



# The 'Twinkie Defense': the relationship between carbonated non-diet soft drinks and violence perpetration among Boston high school students

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## ABSTRACT

**Objectives** To investigate the association of carbonated non-diet soft drink consumption and violence perpetration in a sample of Boston adolescents.

**Methods** In a survey of Boston public high schools, respondents were asked how often they drank non-diet soft drinks and whether they had carried a weapon or engaged in physical violence with a peer. Regression analysis was used to determine the role of soft drink consumption in these behaviours.

**Results** Adolescents who drank more than five cans of soft drinks per week (nearly 30% of the sample) were significantly more likely to have carried a weapon and to have been violent with peers, family members and dates ( $p < 0.01$  for carrying a weapon and  $p < 0.001$  for the three violence measures). Frequent soft drink consumption was associated with a 9–15% point increase in the probability of engaging in aggressive actions, even after controlling for gender, age, race, body mass index, typical sleep patterns, tobacco use, alcohol use and having family dinners.

**Conclusions** There was a significant and strong association between soft drinks and violence. There may be a direct cause-and-effect relationship, perhaps due to the sugar or caffeine content of soft drinks, or there may be other factors, unaccounted for in our analyses, that cause both high soft drink consumption and aggression.

## INTRODUCTION

In 1979, Dan White was tried for the assassinations of San Francisco city district Supervisor Harvey Milk and Mayor George Moscone. His lawyers argued that he had diminished capacity and was unable to premeditate his crime. Part of the evidence for his depressed and altered state of mind was that he had recently changed from a health-conscious diet to junk food and Coca-Cola. Although Twinkies, a popular packaged snack cake filled with cream, were mentioned only in passing during the trial, the legal argument became known as the 'Twinkie Defense'. The defence was successful: White was convicted of voluntary manslaughter rather than homicide.<sup>1</sup>

Although White's lawyers never claimed that sugar led to his violent acts, studies since then have explored this possibility. High consumption of soft drinks, for example, has been found to correlate positively with poor mental health among Norwegian adolescents,<sup>2</sup> and with increased individualism and decreased collectivism, social desirability and ability to understand emotions in a sample of American college students (S Konrath, Research Center for Group Dynamics, University of

Michigan, 2011). A recent meta-analysis examined several purported pathways linking diet and anti-social behaviour.<sup>3</sup> One possible explanation for an association between high sugar intake and aggressive behaviour is that that consumption of sugary beverages is a response to abnormally low blood glucose levels, a physiological state that has been linked with irritable and violent behaviour.<sup>3–4</sup> Another possibility is that soft drinks replace healthier whole foods in the diet, and that a deficiency of micro-nutrients can lead to violent behaviour. Several studies have found that supplementation of micro-nutrients can significantly decrease aggression, but this research remains in its initial stages.<sup>3</sup>

In this paper, we investigate the association of carbonated non-diet soft drink consumption and violence in a sample of Boston adolescents. We focus on whether non-diet soft drinks are linked with weapon carrying, and violence perpetration against siblings, dates and peers.

## METHODS

The Boston Youth Survey (BYS) is a biennial paper-and-pencil survey of 9th–12th grade students in Boston public schools. Religious schools, private schools and other schools that are outside the Boston Public School system are not included. In 2008, all 31 eligible high schools were invited to participate; ineligible schools included those that served adults (eg, 'night' school), short-term schools (eg, for students transitioning back to school following incarceration) and those that serve severely disabled youth. Twenty-two of the eligible schools participated in the survey (71%). The primary reason for school non-participation was scheduling difficulties (eg, conflicts with mandatory standardised testing). There were no significant differences between participating and non-participating schools in terms of the race/ethnicity of the students, school dropout rates and other readily measurable factors.

We used passive consent procedures (ie, students' parents were required to return a signed form if they did not want their child to take the survey). Students were also permitted to decline to participate at any time before or during survey administration. The survey was designed to be able to be completed within a single 40-minute class period. Trained youth workers and others (eg, researchers, graduate students, city employees) administered the survey during regular class time. The Harvard School of Public Health Office of Human Research Administration approved the study protocol.

Within participating schools, required humanities (eg, English) classes were stratified by grade, and classrooms were then randomly selected for survey administration within each grade. About four classrooms per school were selected—in order to sample one classroom per grade for each school—or about 100–110 total students. In those schools with total enrolments of 100 or fewer, the entire school was sampled.

Of the 2725 students who were selected for participation (ie, who were enrolled in the selected classrooms), 69% (1878) answered the survey. The remaining students were absent on the day of the survey ( $n=724$ ), declined to participate ( $n=99$ ) or were not permitted to participate by their parents ( $n=24$ ).

Our key independent variable for this study is consumption of regular (non-diet) carbonated soft drinks. Respondents were asked, “In the past seven days, how often did you drink soda<sup>1</sup>?” They were specifically instructed not to include diet (artificially sweetened) soda. Intake was measured in cans (12 ounces or 355 ml), and respondents were told to count a 20 ounce bottle (a commonly available serving size, equivalent to 590 ml) as two cans. Possible answers were: never or less than 1 can, 1 can in the past 7 days, 2–4 cans in the past 7 days, 5–6 cans in the past 7 days, 1 can per day, 2 cans per day, 3 or more cans per day. Eight-six per cent (1618) of survey respondents answered this question. For ease of exposition, in most analyses, we divided the sample into two groups: those who consumed up to 4 cans of soft drinks in the past 7 days and those who consumed 5 or more cans of soft drinks in the past 7 days. Just under 30% of respondents were classified as heavy consumers of soft drinks.

The purpose of this study was to investigate the effect of carbonated soft drink consumption on aggressive and violent behaviour, which we measured in three ways: whether the respondent had: (1) been violent towards other adolescents (not a date or a child in the family)<sup>ii</sup>; (2) been violent towards another child in the family<sup>iii</sup>; and (3) been violent towards someone in a dating relationship.<sup>iv</sup> We also examined whether the respondent had carried a knife or a gun anywhere in the past year.

The control variables were: (1) gender; (2) age; (3) ethnicity; (4) body mass index (BMI)<sup>v</sup>; (5) any alcohol consumption in the past month; (6) any tobacco use in the past month; (7) any family dinners in the past week; and (8) less than six hours of sleep on an average school night.

t-Tests and  $\chi^2$  tests of association were used in bivariate comparisons and multivariate logistical regression techniques in multivariate analyses to determine risk factors. Robust variance estimators were employed to account for non-independent responses from students at the same school.<sup>5</sup> We used step-wise procedures to eliminate independent variables that were not significant in any of the multivariate regressions.

<sup>i</sup>Soda<sup>1</sup> is the common term for carbonated soft drinks in the northeastern USA.

<sup>ii</sup>In the past 30 days, respondent got into a physical fight with another child (not someone in the respondent's family or someone the respondent had dated) or pushed, shoved, slapped, hit, punched, kicked or choked him or her or attacked or threatened the other child with a weapon.

<sup>iii</sup>In the past 30 days, respondent got into a physical fight with another child in his or her family or pushed, shoved, slapped, hit, punched, kicked or choked him or her or attacked or threatened the other child with a weapon. These analyses were restricted to respondents who had another child in their family.

<sup>iv</sup>In the past 30 days, respondent got into a physical fight with someone they were or had been dating or pushed, shoved, slapped, hit, punched, kicked or choked him or her. These analyses were restricted to respondents who were or had been in a dating relationship during that time.

<sup>v</sup>Respondents were asked their height in inches and their weight in pounds, and these values were used to calculate body mass index.

**Table 1** Descriptive statistics

	Soft drink consumption in past 7 days		
	All	0–4 Cans	5+ Cans
Overall	100%	70.2%	29.8%
BMI (mean)	24.0	23.9	24.2
Female	54.3%	55.2%	52.0%
Age (mean)	16.3	16.3	16.3
Asian	8.2%	10.2%	3.6%***
No family dinner	35.9%	34.4%	39.3%
<6 Hours sleep	24.6%	24.1%	25.7%
Alcohol use	37.5%	34.0%	45.6%***
Tobacco use	12.2%	10.0%	17.1%***
Carried gun or knife	30.8%	26.8%	40.3%***
Violent towards peers	44.4%	39.1%	56.7%***
Violent in dating relationship	19.5%	16.2%	26.2%***
Violent towards children in family	31.6%	27.2%	42.0%***

\*\*\* $p \leq 0.001$ .

## RESULTS

Across the sample, 29.8% of respondents reported drinking more than 5 cans of non-diet soft drinks per week (table 1). BMI for the frequent soft drink consumers was not significantly higher than for those who consumed less. The students ranged from 14 to 18 years old, with less than 5% being older or younger. Gender and age were very similar across the two categories. Half (50%) of the respondents were black or multi-racial, 33% were Hispanic, 9% were white and 8% were Asian. Asians were the only group to show significant differences in soft drink consumption: they were much less likely than other races to drink more than 5 cans of soft drinks per week.

We explored whether high soft drink consumption was associated with other behaviours that might indicate trouble. Over one-third of respondents did not have dinner with their family even once in the preceding seven days, but this proportion did not differ by soft drink consumption. Heavy consumers of soft drinks were no more likely to get insufficient sleep (less than 6 h on average school nights). However, respondents who drank a lot of soft drinks were significantly more likely both to have used alcohol and to have used tobacco at least once in the previous 30 days. The frequent consumers of soft drinks were much more likely to have carried a gun or knife and to have been violent with (1) a sibling, (2) a person they were dating or (3) another young person who was neither a family member nor a romantic partner. These findings also appear when soft drink consumption was divided into four levels of frequency rather than two, suggesting a ‘dose–response’ relationship (table 2).

**Table 2** Soft drink consumption with more categories

	Soft drink consumption in past 7 days			
	≤1 can (N = 722)	2–4 cans (N = 414)	5–7 cans (N = 237)	14+ cans (N = 245)
Carried gun or knife	23.2%	33.1%	37.8%	42.7%
Violent towards peers	35.1%	46.1%	54.7%	58.6%
Violent in dating relationship	15.3%	17.6%	25.3%	26.9%
Violent towards children in family	25.4%	30.3%	38.7%	45.3%

For each variable, percentages were significantly different across the four categories with  $p < 0.001$ .

**Table 3** Probit regression results

Independent variables	Dependent variables							
	Carried a knife or a gun		Violence towards peers		Violence in dating relationship		Violence towards children in family	
	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
5+ Cans soft drinks	0.332***	0.266**	0.408***	0.382***	0.357***	0.349***	0.351***	0.346***
BMI	0.012*	0.009	0.006	0.002	0.010*	0.006	0.007	0.004
Female	-0.622***	-0.694***	-0.144*	-0.176*	0.721***	0.749***	0.355***	0.351***
Age	0.058*	0.020	-0.070*	-0.119***	0.071	0.048	-0.146***	-0.174***
Asian	-0.744***	-0.683***	-0.697***	-0.602***	-0.485	-0.439	-0.416**	-0.325*
Constant	-1.471**	-1.181*	0.850	1.390**	-2.829***	-2.634***	1.441**	1.769***
No family dinner		0.277***		0.169*		0.011		0.016
<6 Hours sleep		0.110		0.220*		0.137		0.063
Alcohol use		0.458***		0.518***		0.260**		0.297***
Tobacco use		0.780***		0.368**		0.443***		0.329**
Pseudo R <sup>2</sup>	0.08	0.16	0.04	0.10	0.08	0.11	0.05	0.07
N	1391	1301	1402	1305	1100	1014	1314	1227

\* $p \leq 0.05$ ; \*\* $p \leq 0.01$ ; \*\*\* $p \leq 0.001$ .

Multivariate analysis showed that soft drinks were an important explanatory variable for our measures of violence and aggression, even when other behaviours were included in the analysis (table 3). Consumption of high quantities of soft drinks resulted in a 9–15% point increase in the probability of engaging in aggressive actions (table 4). The impact of high soft drink consumption on violence was similar in magnitude to the impact of using tobacco or using alcohol, but the influence of soft drink consumption on the probability of carrying a weapon, while significant, was not as strong as the influence of alcohol or tobacco consumption.

In addition to defining soft drink consumption into two categories—high and low—we also tested regression models in which consumption was measured in estimated number of cans per week.<sup>v1</sup> The results were virtually identical (not shown).

## DISCUSSION

We find that among Boston high school students, drinking more soft drinks is associated with engaging in violent behaviour in a variety of contexts, even when controlling for BMI, nightly sleep, demographics and behaviours such as alcohol and tobacco use, and eating dinner with the family. The influence of soft drink consumption on violence appears to be a ‘dose–response’ relationship, with effects visible at low levels of consumption and increasing with greater consumption. Even among respondents who drink alcohol and smoke cigarettes, those who drink more than five cans of soft drinks per week are significantly more likely to be violent than those who drink fewer soft drinks.

We do not know the reason for the association between soft drinks and the perpetration of violence. A direct cause-and-effect relationship between soft drink consumption and aggression is one possibility. Diet can affect aggression,<sup>3</sup> and soft drinks have various ingredients, including carbonated water, high fructose corn syrup, aspartame, sodium benzoate, phosphoric or citric acid, and often caffeine, any of which might affect behaviour. Of the top ten varieties of soft drinks, which together comprise 66% of the total US market, only two, amounting to 7% of the total

market, are caffeine-free.<sup>6</sup> Hence we expect that caffeine is present in most of the soft drinks consumed by respondents.

The two ingredients in soft drinks that have sometimes been associated with aggression are caffeine and sugar. The evidence about both is mixed. For example, high caffeine consumption was associated with aggressive behaviour in a sample of adolescents largely drawn from a clinic focusing on psychiatric disorders and risk-taking,<sup>7</sup> but a recent, thorough review of the effects of caffeine on young people does not even mention aggression,<sup>8</sup> while another cites only the 2008 Martin study.<sup>9</sup> Similarly, sugar has been linked with aggression in some studies,<sup>2 10 11</sup> but the evidence of a direct impact of sugar on behaviour may be weaker than popularly believed.<sup>12 13</sup>

It is possible that an underlying organic factor, such as low blood sugar, may lead to both high soft drink consumption and aggressive behaviour. In addition, soft drink consumption is associated with many behavioural variables that are associated with violence. Our study controls for a variety of factors that have been linked with youth violence, including alcohol and tobacco use,<sup>14–18</sup> sleep<sup>19 20</sup> and family dinners.<sup>21</sup> However, there are many other potential confounders that we could not control for, such as family income and other parenting practices.

Our study has various additional limitations. First, the data are based on self-report. However, we have no reason to expect respondents either to exaggerate or to downplay their consumption of soft drinks. Moreover, we have no a priori reason to expect that students who consume high quantities of soft drinks are any more likely to exaggerate their actual violent behaviour than are students with low or no soft drink consumption.

Second, we have limited information about the type of soft drinks consumed by respondents. We do not know, for example, whether or not they were caffeinated. Subsequent surveys should determine more about the soft drinks consumed. Third, we have no other information about the diet of the students, so we do not know if the ‘empty calories’ of soft drinks may be replacing important nutrients in our sample. Finally, our findings, which deal only with largely black and Hispanic high school students from Boston public schools, may not be generalisable to other populations.

Our principal results are that, for Boston high school students, there is a strong, significant association between carbonated non-diet soft drink consumption and the perpetration of

<sup>v1</sup>Never or less than 1 can=0 cans, ‘1 can in the past 7 days’=1 can, ‘2–4 cans in the past 7 days’=3 cans, ‘5–6 cans in the past 7 days’=5.5 cans, ‘1 can per day’=7 cans, ‘2 cans per day’=14 cans, ‘3 or more cans per day’=21 cans.

**Table 4** Marginal effects of independent variables, evaluated at sample means

Independent variables	Dependent variables							
	Carried a knife or a gun		Violence towards peers		Violence in dating relationship		Violence towards children in family	
	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
5+ Cans soft drinks	0.12***	0.09**	0.16***	0.15***	0.09***	0.09***	0.12***	0.12***
No family dinner		0.09***		0.07*		0.00		0.00
<6 Hours sleep		0.04		0.09*		0.03		0.02
Alcohol use		0.15***		0.20***		0.06**		0.10***
Tobacco use		0.26***		0.14**		0.11***		0.11**

\* $p \leq 0.05$ ; \*\* $p \leq 0.01$ ; \*\*\* $p \leq 0.001$ .

violence against siblings, against peers and against dates. Prior literature on this relationship is limited. We also find a strong association between soft drink consumption and carrying weapons. To the best of our knowledge, no prior study examined this relation. On the other hand, we find no support for a connection between soft drink consumption and BMI; the literature on this association is more extensive, but results are mixed.<sup>22–24</sup>

Our finding of a connection between soft drink and violence was an incidental result; soft drink consumption is rarely included in violence surveys. Even if soft drinks are only a marker for violence rather than on the causal pathway, they may be a highly useful marker since, at least in our study, the association between soft drink consumption and violence is not only significant, but also strong and additive to that of both alcohol and tobacco use. In addition, like those variables, soft drink consumption can be readily determined with simple questions. Further research on this issue is warranted.

A review of the relationship between alcohol and crime concluded that alcohol is part of a high-risk lifestyle that also involves illegal drugs and possibly other forms of delinquency. The authors concluded that ‘it may be beneficial to encourage youth to drink sensibly by using pricing and tax policies to encourage soft drink consumption’.<sup>25</sup> Our findings suggest that policies to encourage soft drink consumption may be a mistake.

### What is already known on the subject

- ▶ Diet can affect behaviour.
- ▶ High consumption of soft drinks in particular has been linked with poor mental health among adolescents in Norway.

### What this study adds

- ▶ A sample of 1878 Boston high school students was asked about carbonated non-diet soft drink consumption and about aggressive behaviour in various contexts.
- ▶ Control variables include gender, age, ethnicity, body mass index, use of alcohol or tobacco, frequency of family dinners and hours of sleep on an average school night.
- ▶ Soft drink consumption was strongly and significantly associated with carrying a weapon and with the perpetration of violence against siblings, against peers and against dates.

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**Competing interests** None.

**Ethics approval** Harvard School of Public Health Office of Human Research Administration.

**Contributors** DH was largely responsible for conception and design and acquisition of data. SS was not involved in that phase of the project. SS conducted the statistical analyses. Both authors participated in analysis and interpretation of data, drafting and revising the article for important intellectual content and both shared final approval of the version to be published.

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