Weight Gain in Older Adolescent Females: The Internet, Sleep, Coffee, and Alcohol

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Objectives To examine whether excessive recreational Internet time, insufficient sleep, regular coffee consumption, or alcoholic beverages promote weight gain.

Study design A longitudinal cohort of >5000 girls (Growing Up Today Study), from all over the United States and aged 14 to 21 years, returned surveys in 2001 reporting typical past-year recreational Internet time, sleep, coffee (with caffeine), and alcohol consumption. We estimated correlations among these 4 exposures. Each girl also reported her height and weight in 2000 and again in 2001. Multivariate models investigated associations between 1-year change in body mass index and same-year exposures, adjusted for adolescent growth/development, activity, and inactivity.

Results The exposures were highly ($P < .0001$) correlated with each other, except for coffee with Internet time ($P > .50$). More Internet time, more alcohol, and less sleep were all associated ($P < .05$) with same-year increases in body mass index. Females, aged 18+ years, who slept ≤5 hours/night ($P < .01$) or who consumed alcohol 2+servings/week ($P < .07$) gained more body mass index from 2000 to 2001. For females in weight-promoting categories of all exposures, this translates to nearly 4 extra pounds gained over 1 year. We found no evidence that drinking coffee promotes weight gain.

Conclusions Older girls may benefit from replacing recreational Internet time with sleep and by avoiding alcohol. *(J Pediatr 2008;153:635-9)*

Increases in the prevalence of adolescent overweight during recent decades are extensively documented,[1] as are associated health and social consequences.[2-3] The rapid rise in prevalence suggests environmental factors are responsible.[4] Physical activity has declined, sedentary activities have increased, and widespread changes in dietary patterns have taken place. Admittedly, genes play an important role in the development of obesity,[5] but for any particular individual, his or her genes are not modifiable, whereas some environmental factors are, although with difficulty.

A review of longitudinal studies of weight gain and childhood inactivity included TV/video watching and playing videogames, not Internet time or sleep.[6] In a cross-sectional study of adolescent girls, those who spent more time on the computer for e-mail, writing, and surfing the Internet were more likely to be overweight.[7] Sleep may be displaced by Internet use; cross-sectional studies of children showed associations between less sleep and overweight.[8-9] A longitudinal study found that British 3-year-olds with short sleep duration were 45% more likely to be obese at age 7 years,[10] and short sleep duration among U.S. third graders was associated with being overweight in sixth grade.[11] Coffee may be partly responsible for reduced sleep time, and thus weight gain, although a study of adolescent girls found no significant association between coffee/tea intakes and body mass index (BMI).[12] Alcoholic beverage intakes rise greatly throughout adolescence, at the same time that coffee use is increasing. A cross-sectional study of 16-17 year old girls found significant correlation between high alcohol intake and percent body fat.[13]

We estimated the correlations among these exposures in adolescent girls and investigated jointly their associations with BMI change over time. To our knowledge, no longitudinal studies of adolescents have studied any of these exposures with regard to excessive weight gain.

METHODS

Established in 1996, the Growing Up Today Study includes 16 771 boys and girls from all 50 states who are children of Nurses' Health Study II (NHSII) participants. The study, approved by Human Subjects Committees at Harvard School of Public Health and

BMI	Body mass index	NHSII	Nurses' Health Study II

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Brigham and Women's Hospital, is described elsewhere.[14] Mothers provided informed consent, and their children assented by completing baseline questionnaires. The cohort, aged 9 to 14 years in 1996, returned follow-up questionnaires annually through 2001. Girls' responses to 1 or more of these follow-ups were 95.5%; more relevant to this analysis is that 70% returned the 2001 survey that asks about all 4 exposures. In both 2000 and 2001, a total of 5502 surveys were returned, the source of data for these analyses.

Children reported their heights and weights in 2000 and again in 2001. Our questionnaire provided specific measuring instructions but suggested they seek assistance; their mothers (nurses) biennially self-report their own heights and weights for NHSII. We assessed relative weight status by computing BMI (weight/height^2, [kg/m^2]). The validity of self-reported BMI is supported by National Longitudinal Study of Adolescent Health analyses that found a correlation of 0.92 between BMI computed from measured values and from self-reports by youth in grades 7 to 12.[15] Our outcome measure is change in relative body weight, $BMI_{2001} - BMI_{2000}$, divided by the time interval (to the month) between survey return dates. After excluding outliers, we had 5036 girls with annualized BMI changes from 2000 to 2001. Analyses of BMI changes are superior to analyzing differences between BMI Z-scores or percentiles.[16]

Recreational Internet Time

In 2001 we asked the participants how many hours/week they typically spent on Internet/computers, not including schoolwork; our 7 response options ranged from none to 31+ hours/week. (The preceding question regarded computer/video game time). A study on self-reported computer use in Minnesota middle school children demonstrated adequate reliability (a week apart, test with retest correlation = 0.60) and validity (test with 7-day log, correlation = 0.39).[17]

Sleep

Our 2001 survey asked "On a typical night when you have school or work the next day, how many hours of sleep do you get?" Eight response options ranged from "less than 5 hours" to "11 or more hours." Validation studies on adolescents indicate they can validly self-report sleep time.[18]

Coffee

Average past year coffee ("not decaf") use was obtained by the 2001 survey. Eight response options ranged from Never to >3 cups/day. Self-reported intakes for beverages in general, and coffee specifically, had high validity in a study on adult women.[19]

Alcohol

The 2001 survey inquired about typical past-year intakes of beer, wine, and liquor. A review article, on the validity of adolescent self-reports of risky behaviors, concluded that the privacy of self-administered questionnaires produces higher, supposedly more valid, reported rates of alcohol use.[20] Studies that incorporated (bogus) saliva tests along with self-reports suggested that adolescents provided valid responses. Test-retest reliability levels were generally high for alcohol, but it is difficult to do validation studies of long-term alcohol use because of the lack of biochemical measures.[20] The validation study we cited for coffee also supported high validity for alcoholic beverages.[19]

Statistical Analyses

We computed Pearson correlations among the 4 exposures collected on our 2001 survey. Any girl who reported that she was a smoker (>100 cigarettes lifetime, and at least 1 within the past month) or who was pregnant (currently or in the past year) was excluded, from these correlations and from all models outlined below, leaving n = 4427 girls for analysis of BMI change.

For analyzing relative weight change from 2000 to 2001, we fitted multivariate linear regression models on the 4 exposures simultaneously. All models were estimated with generalized estimating equations to allow for correlations among the small number of sisters in the cohort.[21] We used a continuous measure of each exposure (typical past-year cups/day of coffee, etc) reported in 2001 to estimate linear associations with BMI change from 2000 to 2001. In a separate model, we used a categorical version of each exposure, to observe and estimate any nonlinear trends. Both models adjusted for adolescent growth and development by including age (age-18.0) and age^2, menstrual status (2000 and 2001), height growth from 2000 to 2001, and prior BMI (2000). Fully adjusted models further included past-year physical activity and TV/videos/computer games,[14] reported in 2001. Finally, these fully-adjusted models were fit to only the oldest (18+ years) girls (n = 1424).

RESULTS

Nearly all participants, daughters of NHSII nurses, are white (95%). At baseline, 12.7% were overweight (85th-95th percentile on BMI charts from the Centers for Disease Control and Prevention), 4.8% were obese (>95th percentile), and 4.7% were very lean (<5th percentile). In 2001, when data were collected on our 4 exposures, 16% of the girls were aged 14 to 15 years, 38% were 16 to 17 years, 34% were 18 to 19 years, and 12% were 20 to 21 years. At that time, 52% of girls were spending 1 to 5 hours/week on the computer for recreation (34%, even more hours), only 31.3% were sleeping 8 or more hours/night, 36% drank coffee, and 35% drank alcohol. The mean annual BMI gains, from year 2000 (when girls were aged 13 to 20 years) to 2001, declined with age, except for age 18 to 19 years (+0.47 kg/m^2), which may reflect weight increases as girls begin college. Beginning at age 18 years, mean alcohol intake (0.22 servings/day) exceeded mean coffee intakes (0.15 servings/day).

Correlations among the 4 exposures were highly significant, except for coffee with Internet time (R = +0.009, P = .54), demonstrating the importance of joint multivariate anal-

Table I. Past-year recreational Internet use (2001 report) and its estimated association (ß, SE) with BMI change (kg/m^2), 2000 to 2001

	Categories of time for Internet use					
	None (referent)	1-5 hrs/wk	6-10 hrs/wk	11-15 hrs/wk	16+ hrs/wk	Continuous Internet time β (SE) (kg/m^2 per hr/day)
Adjust for sleep, coffee, alcohol	0	+.077 (.047)	+.164* (.056)	+.061 (.069)	+.198† (.082)	+.045† (.021)
Further adjust for past year physical activity, TV/videos, computer/video games	0	+.069 (.048)	+.150* (.056)	+.042 (.070)	+.157‡ (.084)	+.034 (.022)
Only girls aged 18+ (height growth and menarche omitted)	0	+.011 (.085)	+.116 (.097)	+.023 (.123)	+.107 (.135)	+.038 (.035)

Models of categorical Internet time appear in middle 5 columns, and continuous Internet models are on right. Models adjust for age, age^2, menarche (2000-2001), height growth (2000-2001), 2000 BMI.
*$P < .01$.
†$P < .05$.
‡$.05 < P < .10$.

Table II. Usual sleep (hours/night), reported in 2001, and its estimated association (ß, SE) with BMI change (kg/m^2) from 2000 to 2001

	Categories of sleep					
	≤5 hours	6 hours	7 hours	8 hours (referent)	9+ hours	Continuous sleep β (SE) (kg/m^2 per hr/night)
Adjust for Internet, coffee, alcohol	+.133‡ (.076)	+.059 (.046)	−.025 (.039)	0	−.028 (.073)	−.034† (.017)
Further adjust for past year physical activity, TV/videos, computer/video games	+.140‡ (.075)	+.061 (.047)	−.020 (.039)	0	−.023 (.073)	−.034† (.016)
Only girls aged 18+ (height growth and menarche omitted)	+.322* (.112)	−.021 (.076)	−.049 (.067)	0	−.134 (.121)	−.076* (.026)

Models of categorical sleep time appear in middle 5 columns, and continuous sleep models are on right. Models adjust for age, age^2, menarche (2000-2001), height growth (2000-2001), and 2000 BMI.
*$P < .01$.
†$P < .05$.
‡$.05 < P < .10$.

yses of these exposures in relation to weight gain. The other correlations (all $P < .0001$) were as follows: Internet with sleep, R = −0.093; Internet with alcohol, R = +0.086; sleep with coffee, R = −0.102; sleep with alcohol, R= −0.116; and coffee with alcohol, R = +0.111.

Girls spending more time on the Internet had significantly greater BMI increases during the same year (Table I, top row), whether Internet time was measured categorically (6 to 10 hours/week and 16+ hours/week) or continuously (hours/day). When we further included past-year physical activity and TV/videos/computer-games in the model, the Internet effect was weaker. Adjusting for TV may be overcontrol because girls watch television at the same time as checking e-mail, Instant Messaging, or surfing the Internet. For girls aged 18+ years, the Internet effects were further weakened and not statistically significant. Older girls are likely also to spend substantial nonrecreational time on the computer for college or employment (data not collected), which may have diminished our estimates.

Associations between sleep and BMI gain were summarized similarly (Table II). Estimates shown in the top row were obtained from the same 2 multivariate models that provided estimates for Tables I, III, and IV. A significant inverse trend was present even after adjusting for physical activity and TV/videos/computer-games. The strongest effects were on the older girls (18+). Those who slept 5 or fewer hours/night gained significantly more BMI (+0.322 kg/m^2) during the year compared with those sleeping 8 hours.

None of the coffee models (Table III) provided evidence that drinking coffee promotes weight gain. In fact, although not significant, the bulk of the evidence (see 5+ cups/week and continuous model estimates) suggested protection against weight gain.

Girls who typically consumed 2+ servings/week of alcoholic beverages gained significantly more weight than those who consumed the least (Table IV). Statistically significant linear trends were observed, as well. For the older girls (18+ years), the estimated effect ($\beta = +0.115$) for the 2+servings/week group, although only marginally significant ($P < .07$), was larger than the significant effect ($\beta = +0.108$) from the full group of girls (both older and younger than 18 years).

Table III. Past-year coffee intake (not decaf, 2001 report) and its estimated association (ß, SE) with BMI change (kg/m^2), 2000 to 2001

	Categories of coffee intake					Continuous coffee β (SE) (kg/m^2 per cup/day)
	None (referent)	1-3 cups/mo	1 cup/wk	2-4 cups/wk	5+ cups/wk	
Adjust for Internet, sleep, alcohol	0	+.033 (.044)	−.006 (.061)	+.078 (.077)	−.089 (.071)	−.035 (.056)
Further adjust for past year physical activity, TV/videos/games	0	+.030 (.044)	−.008 (.061)	+.070 (.077)	−.088 (.072)	−.031 (.056)
Only girls aged 18+ (height growth and menarche omitted)	0	−.022 (.071)	+.051 (.092)	+.169 (.120)	−.097 (.095)	−.032 (.068)

Models of categorical coffee intake appear in middle 5 columns, and continuous coffee models are on right. Models adjust for age, age^2, menarche (2000-2001), height growth (2000-2001), and 2000 BMI.

Table IV. Past-year alcohol consumption (2001 report) and its estimated association (ß, SE) with BMI change (kg/m^2), 2000 to 2001

	Categories of alcohol intake			
	0-3 servings/mo (referent)	1/wk	2+/week	Continuous alcohol β (SE) (kg/m^2 per serving/day)
Adjust for Internet, sleep, coffee	0	+.050 (.063)	+.114* (.047)	+.113* (.048)
Further adjust for past year physical activity, TV/videos/games	0	+.047 (.064)	+.108* (.048)	+.111* (.048)
Only girls aged 18+ (height growth and menarche omitted)	0	+.036 (.086)	+.115† (.063)	+.064 (.054)

Models of categorical alcohol intake appear in middle three columns, and continuous alcohol models appear on far right. Models adjust for age, age^2, menarche (2000-2001), height growth (2000-2001), and 2000 BMI.
*$P < .05$.
†$.05 < P < .10$.

To illustrate the effect of modifying all 4 exposures simultaneously, we compare 2 hypothetical girls who are identical (age 19, same prior BMI, same physical activity, and same TV/videos/computer games) except in the 4 exposures. One girl had no recreational Internet time, slept 8 hours nightly, consumed no alcohol, and drank a cup of coffee daily. The other girl was on the Internet 6 to 10 hours/week, slept 5 hours/night, drank no coffee but regularly consumed 2+ alcohol servings/week. The latter girl gained (according to the categorical exposures model, bottom of Tables I, II, III, and IV) +0.65 more BMI over 1 year. For a 19-year-old of average height and weight, this represents a nearly 4-pound weight gain.

DISCUSSION

Adolescent girls who, between 2000 and 2001, spent more recreational time on the Internet, slept less, or consumed more alcohol, gained more BMI during that year. Although the estimated effects were small, they may accumulate over time and become clinically important as these behaviors are maintained, or more likely magnified, as girls approach adulthood. We found no evidence that coffee consumption promoted weight gain.

Internet time likely promotes weight gain through increased sedentary time, reducing total energy expenditure. Our findings are consistent with a cross-sectional study in which adolescent girls who spent more recreational time on the Internet were more likely to be overweight.[7] The Internet can also be beneficial, as in Internet-aided programs for weight management in children.[22]

Our findings regarding sleep are consistent with longitudinal studies on younger children in which short sleep duration preceded overweight.[10-11] Insufficient sleep might result in daytime fatigue and reduced physical activity, with fewer calories expended during the day, although Patel[23] found no evidence to support this in adult women. Sleep restriction has metabolic effects that may predispose human beings to weight gain and to diabetes.[24] A longitudinal study of adults also showed short sleep duration preceding onset of overweight.[23] A recent study recommended more sleep for children to prevent obesity.[25]

These analyses did not support our hypothesis that coffee promotes weight gain in adolescent girls but instead were consistent with a cross-sectional study finding no association.[12] Because we had no information available on the use of cream, milk, or sugar in coffee, this affects the validity of inferences we can make regarding coffee and weight gain in our cohort. This may partly explain why our findings did not confirm adult studies indicating that coffee consumption may prevent weight gain.[26-28]

Liquid (beverage) calories may not be as well compensated for in the overall diet, by reduced subsequent food/beverage intakes, as calories from food. Thus beverage intakes (including beer, wine and liquor) are more likely to result in

higher total energy intakes and weight gain. A prospective analysis of women showed the heaviest drinkers gained the most weight,[29] and a longitudinal study of older Danish women found that higher alcohol intakes were associated with 5-year increases in waist circumference.[30] A recent cross-sectional analysis of 16- to 17-year-old girls found significant correlation between high alcohol intake and percent body fat.[13] Our results extend to the literature the positive association between weight gain over time and alcohol consumption in adolescent girls.

A major strength of this analysis is the measurement, on a large cohort of girls from all over the United States, of height and weight in 2 consecutive years. Longitudinal observational studies such as ours cannot determine causality as validly as randomized controlled trials, but our study design is superior to cross-sectional studies, where associations may represent reverse causality. Although we controlled for many potential confounders in our models, some residual and unmeasured confounding may remain. We cannot exclude the possibility of incomplete adjustment of some covariates, or confounding through variables not considered, such as employment-related physical activity or inactivity. We omitted from these analyses girls who were pregnant or smokers. The major limitation of our study was the necessity to collect data by self-report on mailed questionnaires, but with our large cohort of participants residing all over the United States, alternatives were not feasible. Errors in reporting sleep, Internet time, and coffee are likely to be nondifferential with respect to weight gain, so that any resulting bias should produce underestimates of the strength of true associations. Regarding alcohol consumption, assurances that we will not release information to parents should help maintain accuracy. But to the extent that some participants may underreport alcohol intake, this also should bias estimates toward the null, obscuring real relationships between alcohol and weight gain. Although our cohort is not representative of U.S. girls, associations among factors within our cohort should still be valid. Because all participants are daughters of nurses, this reduces confounding by socioeconomic and other unmeasured factors, as well as enhances the accuracy of the information provided. But the racial and ethnic makeup of our cohort (95% white) is clearly a limitation to generalizing our findings.

If future studies confirm our findings, that more sleep, less recreational Internet time, and less alcohol may prevent excessive weight gain or promote weight loss, then adolescents could safely and inexpensively use this information to manage their body weight. Aside from preventing obesity, these findings may encourage youth to make lifestyle changes that provide educational and other health benefits as well.

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