessed with a two-part question. Participants were first asked about how often during the past year (“never”, “less than monthly”, “1–3 times a month”, “once a week”, “more than once a week”) they ate a very large amount of food. Participants who reported at least occasional episodes of overeating were directed to a follow-up question that asked whether they felt out of control during these episodes, like they could not stop eating even if they wanted to stop. Binge eating was defined as eating a very large amount of food in a short amount of time and feeling out of control during the eating episode. For our analyses, females who reported that they binge ate “once a week” or “more than once a week” were classified as bingeing frequently. Both the binge eating and purging questions have been validated in the GUTS cohort.³⁴

We used responses to the above questions to determine membership in the disordered-eating groups (“underweight and dieting/weight concern” and “frequent bingeing and purging”) that were our outcomes of interest. First, for each year in which a questionnaire was sent out (1996, 1997, 1998, 1999, 2000, 2001, and 2003), we determined whether each female was classified as having underweight and dieting/weight concern symptoms (i.e., she was classified as underweight *and* was either classified as dieting *or* as having high weight concern) and/or as having frequent bingeing and purging symptoms (i.e., she was classified as bingeing frequently *and* as purging frequently). For the year 2000, dieting and high weight concern information from 1999 were used because they were not assessed in the 2000 questionnaire. Second, females who were classified as having underweight and dieting/weight concern symptoms in *any* of the seven survey years comprised the underweight and dieting/weight concern group, and females who were classified as having frequent bingeing and purging symptoms in *any* of the seven survey years comprised the frequent bingeing and purging group. The small number of females ($n = 6$) who belonged to both disordered-eating groups were included in analyses for each group rather than being treated as their own separate group. (The latter approach was used in one study³ that identified a different SoB pattern for individuals with BN based on whether or not they had a history of AN.) Finally, because the aforementioned spring SoB bias for AN is thought to be greater for early-onset AN¹³, we identified from among the underweight and dieting/weight concern group those females who reported those symptoms in *any* survey year prior to 15 years of age, who then comprised the early-underweight and dieting/weight concern subgroup. (We used a cutoff of age 15 to be consistent with the original study¹ of season of birth and AN.)

Statistical Analysis

For our primary analyses of birth month and season, we compared (1) the overall pattern of birth seasons, (2) each individual birth season versus the other birth seasons, (3) the overall pattern of birth months, and (4) each individual birth month versus the other birth months, for (a) the underweight and dieting/weight concern group versus all “other” GUTS participants not in the underweight and dieting/weight concern group, (b) the early-

underweight and dieting/weight concern subgroup versus all “other” GUTS participants not in the early-underweight and dieting/weight concern subgroup, and (c) the frequent bingeing and purging group versus all “other” GUTS participants not in the frequent bingeing and purging group. We used Fisher's exact test to perform each of the above comparisons, with p-values calculated using 10,000 simulations rather than enumeration for the tests of overall patterns of birth months or seasons (1 and 3). In addition, we used Roger's test of cyclical seasonality³⁵ to compare the overall pattern of birth months (3). We chose to use Fisher's exact test because it is nonparametric and Roger's test because its use was recommended in a comprehensive review of the relationship between season of birth and eating disorders¹³. Further, we chose to compare the three “disordered-eating” groups to all “other” female GUTS participants rather than to the general U.S. population, because the other GUTS participants were similar or identical to the disordered-eating participants with respect to certain variables (e.g., maternal profession) that may affect seasonal birth patterns, thereby eliminating potential sources of systematic or random error.

We also performed two secondary sets of analyses of birth season and month in order to address potential limitations of the analyses described above. First, although Fisher's exact test (and Roger's test) are intended for use with independent observations, approximately 25% of the GUTS females shared the same mother, which can result in Type I error rates greater than their nominal level. In order to address the dependence between the GUTS females, we used generalized estimating equations (GEE)^{36,37} to fit logistic regression models for the effect of birth month or birth season on membership in the underweight and dieting/weight concern group, early-underweight and dieting/weight concern subgroup, or frequent bingeing and purging group, to see whether the estimates and p-values changed when using an exchangeable correlation structure instead of ignoring dependence. Second, Fisher's exact test (and Roger's test) ignore birth year instead of comparing birth month or season for females with and without disordered eating who are born in the same year. In general, birth patterns should not change much from year to year over such a short time period (i.e., 1980–1987). However, in our data the birth patterns for the years 1981–1982 and 1987 were different than for the years 1983–1986 because of the age cutoffs used to determine eligibility for GUTS. In order to make sure that this artifact of selection did not bias the results of our comparisons (although we would not expect it to because the age cutoffs were applicable to all participants regardless of whether or not they were in the disordered-eating groups), we used logistic regression as described above, but with and without adjustment for birth year to see how estimates and p-values changed. One female born in 1980 was excluded from the logistic regression analyses because she was the only female born in that year.

For our exploratory analyses of relative age, we calculated an odds ratio (OR) for membership in each of the three disordered-eating groups for higher (i.e., above median) relative age participants born in August and September versus lower (i.e., below median) relative age participants born in August or September, and then used Fisher's exact test to test whether the OR differed from one. We limited our comparison to participants born in August and September because August and September were the two months with the greatest variability in relative age (due to the typical U.S. school-year entry cutoff). In addition, limiting the analysis to two adjacent months allowed us to compare the effects of relative age on disordered eating while controlling for the potentially confounding effect of season of birth. Participants born in August (September) were classified as having higher relative age if they were approximately six (five) months older than the median relative age for their school year and were classified as having lower relative age if they were approximately six (seven) months younger than the median relative age for their school year. Any participants born in August (or September) who were more than six (or five) months older than the median relative age, or less than six (or seven) months younger than

the median relative age, were excluded because their relative age suggested that they had been held back or skipped one or more school year. Although our relative age analyses ignore the dependence between females who shared the same mother, we would not expect this to result in inflated Type I errors because such a small proportion (approximately 2%) of the GUTS females born in August and September shared the same mother.

RESULTS

Of the 9039 GUTS females, 1.5% ($n = 134$) were in the underweight and dieting/weight concern group; the remaining 98.5% ($n = 9805$) females did not report both underweight and dieting/weight concern symptoms in any of the questionnaire years for which information on these symptoms was available. Of the 134 females in the underweight and dieting/weight concern group, 86 (64%) reported these symptoms before they were 15 years of age and were thus in the early-underweight and dieting/weight concern subgroup. Further, 0.85% ($n = 77$) of the 9039 GUTS females were in the frequent bingeing and purging group; the remaining 99.1% ($n = 8962$) females did not report both frequent bingeing and frequent purging symptoms in any of the questionnaire years for which information on these symptoms was available. As noted, six females belonged to both the underweight and dieting/weight concern and the frequent bingeing and purging groups.

Figure 1 displays the proportion of females born in each month, for all females in the GUTS cohort and for each of the disordered-eating groups. Examination of the figure reveals that the females in the GUTS cohort are not equally likely to be born in every month (January and February are the months with the lowest proportions of births). Further, the figure suggests that females in each of the disordered-eating groups are less likely to be born in the summer and more likely to be born in the early fall than females in the GUTS cohort overall. Table 1 presents information from our primary analyses of individual birth months and individual birth seasons for the three disordered-eating groups. Recall that these analyses used *other* GUTS females (all GUTS females *except* those in the relevant disordered-eating group) as controls, whereas Columns 14 and 15 of Table 1, and also Figure 1, present information for *all* GUTS females (females in the disordered-eating groups included). Table 1 reveals that, for all disordered-eating groups compared to other GUTS females, there was a relative birth peak in the fall (October and November for all groups, and also September for the underweight and dieting/weight concern groups) and a relative birth trough in the summer (especially July for all groups), although only the relative birth peak in the fall consistently reached statistical significance.

In our primary analyses of birth month and season for the underweight and dieting/weight concern group, the difference between the overall pattern of birth seasons and the pattern for other GUTS participants approached statistical significance (Fisher's $p = 0.09$), and the relative fall peak was significant ($OR = 1.54$, Fisher's $p = 0.03$) but the relative summer trough was not ($OR = 0.69$, Fisher's $p = 0.11$). Also for the underweight and dieting/weight concern group, the overall pattern of birth months was not significantly different from the pattern for other GUTS participants according to Fisher's exact test (Fisher's $p = 0.58$) or to Roger's test of seasonality ($\chi^2 = 4.22$, $df = 2$, $p = 0.13$; estimated relative birth peak in October), and none of the results for the individual months were significant (see Table 1, Column 5).

In our primary analyses of birth month and season for the early-underweight and dieting/weight concern subgroup, the difference between the overall pattern of birth seasons and the pattern for other GUTS participants approached statistical significance (Fisher's $p = 0.06$), and the relative fall peak was significant ($OR = 1.78$, Fisher's $p = 0.02$) but the relative summer trough was not ($OR = 0.71$, Fisher's $p = 0.22$). Also for the early-underweight and

diETING/weight concern subgroup, the overall pattern of birth months was not significantly different from the pattern for other GUTS participants according to Fisher's exact test (Fisher's $p = 0.59$), although it approached statistical significance according to Roger's test of seasonality ($\chi^2 = 5.30$, $df = 2$, $p = 0.08$; estimated relative birth peak in October), and none of the results for the individual months were significant (see Table 1, Column 9).

In our primary analyses of birth month and season for the frequent bingeing and purging group, the overall pattern of birth seasons was not significantly different from the pattern for other GUTS participants (Fisher's $p = 0.15$) nor was the relative summer trough ($OR = 0.64$, Fisher's $p = 0.15$), but the relative fall peak was significant ($OR = 1.70$, Fisher's $p = 0.03$). Also for the frequent bingeing and purging group, the difference between the overall pattern of birth months and the pattern for other GUTS participants approached statistical significance according to Fisher's exact test (Fisher's $p = 0.06$) but not Roger's test of seasonality ($\chi^2 = 1.50$, $df = 2$, $p = 0.48$; estimated relative birth peak in December), and the relative October peak ($OR = 2.30$, Fisher's $p = 0.01$) and relative July trough ($OR = 0.14$, Fisher's $p = 0.02$) were both significant (see Table 1, Column 13, for the p -values for other individual months).

Turning to our secondary analyses of birth month and season, using GEE to fit logistic regression models produced estimates and p -values (for the effect of birth season or birth month on membership in each of the disordered-eating groups) that were similar to those described above, regardless of whether the dependence between other GUTS females who shared the same mother was ignored or represented by an exchangeable correlation matrix. In fact, using an exchangeable correlation matrix resulted in effectively identical results as when dependence was ignored. Further, logistic regression produced similar results regardless of whether or not birth year was adjusted for in the regression model; in general, adjusting for year made the aforementioned summer and fall SoB biases larger in magnitude for the underweight and dieting/weight concern group and early-underweight and dieting/weight concern subgroup but smaller in magnitude for the frequent bingeing and purging group. In general, a significant upward fall SoB bias was found for each of the disordered-eating groups regardless of how we analyzed the data, whereas the downward summer SoB bias was much less significant and robust.

Regarding our exploratory analyses of relative age, the ORs for older versus younger relative age were 1.78 (Fisher's $p = 0.19$), 3.56 (Fisher's $p = 0.04$), and 0.19 (Fisher's $p = 0.11$) for the underweight and dieting/weight concern group, the early-underweight and dieting/weight concern subgroup, and the frequent bingeing and purging group, respectively. These results suggest that older relative age is associated with greater odds of underweight and dieting/weight concern symptoms, significantly so if they occur before age fifteen, and potentially associated with lower odds of frequent bingeing and purging symptoms.

DISCUSSION

Regarding season of birth, our results suggest that there is an upward SoB bias in the fall and possibly a downward SoB bias in the summer for U.S. females with underweight and dieting/weight concern symptoms or with frequent bingeing and purging symptoms. In particular, the upward fall SoB bias was most robust to method of analysis. The fall peak in our data is consistent with the studies previously conducted in the U.S.: A study¹⁰ of BN found a significant upward SoB bias in the fall, and two studies^{16,17} of disordered eating found that total scores for various measures of disordered eating were always highest for individuals born in the last third of the year, albeit not significantly so. However, these other studies^{10,16,17} performed in the U.S. did not find a summer trough. As for the studies conducted outside the U.S., most did not find a fall SoB peak or summer SoB trough for

either AN or BN, with the exception of two studies^{11,12}. A study¹¹ of AN found an upward SoB bias in October (as well as in the spring months) for individuals born before 1964, and in a study¹² of AN and BN, there was an upward (but not significant) SoB bias for the fourth quarter and a downward (but not significant) SoB bias for the third quarter for individuals with BN (but not AN). Interestingly, in our study there is no suggestion of an upward spring SoB bias for the underweight and dieting/weight concern group, in contrast with the studies of AN conducted in non-equatorial regions outside the U.S., which consistently found an upward SoB bias in the spring. There is a number of potential explanations for the lack of upward spring SoB bias for the underweight and dieting/weight concern group in our data: a lack of a spring SoB bias for AN in the U.S.; different etiological factors for clinical AN than for the underweight and dieting/weight concern symptoms we used; and random variation, especially given the limited size of our sample.

Regarding explanations for the SoB bias, our results do not support the hypothesis that higher temperatures at the time of conception are responsible for the SoB bias for disordered eating in the U.S. since females born in the fall would have been conceived in the period of the year with lowest temperatures, regardless of where in the U.S. they were conceived. As for our new hypothesis that relative age plays a role in the SoB bias for disordered eating in the U.S., our results suggest that older relative age may play a role in underweight and dieting/weight concern symptoms, especially if they occur before 15 years of age, but that, if anything, younger relative age plays a role in frequent bingeing and purging symptoms. An association between relative age and disordered eating would not be surprising given the wide variety of outcomes with which relative age has been associated to date. Greater relative age has been associated with performance-based outcomes such as better long-term academic performance internationally¹⁹, more leadership roles in high school in the U.S.²⁰, and greater representation in national-level youth soccer in Europe²¹, *inter alia*. More relevantly, however, greater relative age has been associated with more behavior problems in U.S. children and adolescents^{22,23} and with higher psychiatric symptom scores in Norwegian adolescent girls²⁴, although younger relative age has been associated with more psychiatric problems of any type in British children and adolescents²⁵, more problems with peers in Norwegian adolescents²⁴, and a greater likelihood of suicide in Canadian children and adolescents.²⁶ In relation to disordered-eating outcomes, relative age could influence outcomes through a variety of potential mechanisms. For example, the oldest girls in a school-year cohort are on average larger and more developed than their peers during the years when growth and sexual maturation are occurring, potentially making them more likely to develop various risk factors for disordered eating (e.g., dieting in response to dissatisfaction with increase adipose tissue). These potential mechanisms would be similar to those hypothesized to play a role in the association between early menarche and disordered eating, an association that has been demonstrated in some but not all studies.^{38–40}

As with any study, ours is not without limitations. First, all data on participants was self-reported. However, the questions on binge eating and purging have been validated³⁴, and, among the females, the specificity and negative predictive values of self-reported binge eating and purging were high, suggesting that the questionnaire was an excellent tool for identifying females who did not binge or purge. Further, studies examining the accuracy of self-reported height and weight suggest that in general populations they are reasonably accurately reported for normal weight and underweight individuals (but not overweight and obese individuals)⁴¹ and that in eating disorder populations height is reasonably accurately reported but weight is overestimated by individuals with anorexia nervosa⁴². Thus, the number of individuals with high weight concern who were erroneously categorized as underweight is likely to be small. Second, for reasons of confidentiality, we had data on birth month but not birth day, which limited the precision of our analysis. Third, despite

performing a large number of tests in our analysis, we did not perform corrections for multiple comparisons because power to detect SoB bias was already low due to the low prevalence of underweight and dieting/weight concern symptoms and frequent bingeing and purging symptoms and because standard approaches to correction were not appropriate for our analyses. Fourth, because of survey non-response, some females were missing data relevant to determining membership in the disordered-eating groups. However, we would not expect different results if we had treated the missing data differently for two reasons. To begin, it is unlikely that survey non-response depended on the combination of birth month/season and disordered-eating group (although it may have depended on disordered-eating group on its own), and, further, any female who was missing data for the year(s) in which she would have reported disordered-eating symptoms was included in the “other” GUTS participants comparison group, meaning that any relative SoB bias for the disordered-eating groups was likely attenuated rather than exaggerated. A related point is that the “other” GUTS participants comparison group also included some females who reported disordered-eating symptoms that were not sufficiently severe to qualify them for membership in the disordered-eating groups. Again, however, the presence of females with disordered-eating symptoms in our comparison group would likely attenuate rather than exaggerate results. Further, many of the previous studies of season of birth have used the general population, which of course contains some individuals with eating disorders or disordered eating, as controls in their analyses.

Fifth and finally, it is possible that our analysis of relative age was confounded by other factors. In general, the effects of relative age can be confounded with the effects of season of birth or with the effects of variables influencing school retention (i.e., being held back a year), both of which have been shown to be associated with psychiatric outcomes. Confounding by season of birth can be addressed by making use of geographical differences in school-year entry cutoffs, a naturally-occurring experiment that effectively randomizes relative age and allows estimation of its *causal* effects. We addressed confounding by season of birth by limiting our relative age analyses to females born in August and September. However, we cannot assume that relative age among these females was determined solely by differences in school-year entry cutoffs because children can be held back one or more years before beginning kindergarten (referred to as “academic redshirting”⁴³) or after they have begun school. As a result, even though we removed the extremely relatively-old and extremely relatively-young females from our analysis of relative age, relative age was still unlikely to be entirely random in our study and, in some cases, was likely affected by characteristics of the participant that may play a role in disordered eating. Thus, we cannot confidently conclude that relative age has a causal effect on disordered-eating symptoms. Moreover, it is important to be very cautious in asserting that relative age is associated with disordered eating (let alone causally so) because the ORs in our analyses were based on small numbers of participants in the three disordered-eating groups: Out of the 418 (735) participants born in September and August with older (younger) relative ages, 11 (11), 8 (4), and 1 (9) were in the underweight and dieting/weight concern group, the early- underweight and dieting/weight concern subgroup, and frequent bingeing and purging group, respectively.

Our study has considerable strengths, especially the use of a population-based sample and the use of a comparison group that was well matched to the disordered-eating groups in terms of socio-demographic and other factors. In summary, our results, especially when combined with those of studies previously conducted in the U.S., suggest a relative birth peak in the fall for US females with disordered eating or eating disorders. Finally, our preliminary results regarding relative age suggest that it should be taken into consideration in future research on the relationship between season of birth and eating disorders.

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Proportion of US Females Born in Each Month, by Group **Figure 1.**

Proportion born in each month for all females in the study cohort, for females who ever reported underweight and dieting/weight concern symptoms during the study, for females who reported underweight and dieting/weight concern symptoms before age 15 during the study, and for females who ever reported frequent bingeing and purging symptoms during the study

Table 1

Month and season of birth for females who ever reported underweight and dieting/weight concern symptoms during the study, females who reported underweight and dieting/weight concern symptoms before age 15 during the study, females who ever reported frequent bingeing and purging symptoms during the study, and all females in the study cohort

	Underweight ^d and Dieting/Weight Concern ^b Group						Frequent Bingeing and Purging ^c Group						All Females	
	All			Onset Before Age 15			All						All	
	n	%	OR ^d	p ^e	n	%	OR ^d	p ^e	n	%	OR ^d	p ^e	n	%
Winter	32	23.9	1.04	0.84	21	24.4	1.07	0.80	16	20.8	0.87	0.69	2095	23.2
December	10	7.5	0.95	1.00	7	8.1	1.04	0.84	2	2.6	0.31	0.09	707	7.8
January	10	7.5	0.97	1.00	7	8.1	1.06	0.84	6	7.8	1.01	1.00	696	7.7
February	12	9	1.19	0.51	7	8.1	1.07	0.84	8	10.4	1.40	0.39	692	7.7
Spring	32	23.9	0.85	0.50	17	19.8	0.67	0.14	20	26.0	0.95	1.00	2433	26.9
March	9	6.7	0.72	0.45	4	4.7	0.49	0.19	5	6.5	0.69	0.55	822	9.1
April	11	8.2	0.91	0.88	6	7.0	0.76	0.70	9	11.7	1.36	0.42	806	8.9
May	12	9.0	1.01	1.00	7	8.1	0.91	1.00	6	7.8	0.86	1.00	805	8.9
Summer	26	19.4	0.69	0.11	17	19.8	0.71	0.22	14	18.2	0.64	0.15	2325	25.8
June	8	6	0.67	0.35	7	8.1	0.95	1.00	7	9.1	1.07	0.84	774	8.6
July	6	4.5	0.50	0.12	4	4.7	0.52	0.25	1	1.3	0.14	0.01	776	8.6
August	12	9	1.05	0.88	6	7	0.80	0.85	6	7.8	0.90	1.00	775	8.6
Fall	44	32.8	1.54	0.03	31	36.0	1.78	0.02	27	35.1	1.70	0.03	2186	24.2
September	15	11.2	1.42	0.20	10	11.6	1.48	0.24	5	6.5	0.78	0.83	742	8.2
October	15	11.2	1.42	0.20	11	12.8	1.66	0.11	13	16.9	2.30	0.01	739	8.2
November	14	10.4	1.39	0.25	10	11.6	1.56	0.22	9	11.7	1.57	0.20	705	7.8
Total	134				86				77				9039	

^a Underweight defined as having a body mass index equivalent to 17.5 or lower at age 18.

^b Weight concern defined as reporting dieting or reporting high concern about weight.

^c Frequent bingeing and purging defined as reporting bingeing and purging, one or more times per week each.

^d OR (odds ratio) = $\frac{\text{odds (born in given month or season versus other months or seasons | in symptom group)}}{\text{odds (born in given month or season versus other months or seasons | not in symptom group)}}$

^e p = p-value from two-sided Fisher's exact test of the null hypothesis that the above odds ratio equals one