Consumption of Soft Drinks and Hyperactivity, Mental Distress, and Conduct Problems Among Adolescents in Oslo, Norway

Lars Lien, MD, MSc, Nanna Lien, PhD, Sonja Heyerdahl, PhD, Magne Thoresen, PhD, and Espen Bjertness, PhD

Objectives. We examined whether high levels of consumption of sugar-containing soft drinks were associated with mental distress, hyperactivity, and conduct problems among adolescents.

Methods. A cross-sectional population-based survey was conducted with 10th-grade students in Oslo, Norway (n=5498). We used the Hopkins Symptom Checklist and the Strengths and Difficulties Questionnaire to assess mental health outcomes.

Results. There was a J-shaped dose–response relationship between soft drink consumption and mental distress, conduct problems, and total mental health difficulties score; that is, adolescents who did not consume soft drinks had higher scores (indicating worse symptoms) than those who consumed soft drinks at moderate levels but lower scores than those with high consumption levels. The relationship was linear for hyperactivity. In a logistic regression model, the association between soft drink consumption and mental health problems remained significant after adjustment for behavioral, social, and food-related variables. The highest adjusted odds ratios were observed for conduct problems among boys and girls who consumed 4 or more glasses of sugar-containing soft drinks per day.

Conclusions. High consumption levels of sugar-containing soft drinks were associated with mental health problems among adolescents even after adjustment for possible confounders. (*Am J Public Health.* 2006;96:1815–1820. doi:10.2105/AJPH.2004.059477)

Refined sugar has gained worldwide attention as a result of its possible adverse effects on conditions such as obesity and dental caries.[1] Evidence of the negative effects of sugar on mental health has not been as convincing,[2] although for many years parents and teachers have claimed that high sugar intakes lead to attention and conduct problems in children.[3–5] Norway has the highest soft drink consumption rate in the world, 115 L (245 pt) per inhabitant per year.[6] One of the primary ingredients in soft drinks is sugar, with an average soft drink containing 100 g/L.

Two ecological studies have shown a correlation between per capita sugar consumption levels and prevalence rates of depression.[7,8] In addition, in both a cross-sectional investigation and a cohort study, insulin resistance was found to be inversely linked to suicide rates and depression, probably as a consequence of increased serotonin concentrations.[9,10] To our knowledge, no population-based cross-sectional studies have analyzed the association between sugar consumption and mental health problems among adolescents.

Hypothesizing that Norwegian adolescents who consumed large quantities of sugar-containing soft drinks would tend to report more mental health problems than adolescents who consumed low or moderate amounts of such beverages, we examined the association between intake of soft drinks and mental distress, conduct problems, and hyperactivity, controlling for eating habits and social and behavioral variables.

METHODS

Data collection was conducted as part of the Oslo Health Study 2000–2001, a joint collaboration of the University of Oslo, the Norwegian Institute of Public Health, and the municipality of Oslo. The youth portion of the study included all 10th-grade students (aged 15–16 years) who appeared on the class lists of each school in Oslo County in the spring of 2000 and 2001.

Of the 8316 eligible students, 7343 (88.3%) were enrolled in the study. As a result of error associated with data coupling, information on gender was missing for 38 participants; these participants were excluded. Thus, participation rates among boys and girls were 86.1% (n=3611) and 90.6% (n=3694), respectively. The self-report questionnaires used in the study were completed during 2 school hours. The gender and age distributions among those who did not participate were the same as the distributions among those who took part.

Of the total of 7305 participants, 1758 (24.2%) were coded as minority students, defined here as both parents being born outside of Norway. Because food consumption patterns and mental health indicators among minority groups in Norway have been shown to be different from those of native Norwegians, we chose to exclude these minority adolescents. We were then left with 5547 (75.8%) students with least 1 parent born in Norway.

Dependent Variables

We used the 10-item Hopkins Symptom Checklist (HSCL-10) to measure mental distress. This instrument has been shown to have high reliability (Cronbach $\alpha=0.8$), and its correlations with other similar instruments, including the HSCL-90, are in the range of 0.87 to 0.97.[11–13] The 10 items included in the short version used here (assessed in terms of the past week) are as follows: feeling panicky, anxious, dizzy, tense, sleepless, sad, worthless, and hopeless; finding fault within the self; and finding everything a burden. Each item is rated on a scale ranging from 1

(not at all) to 4 (extremely). An average score of 1.85 or higher for the 10 items overall, corresponding to the 1.75 cutoff score for the HSCL-25, has been shown to be a valid predictor of mental distress among individuals aged 16 to 24 years.[13]

The Strengths and Difficulties Questionnaire assesses the mental health status of children and adolescents. This 25-item instrument contains 5 subscales: (1) Emotional Symptoms, (2) Conduct Problems, (3) Hyperactivity, (4) Peer Problems, and (5) Prosocial Behavior. Scores from the first 4 subscales are summed and used to calculate a total difficulties score. The questionnaire has been found to have acceptable internal consistency reliability values (mean Cronbach $\alpha=0.73$) and acceptable validity in terms of its effectiveness in independently diagnosing psychiatric disorders (mean odds ratio [OR]=6.2).[14,15]

We used 2 of the subscales, Hyperactivity and Conduct Problems, together with the total difficulties score. We did not include the Peer Problems and Prosocial Behavior subscales, because they were not directly relevant for the aim of our study, or the Emotional Symptoms subscale, because such symptoms were covered with the HSCL-10. Each subscale item is rated on a scale ranging from 1 (not correct) to 3 (completely correct). Similar to the practice in several earlier studies (including 1 Norwegian study), we set the cutoff point at the 90th percentile of sample scores.[16–18]

Explanatory Variable

The primary explanatory variable was consumption of sugar-containing soft drinks. Participants were asked, "How much do you normally drink cola or 'fizzy' drinks with sugar?" (This question had also been used in another study involving Norwegian adolescents.[19]) Response categories were as follows: seldom/never, 1 to 6 glasses per week, 1 glass per day, 2 to 3 glasses per day, or 4 glasses or more per day. A "glass" was defined as containing approximately 200 mL.

We assessed the possible confounding properties of food-related variables and adjusted these variables as necessary in a logistic regression model. We also assessed social and behavioral variables.

Breakfast and lunch consumption. Participants were asked, "How often do you eat breakfast, lunch, and dinner in an ordinary week?" They were more likely to report skipping breakfast and lunch than to report skipping dinner, and those who skipped breakfast and lunch were more likely to report increased soft drink consumption. Therefore, we elected to compare those consuming breakfast and lunch daily with those consuming breakfast and lunch less than daily.

Consumption of fruits/berries, chocolates/sweets, and potato chips. Participants were asked to rate the frequency with which they consumed these foods on a 6-category scale ranging from never/seldom to 3 times or more per day. These categories were dichotomized into consumption frequencies of 1 to 3 times per week or less and 4 to 6 times per week or more.

Parents' educational level. Statistics Norway registers data on the educational levels of all of the country's residents via the Norwegian Educational Standard coding system.[20] We used this system to link data on parents' educational levels with the data of our adolescent participants. Because only small numbers of parents had no formal education or had completed only primary school, these groups were classified together with those for whom completion of secondary school was their highest educational level. The 2 other groups were defined as those having completed fewer than 4 years of college and those having completed 4 years of college or more.

Family structure. Participants provided self-reported data on the type of family structure within which they lived. In the analyses, living with both parents was compared with all other forms of family structure.

Social support. As a means of assessing social support, participants completed items focusing on support received from family, friends, classmates, and teachers. Ratings were made on a scale ranging from completely agree (1) to completely disagree (4). Median ratings were used to dichotomize those at high and low levels of perceived social support.[21]

Alcohol use. Participants were asked (1) whether they had ever consumed alcohol, (2) whether they had ever been intoxicated, and (3) to indicate their alcohol intake (in terms of overall quantity) in the past year. We considered the question focusing on whether participants had even been intoxicated as more useful than the other 2 questions because almost all of the participants had consumed alcohol and we were more interested in the behavior of drunkenness than in the quantity of alcohol consumed. In particular, we were concerned about misclassification in terms of the quantification question. However, the correlation between the questions focusing on intoxication and quantity consumed was strong ($r=0.65$, $P<.01$).

Smoking status. This variable was dichotomized into participants who did not smoke and those who smoked daily or occasionally.

Statistical Analyses

We used SPSS version 11 (SPSS Institute, Chicago, Ill) to conduct the statistical analyses. We generated frequency tables and cross tabulations, and we calculated Pearson χ^2 tests and odds ratios using a logistic regression model. The level of significance was set at $P<.05$, and 95% confidence intervals (CIs) were calculated. We used consumption of 1 to 6 glasses of sugar-containing soft drinks per week as the reference category in the logistic regression model.

RESULTS

More than 1 in 4 girls and fewer than 1 in 10 boys had an HSCL-10 score above 1.85 (Table 1). More girls than boys had total difficulties and hyperactivity scores above the 90th percentile, whereas 10% of boys and 5% of girls had conduct problem scores above the 90th percentile.

Most of the participants consumed an average of between 1 and 6 glasses of sugar-containing soft drinks each week. However, there were marked differences according to gender: 21% of girls and 46% of boys consumed 1 glass or more every day (Table 2). A third of the participants' parents had completed only primary school or secondary school (Table 1). Almost 25% of parents were divorced; only 1% of the participants lived in foster homes. Sixty-four percent of boys had stopped smoking or had never smoked, and the corresponding figure for girls was 53%.

Among both male and female participants, mean HSCL-10 scores, mean total difficulties scores, and mean conduct problem scores took the form of J-shaped curves

TABLE 1—Prevalence Rates for Response Variables and Social/Behavioral Variables, by Gender: 15- and 16-Year-Old Students in Oslo, Norway, 2000–2001

	Boys (n = 2646), No. (%)	Girls (n = 2717), No. (%)	P[a]
Mental distress (HSCL-10 score > 1.85)	236 (8.7)	720 (25.8)	<.001
Hyperactivity (score > 90th percentile)	221 (8.2)	281 (10.1)	
Conduct problems (score > 90th percentile)	276 (10.2)	146 (5.4)	
Total difficulties score (> 90th percentile)	167 (6.2)	313 (11.2)	
Parental educational level			.85
College or more	587 (21.7)	585 (21.0)	
Some college	807 (29.8)	840 (30.1)	
Secondary/primary	910 (33.6)	929 (33.3)	
Family structure			.53
Lives with both parents	1991 (73.5)	2024 (72.6)	
All other family structures	684 (25.2)	732 (25.9)	
Social support			.59
High	1413 (52.1)	1474 (52.9)	
Low	1202 (44.4)	1217 (43.6)	
Ever been intoxicated	1156 (57.7)	1806 (64.7)	<.001
Smoking status			<.001
Never smoked	1730 (63.8)	1466 (52.6)	
Former or current smoker	969 (35.8)	1315 (47.1)	

Note. HSCL = Hopkins Symptom Checklist. Some percentages do not sum to 100 as a result of missing data.
[a]For the difference between boys and girls (Pearson χ^2 test).

TABLE 2—Prevalence Rates for Food-Related Variables, by Gender: 15- and 16-Year-Old Students in Oslo, Norway, 2000–2001

	Boys (n = 2646), No. (%)	Girls (n = 2717), No. (%)
Soft drink consumption		
Seldom/never	156 (5.8)	1633 (58.6)
1–6 glasses/wk	1306 (48.2)	542 (19.4)
1 glass/d	522 (19.3)	323 (11.6)
2–3 glasses/d	424 (15.7)	195 (7.0)
≥4 glasses/d	275 (10.2)	75 (2.7)
Potato chip consumption		
≤1–3 times/wk	2046 (75.5)	2378 (85.4)
≥3–4 times/wk	633 (23.4)	389 (13.8)
Consumption of chocolates/sweets		
≤1–3 times/wk	1360 (50.2)	1631 (58.5)
≥3–4 times/wk	1318 (48.7)	1136 (40.7)
Consumption of fruit and berries		
≤1–3 times/wk	1264 (46.7)	967 (34.7)
≥3–4 times/wk	1398 (51.6)	1785 (64.0)
Breakfast frequency		
Daily	1903 (52.9)	1697 (47.1)
Less than daily	793 (42.2)	1084 (57.7)
Lunch frequency		
Daily	1575 (70.3)	1364 (59.8)
Less than daily	1112 (29.3)	1413 (39.0)

Note. One glass = 200 ml. Some percentages do not sum to 100 as a result of missing data. All *P* values for differences between boys and girls (Pearson χ^2 tests) were significant at the .001 level.

when number of soft drinks was plotted on the x-axis (Figure 1); that is, adolescents who did not consume soft drinks had higher scores (indicating worse symptoms) than those who consumed soft drinks at moderate levels but lower scores than those who consumed soft drinks at high levels. The means were lowest for those consuming 1 to 6 glasses per week, after which means increased with increasing numbers of glasses consumed. There was a direct dose–response relationship between hyperactivity score and number of soft drinks consumed.

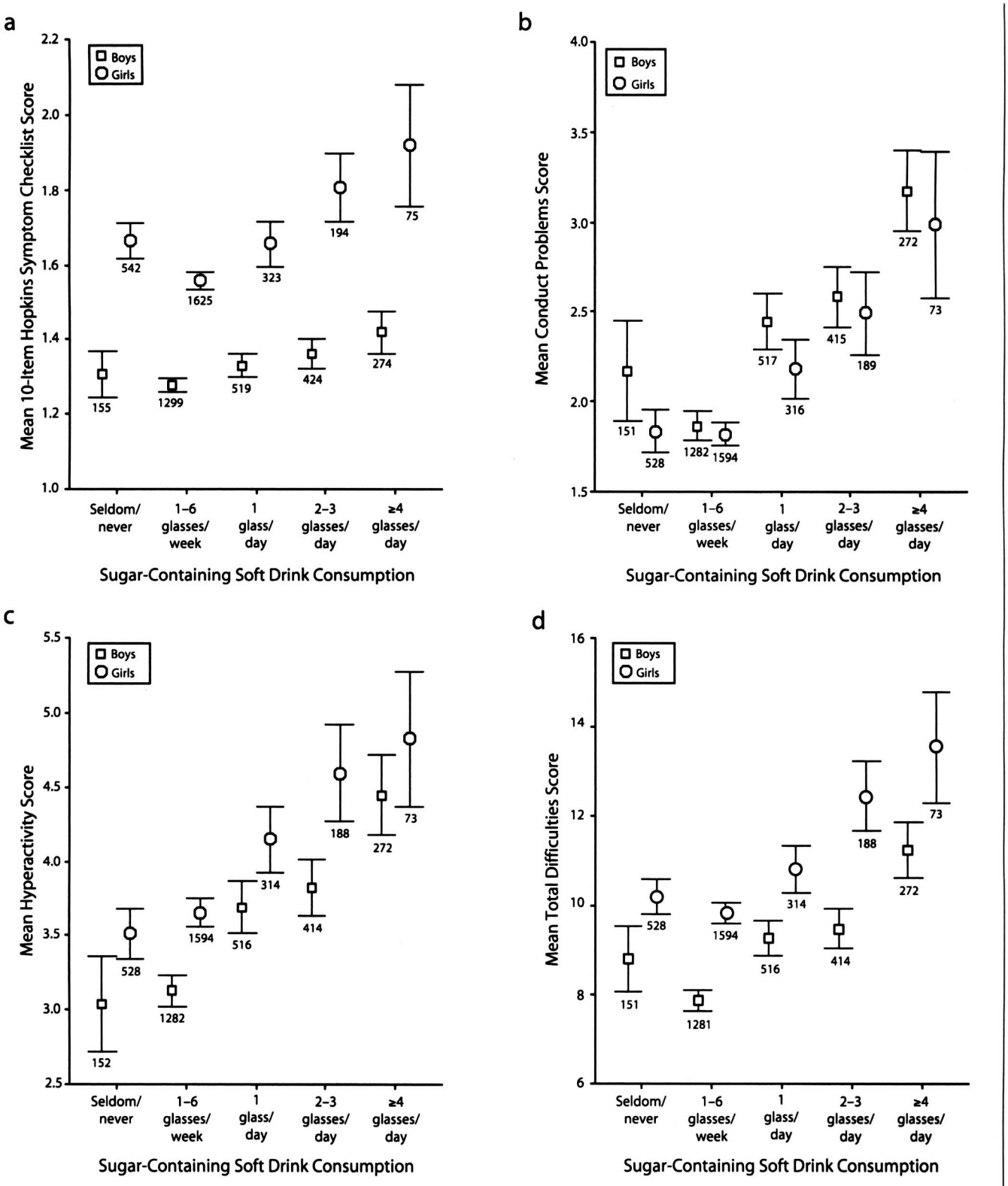
The highest crude odds ratios were found for total difficulties scores among boys consuming 4 glasses or more per day and for conduct problem scores among girls consuming the same amount (Table 3). After adjustment for food-related, social, and behavioral variables, odds ratios dropped relative to crude rates at all soft drink consumption levels. The J-shaped curve remained for each of the dependent variables other than conduct problems for boys and hyperactivity for girls. With the exception of hyperactivity scores among girls consuming 4 or more glasses per day, odds ratios were significant for all dependent variables after adjustment. Among both boys (OR = 2.8; 95% CI = 1.8, 4.4) and girls (OR = 4.1; 95% CI = 2.0, 8.4), adjusted odds ratios were highest for conduct problems.

DISCUSSION

There was a strong association between soft drink consumption and mental health problems among Oslo 10th graders. This association remained significant after adjustment for social, behavioral, and food-related factors. With the exception of hyperactivity score, all of the response variables exhibited a J-shaped dose–response relationship with soft drink consumption. One possible explanation for the non–J-shaped association between consumption and hyperactivity is that hyperactivity is more related to consumption of sugar than the other variables assessed, even at small doses.

A strength of this study of all 15- to 16-year-old adolescents in Oslo was the high response rate (88.3%) for 2 consecutive years. Selection bias thus was only a minor problem. We used a pair of validated questionnaires in assessing mental health problems, and we were able to control for known possible confounders in our multivariate analyses.

To our knowledge, this is the first population-level study to investigate the association between consumption of a sugar-rich nutrient and mental health problems among adolescents. Other experimental studies have explored the relation between sugar consumption and attention deficit–hyperactivity disorder.[2] In meta-analyses and literature reviews conducted in the mid-1990s, it was concluded that sugar had no detrimental effects on children with this disorder.[22,23]



Note. HSCL = Hopkins Symptom Checklist. Numbers represent sample sizes.

FIGURE 1—Gender-specific 95% confidence intervals and mean scores for mental distress (a), conduct problems (b), hyperactivity (c), and total difficulties (d), by number of glasses of sugar-containing soft drinks consumed, among 15- and 16-year-old students in Oslo, Norway, 2000–2001.

TABLE 3—Gender-Specific Crude and Adjusted Odds Ratios for Mental Distress, Hyperactivity, Conduct Problems, and Total Difficulties, by Soft Drink Consumption Level: 15- and 16-Year-Old Students in Oslo, Norway, 2000–2001

Consumption Level	Mental Distress	Hyperactivity	Conduct Problems	Total Difficulties Score
		Boys, crude OR (95% CI)		
>4 glasses/d	2.95 (2.00, 4.36)	4.15 (2.80, 6.16)	5.11 (3.57, 7.32)	5.52 (3.51, 8.68)
2-3 glasses/d	2.01 (1.39, 2.91)	2.19 (1.47, 3.27)	2.19 (1.51, 3.18)	2.45 (1.51, 3.96)
1 glass/d	1.22 (0.82, 1.82)	1.98 (1.35, 2.90)	2.17 (1.53, 3.08)	2.34 (1.48, 3.69)
1-6 glasses/wk (reference)	1.00	1.00	1.00	1.00
Never/seldom	1.61 (0.90, 2.87)	1.30 (0.65, 2.58)	1.47 (0.80, 2.72)	2.38 (1.19, 4.73)
		Boys, adjusted OR[a] (95% CI)		
>4 glasses/d	1.94 (1.21, 3.11)	1.99 (1.23, 3.24)	2.81 (1.79, 4.39)	2.74 (1.53, 4.91)
2-3 glasses/d	1.35 (0.88, 2.08)	1.38 (0.88, 2.17)	1.36 (0.88, 2.10)	1.81 (1.04, 3.15)
1 glass/d	0.96 (0.62, 1.48)	1.42 (0.92, 2.19)	1.66 (1.11, 2.47)	1.83 (1.07, 3.12)
1-6 glasses/wk (reference)	1.00	1.00	1.00	1.00
Never/seldom	1.32 (0.65, 2.72)	1.38 (0.60, 3.17)	0.97 (0.40, 2.38)	1.58 (0.59, 4.25)
		Girls, crude OR (95% CI)		
>4 glasses/d	2.62 (1.63, 4.19)	2.17 (1.16, 4.04)	7.05 (3.83, 12.99)	4.74 (2.81, 8.00)
2-3 glasses/d	2.12 (1.55, 2.90)	2.53 (1.71, 3.76)	2.97 (1.75, 5.05)	2.61 (1.76, 3.88)
1 glass/d	1.40 (1.07, 1.83)	1.72 (1.20, 2.45)	1.88 (1.14, 3.11)	1.64 (1.14, 2.36)
1-6 glasses/wk (reference)	1.00	1.00	1.00	1.00
Never/seldom	1.43 (1.15, 1.92)	0.73 (0.50, 1.07)	1.30 (0.81, 2.08)	1.37 (1.01, 1.88)
		Girls, adjusted OR[a] (95% CI)		
>4 glasses/d	1.75 (1.00, 3.08)	0.99 (0.47, 2.10)	4.11 (2.01, 8.44)	2.25 (1.18, 4.28)
2-3 glasses/d	1.27 (0.86, 1.87)	1.50 (0.94, 2.39)	1.31 (0.68, 2.52)	1.22 (0.74, 1.99)
1 glass/d	1.13 (0.83, 1.54)	1.35 (0.90, 2.00)	1.40 (0.81, 2.43)	1.15 (0.74, 1.76)
1-6 glasses/wk (reference)	1.00	1.00	1.00	1.00
Never/seldom	1.41 (1.09, 1.82)	0.75 (0.49, 1.14)	1.36 (0.80, 2.29)	1.52 (1.05, 2.21)

Note. OR = odds ratio; CI = confidence interval. One glass = 200 mL.
[a]Adjusted for consumption of potato chips, chocolates/sweets, and fruit/berries; regular consumption of lunch and breakfast; parental educational level; family structure; perceived social support; history of intoxication; and smoking status.

However, these conclusions have recently been contested.[24] First, the experimental studies were carried out in a laboratory environment, masking the effects of sugar on behavior. Second, the artificial sweetener used as a placebo in these studies may have had behavioral effects. Third, the studies' sample sizes were small, and the sugar consumption levels assessed were lower than children's typical consumption levels.[25]

The associations we found might be spurious. For example, we have not been able to determine whether other sugar-rich food items may have an influence on mental health status. Furthermore, we have not been able to determine whether substances in soft drinks other than sugar may trigger mental health problems. One such ingredient is caffeine, a well-known stimulant found in cola products. More detailed information is needed to explore possible associations between caffeine consumption and mental health problems among adolescents.

The effects of sugar consumption on mental health may not be direct; rather, they may be mediated through other nutritional or behavioral factors. Micronutrients, which some studies have shown to be related to conduct problems, may represent one such confounder.[26,27] A recent study of Norwegian adolescents revealed that fruit and vegetable intakes were 30% to 40% lower among those with a diet rich in refined sugar than among those with a diet containing less refined sugar. Added sugar intakes seemed to displace consumption of micronutrient-rich foods and to dilute the nutrient density of these adolescents' diets.[28]

Limitations

A specific problem with cross-sectional studies is that individuals who report exposures also report outcomes at the same point in time. This situation can result in dependent information bias, which may falsely inflate associations.[29] For example, some responders may systematically report the most negative exposures and outcomes, and others may report the most positive exposures and outcomes. One way to eliminate this possible source of bias is to obtain objective information on exposures and outcomes.

However, we have no reason to believe that our participants had any preconceived thoughts about a connection between soft drink consumption and mental health status. Another type of problem with such studies is that some respondents may systematically tend to mark the response alternatives that appear at either the right or the left, thus, possibly deflating or inflating the results.[30]

After considering possible sources of bias, we conclude that there is in fact an association between consumption of sugar-containing soft drinks and mental health problems among Oslo adolescents. The effects of sugar consumption on mental health need to be explored further within ongoing international efforts to map sugar's harmful health consequences.

Public Health Implications

As a result of their daily average intake of 2 to 3 glasses or more of sugar-containing soft drinks, 25% of boys 15 and 16 years of age in Oslo consume a minimum of 50 g of sugar per day from these beverages. On the basis of the recommendation of Norway's National Council for Nutrition that added sugar should account for only 10% of daily calorie intake,[31] average recommended daily sugar intakes for 15- and 16-year-old boys and girls would be approximately 65 g and 50 g, respectively. Given the harmful effects of excessive sugar consumption, policymakers should aim at reducing sugar intakes in this population. One obvious option is to reduce soft drink consumption.

Several studies have shown that price affects food choices among adolescents.[32] For

example, a recent Norwegian study showed that a doubling of taxes on the production and sales of soft drinks would result in a 27% price increase and a 44% reduction in household consumption.[33] Types of foods available in schools are also important determinants of adolescents' eating habits.[34] Studies have shown that dietary habits are established in the midteens and that these habits are closely associated with lifestyles.[35,36] Thus, young adolescents represent a prime target group for nutrition education programs, including programs focusing on the harmful effects of excessive sugar consumption. Finally, one simple and effective measure to reduce soft drink consumption in this age group would be to remove soft drink machines from schools and other public places where adolescents gather. ■

About the Authors

The authors are with the University of Oslo, Oslo, Norway. Lars Lien and Espen Bjertness are with the Section for Preventive Medicine and Epidemiology, Institute of General Practice and Community Medicine. Nanna Lien is with the Department for Nutritional Research, Institute of Basic Medical Sciences. Magne Thoresen is with the Department of Biostatistics, Institute of Basic Medical Sciences. Sonja Heyerdahl is with the Regional Centre for Child and Adolescent Psychiatry.

Requests for reprints should be sent to Lars Lien, MD, MSc, Section for Preventive Medicine and Epidemiology, University of Oslo, PO Box 1130, Blindern 0138 Oslo, Norway (e-mail: lars.lien@medisin.uio.no).

This article was accepted November 1, 2005.

Contributors

L. Lien carried out the statistical analyses and wrote the article. N. Lien assisted in the statistical analyses and commented on the article. S. Heyerdahl and M. Thoresen contributed to the Methods section and commented on the article. E. Bjertness assisted in the planning of the study, contributed to its design and coordination, and commented on the article.

Acknowledgments

The study was funded by the Norwegian Public Health Institute, the Municipality of Oslo, and the University of Oslo.

Special thanks to Brit Oppedal of the Norwegian Public Health Institute.

Data collection was conducted as part of the Oslo Health Study 2000–2001 in collaboration with the National Health Screening Service of Norway (now the Norwegian Institute of Public Health).

Human Participant Protection

The study protocol was reviewed by the Regional Committee for Medical Research Ethics and approved by the Norwegian Data Inspectorate. Participants provided written informed consent.

References

1. *Joint WHO/FAO Expert Report on Diet, Nutrition and the Prevention of Chronic Disease.* Geneva, Switzerland: World Health Organization; 2003.

2. Lahey MRS. Diet and its possible role in developmental disorders. Available at: http://www.bamford-lahey.org. Accessed July 16, 2005.

3. Bussing R, Schoenberg NE, Perwien AR. Knowledge and information about ADHD: evidence of cultural differences among African-American and white parents. *Soc Sci Med.* 1981;46:919–928.

4. Conners CK. *Feeding the Brain: How Food Affects Children.* New York, NY: Plenum Press; 1989.

5. McLoughlin JA, Nall M. Teacher opinion of the role of food allergy on school behavior and achievement. *Ann Allergy.* 1988;61:89–91.

6. Facts and figures. Available at: http://www.brom.no. Accessed August 15, 2005.

7. Westover AN, Marangell LB. A cross-national relationship between sugar consumption and major depression? *Depression Anxiety.* 2002;16:118–120.

8. Peet M. International variations in the outcome of schizophrenia and the prevalence of depression in relation to national dietary practices: an ecological analysis. *Br J Psychiatry.* 2004;184:404–408.

9. Golomb BA, Tenkanen L, Alikoski T, et al. Insulin sensitivity markers: predictors of accidents and suicides in Helsinki Heart Study screenees. *J Clin Epidemiol.* 2002;55:767–773.

10. Lawlor DA, Smith GD, Ebrahim S. Association of insulin resistance with depression: cross sectional findings from the British Women's Heart and Health Study. *BMJ.* 2003;327:1383–1384.

11. Lipman RS, Covi L, Shapiro AK. The Hopkins Symptom Checklist (HSCL)—factors derived from the HSCL-90. *J Affect Disord.* 1979;1:9–24.

12. Sandanger I, Moum T, Ingebrigtsen G, Sorensen T, Dalgard OS, Bruusgaard D. The meaning and significance of caseness: the Hopkins Symptom Checklist-25 and the Composite International Diagnostic Interview. *Soc Psychiatry Psychiatr Epidemiol.* 1999;34:53–59.

13. Strand BH, Dalgard OS, Tambs K, Rognerud M. Measuring the mental health status of the Norwegian population: a comparison of the instruments SCL-25, SCL-10, SCL-5 and MHI-5 (SF-36). *Nord J Psychiatry.* 2003;57:113–118.

14. Goodman R. Psychometric properties of the Strengths and Difficulties Questionnaire. *J Am Acad Child Adolesc Psychiatry.* 2001;20:1337–1345.

15. Goodman R, Meltzer H, Bailey V. The Strengths and Difficulties Questionnaire: a pilot study on the validity of the self-report version. *Int Rev Psychiatry.* 2003;15:173–177.

16. Goodman R, Gledhill J, Ford T. Child psychiatric disorder and relative age within school year: cross sectional survey of a large population sample. *BMJ.* 2003; 327:472–475.

17. Goodman R, Ford T, Simmons H, Gatward R, Meltzer H. Using the Strengths and Difficulties Questionnaire (SDQ) to screen for child psychiatric disorders in a community sample. *Br J Psychiatry.* 2000; 177:534–539.

18. Ronning J, Handegaard B, Sourander A, Morch W-T. The Strengths and Difficulties Self-Reported Questionnaire as a screening instrument in Norwegian community samples. *Eur Child Adolesc Psychiatry.* 2004;13:73–82.

19. Wold B, Hetland J, Aaro LE, Samdal O, Torsheim T. *Development Trends in Health and Lifestyles Among Children and Adolescents From Norway, Sweden, Hungary and Wales.* Bergen, Norway: University of Bergen; 2000.

20. *Den Individbaserte Utdanningsstatistikken.* Oslo, Norway: Statistics Norway; 2001.

21. Ystgaard M. Life stress, social support and psychological distress in late adolescence. *Soc Psychiatry Psychiatr Epidemiol.* 1997;32:277–283.

22. Krummel DA, Seligson FH, Guthrie HA. Hyperactivity: is candy causal? *Crit Rev Food Sci Nutr.* 1996;36: 31–47.

23. Wolraich ML, Wilson DB, White JW. The effect of sugar on behavior or cognition in children: a meta-analysis. *JAMA.* 1995;274:1617–1621.

24. Kidd P. Attention deficit/hyperactivity disorder (ADHD) in children: rationale for its integrative management. *Altern Med Rev.* 2000;5:402–428.

25. Schnoll R, Burshteyn D, Cea-Aravena J. Nutrition in the treatment of attention-deficit hyperactivity disorder: a neglected but important aspect. *Appl Psychophysiol Biofeedback.* 2003;28:63–75.

26. Gesch CB, Hammond SM, Eves A, Crowder MJ. Influence of supplementary vitamins, minerals and essential fatty acids on the antisocial behaviour of young adult prisoners. *Br J Psychiatry.* 2002;181:22–28.

27. Schoenthaler S, Bier ID. The effect of vitamin-mineral supplementation on juvenile delinquency among American schoolchildren: a randomized, double-blind placebo-controlled trial. *J Altern Complement Med.* 2000;6:7–17.

28. Overby NC, Lillegaard IT, Johansson L, Andersen LF. High intake of added sugar among Norwegian children and adolescents. *Public Health Nutr.* 2004;7: 285–293.

29. Podsakoff PM, MacKenzie SB, Lee JY, Podsakoff NP. Common method biases in behavioral research: a critical review of the literature and recommended remedies. *J Appl Psychol.* 2003;88:879–903.

30. Kristensen P. Bias from dependent errors in observational studies [in Norwegian]. *Tidsskr Nor Laegeforen.* 2005;2:173–175.

31. *Norske Næringsstoff Anbefalinger.* Oslo, Norway: National Council for Nutrition; 1997.

32. French S. Pricing effects on food choices. *J Nutr.* 2004;133:841–843.

33. Gustavsen G. *Etterspørsel Etter Brus.* Aas, Norway: Norwegian Institute for Agricultural-Economical Research; 2004. Report 2004-13.

34. Kubik MY, Lytle LA, Hannan PJ, Perry CL, Story M. The association of the school food environment with dietary behaviors of young adolescents. *Am J Public Health.* 2003;93:1168–1173.

35. Lytle LA, Seifert S, Greenstein J, McGovern P. How do children's eating patterns and food choices change over time? Results from a cohort study. *Am J Health Promotion.* 2000;14:222–228.

36. Lien N, Lytle LA, Klepp KI. Stability in consumption of fruit, vegetables, and sugary foods in a cohort from age 14 to age 21. *Prev Med.* 2001;33:217–226.