



# The mediating effect of daily nervousness and irritability on the relationship between soft drink consumption and aggressive behaviour among adolescents

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## Abstract

**Objectives** This study investigated whether soft drink consumption is related to fighting and bullying behaviour among school-aged children and whether nervousness and irritation mediated this relationship.

**Methods** The data on 7583 adolescents aged 11–15 years from the Slovak part of the Health Behaviour in School-Aged Children (HBSC) study 2010 were analysed. Self-reported soft drink intake, bullying, fighting, nervousness, irritability and confounding variables were analysed using

logistic regressions. To assess the potential mediation of daily nervousness and irritability on the association between soft drink consumption and aggressive behaviour, we used Sobel tests.

**Results** Adolescents' daily soft drink consumption was associated with bullying and fighting, and these relationships were partially mediated by nervousness and irritability. Adjustment of the analyses on gender, age and family affluence did not change the estimates.

**Conclusions** Adolescents' daily soft drink consumption was associated with negative mood deviations such as nervousness and irritability and with aggressive behaviour in the form of bullying and fighting. Our findings provide new evidence about soft drink consumption-related risks and thus can contribute to the preventive actions aimed at reducing them.

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## Introduction

Adolescents in industrialized countries consume on average a great many soft drinks, a behaviour which has a number of unfavourable side effects (Naska et al. 2010). Recent studies show soft drink consumption to be significantly linked to higher rates of overweight, obesity and diabetes (Basu et al. 2013) as well as to metabolic syndrome (Høstmark 2010). Regarding psycho-social issues, mental health problems among adolescents have been shown to be more likely in cases of frequent and steady consumption of sugar-containing soft drinks (Lien et al. 2006; Shi et al. 2010). Also, unhealthy behaviours, such as frequent television viewing, screen-based activities

(Olafsdottir et al. 2014; Hasselkvist et al. 2014; te Velde et al. 2014) or frequent meals in fast food restaurants (Verzeletti et al. 2010), were significantly linked to soft drink intake. To conclude, soft drink intake seems to be associated with a number of health and behavioural problems.

Generally, the prevalence of daily soft drink consumption was found to be higher among boys. When considering socioeconomic status, in Central and Eastern European countries, a significant increase in soft drink consumption was found with increasing family affluence (Vereecken et al. 2005). Particularly in Slovakia, only boys of higher family affluence reported significantly higher soft drink consumption than other affluence groups (Currie et al. 2012).

Bullying and fighting are the most common forms of problematic aggressive behaviour among school-aged children. Recent research has shown that aggressive behaviour of adolescents is associated with fluctuations in their blood sugar level (DeWall et al. 2011). A high intake of soft drinks makes such fluctuations more likely and can thus be indirectly linked to a higher prevalence of violent behaviour among children and adolescents. Such a relationship was confirmed in a recent study dealing with weapon carrying and violence towards peers, family members and dates (Solnick and Hemenway 2012). In addition, adolescents with high soft drink consumption reported more likely involvement in a physical fight, feeling sad or hopeless and having suicidal thoughts and actions (Solnick and Hemenway 2014).

A high soft drink intake may also make bullying and fighting among school-aged children more likely, either directly or mediated by other behavioural factors. Previous research showed that high and daily soft drink intake was significantly associated with a broad range of mental distress symptoms, such as anxiety, sadness, feeling panicked or being tense, among adolescents (Lien et al. 2006). Further, irritability was associated with high physical and verbal aggression (Caprara et al. 2007). In other words, children with daily soft drink intake might be more vulnerable to suffering from nervousness, irritability or other types of mental distress, and this may result in aggressive behaviour. Thus, the connection between daily soft drink intake and adolescents' involvement in bullying and physical fight may be explained by this self-reported nervousness and irritability. Evidence on this potential association is lacking, even though both soft drink consumption and violent behaviour among children and adolescents have become serious public health and public policy issues. Therefore, we investigated whether soft drink consumption was related to the fighting and bullying behaviour of school-aged children, and whether nervousness and irritation mediated this relationship.

## Methods

### Sample and procedure

The data from the Health Behaviour in School-aged Children (HBSC) study conducted in 2010 in Slovakia were analysed. To obtain a representative sample, we used a two-step sampling. In the first step, 134 larger and smaller elementary schools located in rural as well as in urban areas from all regions of Slovakia were asked to participate. These were randomly selected from a list of all eligible schools in Slovakia obtained from the Slovak Institute of Information and Prognosis for Education. School response rate (RR) was 98.1 %.

In the second step, the data from 8491 adolescents from the fifth to ninth grades of these schools (RR: 79.5 %) were obtained. The sample was reduced to adolescents aged 11–15 years, leading to a final sample of 7583 adolescents (mean age: 12.89; 48.2 % boys) in the target age group.

The study was approved by the Ethics Committee of the Medical Faculty at the P. J. Safarik University in Kosice. Parents were informed about the study via the school administration and could opt out if they disagreed with their child's participation. Participation in the study was fully voluntary and anonymous with no explicit incentives provided for participation.

### Measures

The present study uses HBSC data related to adolescents' reports of soft drink consumption rate, bullying behaviour, involvement in physical fights, nervousness, irritation and socio-demographic characteristics (age, family affluence and gender).

*Soft drink consumption* was measured by the question: "How many times a week do you usually drink coke or other soft drinks that contain sugar?" Possible responses were: "never", "less than once a week", "once a week", "2–4 days a week", "5–6 days a week", "once a day, every day", "every day, more than once". To obtain two groups of adolescents—those who drink soft drinks once a day or more and the others, we dichotomized the responses.

*Bullying* The role of the adolescent in bullying was measured using the revised Olweus Bully/Victim Questionnaire (Solberg and Olweus 2003). After having read a standard definition of bullying, respondents were asked about their involvement in bullying—how often they had bullied others in school in the last few months. Responses were rated on a five-point scale ("I haven't been bullied/bullied other students at school in the past couple of months", "only once or twice", "two or three times a month", "about once a week", "several times a week"). We chose the cutoff point of "two or three times a month"

and dichotomized the responses to get two categories of bullying behaviour.

*Physical fight involvement* was measured by the question “During the past 12 months, how many times were you in a physical fight?” Response categories were: “I have not been in a physical fight in the past 12 months”, “one time”, “two times”, “three times”, “four times or more”. We dichotomized the responses to obtain category of adolescents who are involved in a physical fight more than three times in the past 12 months.

*Nervousness and irritation* was measured by two items from the HBSC symptom checklist (HBSC-SCL): “In the last 6 months: how often have you had the following...?” and we focused on irritability and being nervous, with possible responses: “about every day”, “more than once a week”, “about every week”, “about every month”, “rarely or never”. In the dichotomization we distinguished the group of adolescents with daily complaints.

*Family affluence* was used to determine the socio-economic status of adolescents and their families, measured with the Family Affluence Scale (FAS) widely used in the HBSC questionnaire. FAS items ask students about things they are likely to know about in their family (car, bedrooms, vacations and computers), thus limiting the number of non-responses in the study (Schnohr et al. 2013). The items and their response categories were: “Does your family own a car, van or truck?” (no = 0, yes, one = 1, yes, two or more = 2), “Do you have your own bedroom for yourself?” (no = 0, yes = 1), “During the past 12 months, how many times did you travel away on holiday with your family?” (not at all = 0, once = 1, twice = 2, more than twice = 3), “How many computers does your family own?” (none = 0, one = 1, two = 2, more than two = 3). The final score of every respondent determines the socioeconomic status (low—0 to 2 points; medium—3 to 5 points; high—6 to 9 points).

#### Statistical analyses

First, the socio-demographic characteristics were described: gender, family affluence, age and the prevalence of soft drink consumption, involvement in bullying and a physical fight and daily nervousness and irritability. Differences between the groups were tested using Chi-square tests.

Second, we assessed the crude associations of daily soft drink consumption, irritability and being nervous and the confounding variables (gender, family affluence, age) with involvement in bullying and a physical fight (Model 1). We adjusted the crude effect of soft drink consumption on bullying and involvement in a physical fight for gender, age and family affluence (Model 2).

Third, we assessed the effect of soft drink consumption on bullying and on involvement in a physical fight after adding in daily health complaints—being irritated (Model 3a) and being nervous (Model 3b). To assess the mediating effect of nervousness and irritability, we used the Sobel test to explore whether the indirect effect of the independent variable on the dependent variable through the mediator variable was significant. The following formula was used:

$$t = \frac{\beta_a \beta_b}{\sqrt{(\beta_a^2 SE_{\beta_b}^2) + (\beta_b^2 SE_{\beta_a}^2)}}$$

where  $\beta_a$  is the regression coefficient for the relationship between the independent variable and the mediator variable,  $\beta_b$  is the regression coefficient for the relationship between the mediator variable and the dependent or the outcome variable,  $SE_{\beta_a}$  is the standard error of  $\beta_a$  (the relationship between the independent variable and the mediator variable), and  $SE_{\beta_b}$  is the standard error of  $\beta_b$  (the relationship between the mediator variable and the dependent or outcome variable). A significant Sobel test outcome suggests the existence of mediation between the independent variable and the dependent or the outcome variable (Sobel 2008). The degree of reduction of the odds ratios (ORs) was computed using the formula:  $(OR_{\text{crude}} - OR_{\text{adjusted}})/(OR_{\text{crude}} - 1) \times 100\%$ . All data were analysed using IBM SPSS statistics 20.0 for Windows, and the Sobel tests were calculated via <http://www.danielsoper.com>.

#### Results

Almost 40 % of our sample reported daily soft drink consumption. As to the aggressive behaviour, over 10 % of our sample bullied others two or three times a month and more and was involved in a physical fight three times or more in the last year. Daily nervousness and irritability were reported by one-tenth of the sample. Descriptive characteristics of the sample are shown in Table 1.

Daily soft drink consumption was significantly associated with bullying others and involvement in a physical fight, and crude and also adjusted for potential confounders (Table 2). Odds ratios for soft drink consumption changed only marginally after adjustment. Adolescents who reported daily consumption were more likely to behave aggressively (to bully or fight with others).

The association between soft drink consumption and aggressive behaviour (fighting and bullying) remained significant after additional adjustment for potential mediators, i.e. daily nervousness and irritability, separately (Models 3a and 3b) and combined (Model 4). Changes in the odds ratios (OR) in this relationship after inclusion of

**Table 1** Background characteristics of the sample—gender, family affluence and prevalence of daily irritability, nervousness, bullying and involvement in physical fight—overall and by category of soft drink consumption; HBSC study Slovakia, 2009/2010

	Total <i>N</i> = 7583 <i>N</i> (%)	Soft drink consumption		Daily vs. irregular soft drink consumer <i>p</i> value
		Daily <i>N</i> = 2722 (37 %) <i>N</i> (%)	Irregular <i>N</i> = 4644 (63 %) <i>N</i> (%)	
Gender				<0.001
Boy	3654 (47.9)	1379 (18.7)	2148 (29.2)	
Girl	3921 (52.1)	1341 (18.2)	2490 (33.8)	
Family affluence				0.096
Low	1659 (24.1)	572 (8.6)	1036 (15.5)	
Medium	3482 (51.2)	1219 (18.2)	2201 (32.9)	
High	1696 (24.8)	638 (9.5)	1016 (15.2)	
Irritability (daily)				<0.001
Yes	673 (8.9)	302 (4.2)	341 (4.7)	
No	6766 (91.1)	2377 (32.8)	4231 (58.4)	
Feeling nervous (daily)				<0.001
Yes	771 (10.2)	345 (4.8)	392 (5.4)	
No	6676 (89.8)	2331 (32.1)	4190 (57.7)	
Bullying				<0.001
Yes	961 (13.3)	416 (5.8)	545 (7.6)	
No	6250 (86.7)	2243 (31.1)	4007 (55.6)	
Fighting				<0.001
Yes	1028 (14.2)	479 (6.6)	549 (7.6)	
No	6197 (85.8)	2186 (30.3)	4011 (55.5)	

Only valid percentages are presented; missing values: gender *N* = 8 (0.1 %); soft drink consumption *N* = 217 (2.9 %); family affluence *N* = 746 (9.8 %); irritability *N* = 144 (1.9 %); feeling nervous *N* = 136 (1.8 %); bullying *N* = 174 (2.3 %); fighting *N* = 156 (2.1 %)

daily nervousness and irritation in the model suggest that these have a mediating role. As shown in Table 3, the outcomes of the Sobel tests confirmed the mediating role of daily nervousness and irritability on the association of daily soft drink consumption and aggressive behaviour—bullying and fighting of adolescents. The conceptual model of mediation is illustrated in Fig. 1.

## Discussion

This study explored the associations between daily soft drink intake and bullying and fighting, and whether nervousness and irritability mediated these associations. Daily soft drink consumption was related to aggressive behaviour (bullying and fighting) among school-aged children. Furthermore, this relationship was found to be mediated by daily nervousness and irritability.

Our findings about the connection between soft drink consumption and aggressive behaviour of school-aged children are in line with previous findings. Solnick and Hemenway found an association between soft drink consumption and violent behaviour among high school

students (Solnick and Hemenway 2012). In addition, Shakira et al. found this association among 5-year-old children (Suglia et al. 2013). Other studies investigated the connection between consumption of caffeine, which is consumed by adolescents mostly via soft drinks, and violent behaviour of adolescents and found a significant relation (Kristjansson et al. 2013; Martin et al. 2008). Although the results of the first two studies did not take into account the socioeconomic status of adolescents' families as we did, we found the same results.

As we investigated the connection between soft drink intake and aggressive behaviour of adolescents cross-sectionally, our findings can be explained in two ways. Firstly, soft drink consumption may lead to frequent aggressive behaviour among adolescents. This causal path might be due to the influence of soft drink content, such as sugar, artificial sweeteners or caffeine, on adolescents' behaviour. Although previous studies have shown that consumption of artificial sweeteners (e.g. aspartame) had no relation to problem behaviour (Saravis et al. 1990; Van den Eeden et al. 1994), these studies focused on the short-term behaviour immediately after consumption. However, daily consumption of this substance can cause dramatic

**Table 2** The association between daily soft drink consumption of adolescents and their involvement in bullying and fighting, crude and adjusted for age, gender and family affluence, and additionally adjusted for irritability and nervousness, separately and combined; odds ratios (OR) and 95 % confidence intervals (CI) in parentheses; HBSC study Slovakia, 2009/2010

	Model 1 OR (95 % CI)	Model 2 OR (95 % CI)	Model 3a OR (95 % CI)	Model 3b OR (95 % CI)	Model 4 OR (95 % CI)
<b>Bullying</b>					
Daily soft drink consumption	1.36 (1.18–1.56)	1.31 (1.13–1.51)	1.25 (1.08–1.45)	1.26 (1.09–1.46)	1.24 (1.07–1.44)
Gender (boy)	1.77 (1.54–2.03)	1.87 (1.62–2.17)	1.90 (1.64–2.20)	1.90 (1.64–2.20)	1.90 (1.64–2.21)
Age in years	1.11 (1.05–1.17)	1.08 (1.02–1.15)	1.09 (1.02–1.15)	1.08 (1.02–1.15)	1.09 (1.03–1.15)
Family affluence					
High	1 (ref)	1 (ref)	1 (ref)	1 (ref)	1 (ref)
Medium	0.80 (0.67–0.94)	0.81 (0.68–0.96)	0.81 (0.68–0.97)	0.80 (0.67–0.95)	0.81 (0.68–0.96)
Low	0.93 (0.77–1.13)	0.97 (0.79–1.18)	0.94 (0.77–1.15)	0.93 (0.76–1.14)	0.93 (0.75–1.14)
Irritability (daily)	2.62 (2.17–3.16)	–	2.54 (2.07–3.12)	–	2.01 (1.58–2.56)
Feeling nervous (daily)	2.10 (1.74–2.53)	–	–	2.14 (1.75–2.62)	1.55 (1.22–1.96)
Change of OR for soft drinks <sup>a</sup>	–	13.9 %	19.4 %	16.1 %	22.6 %
Cases included in the model N (%)		6568 (86.6)	6494 (85.6)	6497 (85.7)	6467 (85.3)
<b>Fighting</b>					
Daily soft drink consumption	1.60 (1.40–1.82)	1.52 (1.31–1.76)	1.46 (1.26–1.70)	1.45 (1.25–1.69)	1.45 (1.24–1.68)
Gender (boy)	4.55 (3.91–5.30)	4.61 (3.92–5.42)	4.55 (3.85–5.37)	4.61 (3.90–5.45)	4.62 (3.91–5.46)
Age in years	0.98 (0.94–1.03)	0.97 (0.92–1.03)	0.97 (0.92–1.03)	0.97 (0.91–1.03)	0.97 (0.92–1.03)
Family affluence					
High	1 (ref)	1 (ref)	1 (ref)	1 (ref)	1 (ref)
Medium	0.70 (0.59–0.82)	0.72 (0.61–0.85)	0.76 (0.64–0.90)	0.73 (0.61–0.87)	0.74 (0.63–0.88)
Low	0.60 (0.49–0.73)	0.69 (0.56–0.85)	0.69 (0.56–0.85)	0.66 (0.53–0.82)	0.66 (0.53–0.82)
Irritability (daily)	2.29 (1.89–2.77)	–	2.39 (1.93–2.97)	–	1.69 (1.31–2.18)
Feeling nervous (daily)	3.35 (1.97–2.81)	–	–	2.50 (2.04–3.07)	1.94 (1.52–2.48)
Change of OR for soft drinks <sup>a</sup>	–	13.3 %	11.5 %	13.5 %	13.5 %
Cases included in the model N (%)		6595 (87.0)	6519 (86.0)	6525 (86.0)	6493 (85.6)

Model 1: crude effect of each variable separately on bullying and fighting

Model 2: effect of each variable separately on bullying and fighting adjusted for family affluence, gender and age

Model 3a: adjusted effect of daily soft drink consumption controlled for irritability

Model 3b: adjusted effect of daily soft drink consumption controlled for being nervous

Model 4: adjusted effect of daily soft drink consumption controlled for irritability and being nervous

<sup>a</sup> Decrease of OR for daily soft drink consumption due to adjustment, compared with Model 1 (in Model 2) and Model 2 (in Models 3a, 3b and 4); HBSC study Slovakia, 2009/2010

fluctuations in the blood glucose levels or even metabolic syndrome (Kristjansson et al. 2013; Tandel 2011), which has been found to be related to behaviour deviations and violence (Benton 2007). According to these findings, the components of soft drinks might provoke aggressive behaviour, although evidence on this causal relationship is lacking. A second possible explanation of the relationship we found is that adolescents reporting aggressive behaviour are more inclined to drink sweetened beverages than nonaggressive adolescents.

We found that daily self-reported nervousness and irritability mediated the relationship between daily soft drink intake and aggressive behaviour—bullying and fighting of adolescents. This means that children with daily soft drink

intake might be more vulnerable to suffering from nervousness and irritability, which may result in aggressive behaviour. Thus, the connection between daily soft drink intake and adolescents' involvement in bullying and physical fighting may be explained by the self-reported nervousness and irritability.

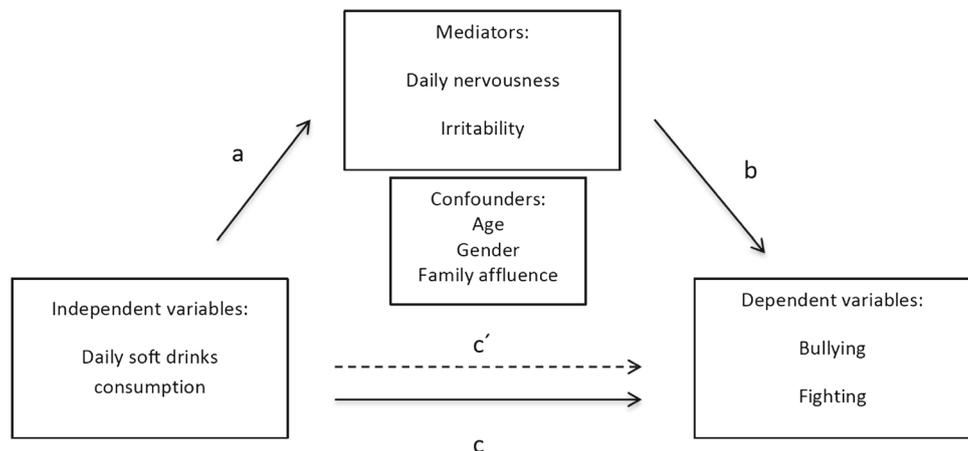
#### Strengths and limitations

We consider the large and representative study sample of adolescents aged from 11 to 15 years and the high response rate to be the major strengths of this study. In addition, we used validated measures of frequency of soft drink consumption (Vereecken et al. 2008; Vereecken and Maes

**Table 3** Mediation effects of daily irritability and nervousness on the relationship between daily soft drink consumption and bullying and fighting; results of the Sobel tests; HBSC study Slovakia, 2009/2010

Indirect path	$\beta_a$ (SE $\beta_a$ )		$\beta_b$ (SE $\beta_b$ )		<i>t</i>	<i>p</i> value
Soft drink consumption	0.459 (0.078)		0.743 (0.095)			
	→	Nervousness	→	Bullying	5.06	<0.001
Soft drink consumption	0.455 (0.083)		0.963 (0.096)			
	→	Irritability	→	Bullying	4.97	<0.001
Soft drink consumption	0.459 (0.078)		0.856 (0.091)			
	→	Nervousness	→	Fighting	5.31	<0.001
Soft drink consumption	0.455 (0.083)		0.830 (0.096)			
	→	Irritability	→	Fighting	4.80	<0.001
Direct path	$\beta_c$ (SE $\beta_c$ )		$\beta_{c'}$ (SE $\beta_{c'}$ )			
Soft drink consumption	0.310 (0.70)		0.260 (0.072)			
		→		Bullying		
Soft drink consumption	0.471 (0.068)		0.441 (0.70)			
		→		Fighting		

$\beta$  Standardized coefficient, *SE* standard error, *a* association between soft drink consumption and potential mediators, *b* associations between the mediators and aggressive behaviour, *c* total association between soft drink consumption and aggressive behaviour, unadjusted for the mediators, *c'* direct association between soft drink consumption and aggressive behaviour, adjusted for the mediators

**Fig. 1** Conceptual model for the mediated effect of daily health complaints on the association between soft drink consumption and aggressive behaviour (bullying and fighting)

*a* = Association between soft drinks consumption and potential mediators. *b* = Associations between the mediators and aggressive behaviour. *c* = Total association between soft drinks consumption and aggressive behaviour, unadjusted for the mediators. *c'* = Direct association between soft drinks consumption and aggressive behaviour, adjusted for the mediators.

2003), nervousness and irritability (Haugland and Wold 2001), fighting (Brener et al. 1995) and bullying (Vessey et al. 2014), which have been well validated and the reliability ascertained with extensive use in a variety of reports and peer-reviewed publications at national and cross-national levels. A limitation of the current study is its cross-sectional design. Therefore, inferences regarding the cause and effect were not possible. In addition, our data were based on self-reports, which can be inaccurate or influenced by social desirability, though previous research has shown them to be valid.

## Implications

Taken together, our findings on the intake of soft drinks have important implications for interventions taking place both in the school and family environments. The association between excessive soft drink consumption and several health and behavioural problems, be it causal or not, provides a reason to monitor the soft drink intake at schools. If the relationship is indeed causal, preventive activities focused on adolescents during school time could aim at banning soft drinks at schools or providing information

about adverse effect of soft drink consumption to adolescents and parents. However, this evidently requires further research on causality via a longitudinal study, and on the effectiveness of interventions. Further research is needed to examine the biological and psycho-social mechanisms affecting the relationship between soft drink consumption and aggressive behaviour.

## Conclusion

In conclusion, our results underline the fact that adolescents' daily soft drink consumption is associated with aggressive behaviour and that this relationship is mediated by negative mood deviations such as nervousness and irritability. Our findings provide new evidence about risks related to soft drink consumption and thus can contribute to preventive actions aimed to reduce these. Longitudinal studies should explore the causal relationships between soft drink intake and health and behavioural outcomes among adolescents.

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**Compliance with ethical standards** The study was approved by the Ethics Committee of the Medical Faculty at the P. J. Safarik University in Kosice. Parents were informed about the study via the school administration and could opt out if they disagreed with their child's participation. Participation in the study was fully voluntary and anonymous with no explicit incentives provided for participation.

**Conflict of interest** The authors declare that they have no conflict of interest.

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