

Regular energy drink consumption is associated with the risk of health and behavioural problems in adolescents

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Abstract Consumption of energy drinks has become popular and frequent among adolescents across Europe. Previous research showed that regular consumption of these drinks was associated with several health and behavioural problems. The aim of the present study was to determine the socio-demographic groups at risk for regular energy drink consumption and to explore the association of regular energy drinks consumption with health and

behavioural problems and negative school experiences in adolescents. Data from the Health Behaviour in School-aged Children Study conducted in 2014 in Slovakia were analysed. We assessed socio-demographic characteristics, energy drink consumption, health and behavioural problems and negative school experiences based on self-reports from 8977 adolescents aged 11–15 years (mean age/standard deviation 13/1.33; 50.0% boys). The prevalence of regular energy drink consumption in the present sample was 20.6% (95%CI: 20%–21%). Regular energy drink consumption was more frequent among boys and older adolescents. Adolescents with a medium-level family affluence were less likely to drink energy drinks regularly. Adolescents who consumed energy drinks regularly had more health and behavioural problems and negative school experiences.

Conclusion: Adolescents drinking energy drinks are at risk of a wide range of negative outcomes and should be specifically addressed by preventive interventions.

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What is Known

- Energy drink consumption has become popular and frequent among adolescents across Europe.
- There is growing evidence that energy drink consumption is related to negative social, emotional and health outcomes, but only a few studies have explored this relationship in adolescents.

What is New

- Regular energy drink consumption was more frequent among boys and adolescents reporting low family affluence and increased with age.
- Adolescents reporting regular energy drink consumption were in higher risk to suffer from health and behavioural problems and negative school experiences.

Keywords Adolescents · Energy drinks · Health and behavioural problems · Negative school experience

Abbreviations

CIs	Confidence intervals
ED	Energy drinks
FAS	Family Affluence Scale
HBSC	Health Behaviour of School-aged Children
ORs	Odds ratios
SPSS	Statistical Package for the Social Sciences

Introduction

Health experts have given numerous warnings on the unsuitability of energy drinks (ED) for adolescents [30, 38], but despite this the consumption of these drinks has become popular and frequent among adolescents across Europe. Several studies from Europe and the USA confirm that the prevalence of adolescents reporting ED consumption vary from 20 to 50% [10, 31, 38].

ED are beverages which contain large doses of caffeine, sugar and a variety of other stimulants and substances such as guarana, taurine or vitamins [14]. Caffeine is considered as the main substance which is associated with adverse health consequences among adolescents [29, 34]. Also, the high amounts of sugar contained in these beverages have previously been linked to adverse health and behavioural outcomes in adolescence [15, 29]. The effect of other ingredients contained in ED on health and behaviour of adolescents remains unclear [31]. In addition, information lacks on a potentially synergistic effect of the ED content—caffeine, sugar and other substances—on negative health and behavioural outcomes in adolescents.

Evidence indicating adverse health effects of ED consumption is growing. Regular ED consumption among adolescents was found to be associated with cardiovascular problems, diabetes [12, 19, 31, 36] and depression [2]. Behavioural correlates were also found, with ED consumption being associated with more video game use [21], attention deficit hyperactivity disorder symptoms, delinquency, violent behaviours [19, 20], physiological symptoms such as problems with breathing, headaches, an upset stomach, insomnia, anxiety, agitation, heart palpitations, visual disturbance [3, 7, 18], sensation seeking, risk-taking behaviour [1, 24] substance use [2, 6, 10, 23, 27, 35], stress, sleep dissatisfaction, mood and suicidality [26]. Adolescents consuming ED are at risk for later alcohol use [25]. Furthermore, it has been suggested that ED consumption in adolescence may serve as a gateway to other forms of drug dependence [28].

The worldwide prevalence of ED consumption is high and a growing body of evidence has documented the potential adverse effects of these drinks on health and behaviour. General awareness of the adverse effects of ED consumption is increasing, but evidence on this topic regarding young adolescents is limited. Therefore, the aim of present study was to

determine the socio-demographic groups at risk for regular energy drink consumption and to explore the associations of regular energy drink consumption with negative health and behavioural outcomes and negative school experiences in adolescents. These findings should help making a choice between preventive programs and implement evidence-based practices that will better target adolescents.

Materials and methods

Sample and procedure

We used data from the Health Behaviour in School-aged Children (HBSC) Study conducted in 2014 in Slovakia. To obtain a representative sample, we used two-step sampling. In the first step, 151 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 86.1%. In the second step, we obtained data from 8977 adolescents from the fifth to ninth grades of elementary schools in Slovakia in the target group of 11–15 years old, one from each grade per school.

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

Data for the present analyses were collected using questionnaires from the standardized research protocols for the 2014 WHO-collaborative HBSC study.

Energy drink consumption was measured by the question: “How many times a week do you usually drink energy drinks, for example Red Bull?” with the following as response options: never; less than once a week; once a week; 2–4 days a week; 5–6 days a week; once a day, every day and every day, more than once. The European Food Safety Authority has identified adolescents consuming ED once a week and more as chronic users of this beverage [38]. In line with this policy, we dichotomised responses on use of energy drinks to obtain two groups of adolescents—regular (chronic) energy drinks consumers (once a week and more) and the other ones.

Daily health complaints were measured by the HBSC symptom checklist (HBSC-SCL): “In the last 6 months: how often have you had the following...?” With the following

options: “headache, stomach-ache, backache, feeling low, irritability or bad temper, feeling nervous, difficulties in getting to sleep, feeling dizzy” with the following response options: about every day, more than once a week, about every week, about every month, rarely or never. We dichotomised the response options to obtain two groups of adolescents: those who reported daily health complaints and others.

Self-rated health assesses the general health of adolescents and was measured by the question “Would you say your health is...?” with the following response options: excellent, good, fair or poor. The response options were dichotomised to get two groups of adolescents: those who reported fair or poor health and other ones consistently with previous research [5].

School liking is an item assessing the emotional and psychological connectedness to school in terms of liking school: “How do you feel about school at present?” The following are the response options: I like it a lot, like it a bit, not very much and not at all. We dichotomised the response options to get the group of adolescents who liked school a bit or a lot.

Physical fight involvement was measured by the question “During the past 12 months, how many times were you in a physical fight?” with the following response options: I have not been in a physical fight in the past 12 months, 1 time, 2 times, 3 times and 4 times or more. We dichotomised the response options to obtain the category of adolescents who were involved in a physical fight more than 3 times in the past 12 months.

Bullying behaviour of adolescents was measured using the revised Olweus Bully/Victim Questionnaire. 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 with the following response options: I haven’t 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 and several times a week. We chose “two or three times a month” as a cut-off point and dichotomised the responses to get two categories of bullying behaviour.

Truancy was measured by asking: “How many days have you skipped classes or school (without permission) this term?” with the following response options: never, 1, 2, 3 days or 4 days or more. We dichotomised the responses to distinguish those who skipped school more than once from the others.

Current smoking status was defined on the basis of the question “How often do you smoke tobacco at present?” with the following response options: every day; at least once a week but not every day; less than once a week; or never. We focused on adolescents smoking at least once a week.

Drunkenness was assessed with the question: “Have you ever had so much alcohol that you were really drunk?” with the following response options: never, once, two or three times, four to ten times and more than ten times. We identified adolescents being drunk more than once in the last 30 days.

Perceived school performance was measured by the item “In your opinion, what does your class teacher(s) think about your school performance compared to your classmates?” with the following response options: very good, good, average and below average. Responses were dichotomised to obtain the group of adolescents reporting academic achievement below average.

Family affluence was measured using the Family Affluence Scale III (FAS III), which consists of six questions: “Does your family own a car, van or truck?” “Do you have your own bedroom for yourself?” “How many computers does your family own?” “How many bathrooms (room with a bath/shower or both) are in your home?” “Does your family have a dishwasher at home?” “How many times did you and your family travel out of Slovakia for a holiday/vacation last year?” We converted the FAS summary scores to a final score, which has a consistent, normal distribution and a range from 0 to 1. We then created groups of low (0–.333), middle (.334–.666) and high (.667–1) socio-economic position [9].

Statistical analyses

In the first step, the socio-demographic characteristics of the sample were described: the prevalence of gender and family affluence was computed for the total sample and stratified by category of ED consumption. Moreover, prevalence of several types of negative outcomes such as health complaints, self-rated health, fighting, bullying, smoking, drunkenness, school dislike, low academic achievement and truancy were described for the total sample and stratified by category of ED consumption. Differences between regular and irregular consumers of ED were tested using Chi-square tests (Table 1). Second, associations between regular ED consumption and gender, age and family affluence were assessed (Table 2). Third, the associations (crude—model 1 and adjusted for potential confounders—model 2) of regular ED consumption with health and behavioural outcomes were assessed using a multiple logistic model to estimate crude and adjusted ORs and corresponding 95% confidence intervals (Table 3). Statistical analyses were performed using IBM SPSS statistics 20.0 for Windows.

Results

The study sample consisted of 8977 adolescents aged 11–15 years (mean age/standard deviation 13.49/1.33; 50.0% boys). Regular consumption of ED was reported by 20.6% of adolescents (95%CI: 20%–21%) (Table 1).

Regular ED consumption was more frequent among boys and increased with age, and adolescents reporting family affluence at a medium level were at a lower risk to drink ED regularly than those reporting low family affluence (Table 2).

Table 1 Background characteristics of the sample—gender, family affluence and the prevalence of health and behavioural problems—overall and by category of energy drinks consumption

		Total <i>N</i> = 8977 (100%)	Regular energy drink consumption <i>N</i> = 1849 (20.6%)	Irregular energy drink consumption <i>N</i> = 7128 (79.4%)	Regular vs. irregular energy drink consumption <i>p</i> value
Gender	Boys	4490 (50.0)	1239 (27.6)	3251 (72.4)	<0.001
	Girls	4487 (50.0)	610 (13.6)	3877 (86.4)	
Family affluence	Low	3148 (39.7)	650 (20.6)	2498 (79.4)	Ns
	Middle	2237 (28.2)	413 (18.5)	1824 (81.5)	
	High	2548 (32.1)	506 (19.9)	2042 (80.1)	
Health complaints (daily)	Head ache	1707 (19.2)	486 (26.8)	1221 (17.3)	<0.001
	Stomach-ache	1166 (13.1)	332 (18.2)	834 (11.8)	<0.001
	Back ache	1261 (14.4)	372 (20.8)	889 (12.7)	<0.001
	Feeling low	1728 (19.6)	474 (26.3)	1254 (17.9)	<0.001
	Irritability or bad temper	2489 (28.1)	654 (36.0)	1835 (26.0)	<0.001
	Feeling nervous	2538 (28.7)	673 (37.2)	1865 (26.5)	<0.001
	Difficulties with sleeping	1413 (16.0)	389 (21.6)	1024 (14.5)	<0.001
	Feeling dizzy	885 (10.0)	277 (15.3)	608 (8.6)	<0.001
Self-rated health (fair and poor)		983 (11.1)	280 (15.4)	703 (10.0)	<0.001
Fighting (three times and more)		1143 (13.0)	450 (25.1)	693 (9.9)	<0.001
Bullying (two or three times a week)		1159 (13.2)	358 (20.0)	801 (11.4)	<0.001
Smoking (more than once a week)		407 (4.6)	280 (15.4)	127 (1.8)	<0.001
Drunkenness (more than once in last 30 days)		651 (7.7)	334 (20.4)	317 (4.6)	<0.001
School dislike (not very much or not at all)		3511 (39.3)	1087 (59.0)	2424 (34.1)	<0.001
Academic achievement (below average)		338 (3.8)	164 (8.9)	174 (2.5)	<0.001
Truancy (once and more)		1466 (16.6)	533 (29.6)	933 (13.2)	<0.001

Only the percentages of valid answers are presented; missing values: Energy drink consumption 0 (0), Gender 0 (0), Family affluence 1044 (11.6), Head ache 88 (1.0), Stomach-ache 96 (1.1), Back ache 190 (2.1), Feeling low 161 (1.8), Irritability or bad temper 111 (1.2), Feeling nervous 121 (1.3), Difficulties with sleeping 134 (1.5), Feeling dizzy 102 (1.1), Self-rated health 106 (1.2), School dislike 36 (0.4), Fighting 155 (1.7), Bullying 185 (2.1), Truancy 127 (1.4), Smoking 103 (1.1), Drunkenness 516 (5.7), Academic achievement 66 (0.7)

Ns non-significant

Results of logistic models showed that regular ED consumption among adolescents was related to negative health and behavioural outcomes and negative school experiences and problem behaviours. Adolescents reporting regular ED consumption were at higher risk suffering from various health complaints, reporting unfavourable self-rated health and disliking school. In addition, these adolescents were more likely to fight, bully others, skip the school lessons, smoke, drink alcohol and report low academic achievement. Adding gender, age and family affluence to the models did not affect the strength of the association of regular ED consumption with the examined types of negative outcomes (Table 3).

Discussion

The aim of this study was to explore the relationship between regular ED consumption among adolescents and health and behavioural outcomes. We found that regular consumers of ED were more likely to report a wide range of damaging

health and behavioural outcomes and negative school experiences, such as daily health complaints, poor self-rated health, school dislike, low academic achievement, truancy, fighting, bullying, smoking and drunkenness.

ED consumption was more prevalent among boys and older adolescents which fits with previous evidence [10]. In general, boys and older adolescents were identified as being more vulnerable to having unhealthy eating habits [33]. Adolescents reporting low family affluence showed higher ED consumption than their peers. Generally, a low socio-economic status was previously associated with higher consumption of ED as a part of an unhealthy dietary pattern [4, 11].

Present study showed that adolescents reporting regular ED consumption were at a higher risk of several health and behavioural problems such as daily health complaints, poor self-rated health, school dislike, low academic achievement, truancy, fighting, bullying, smoking and drunkenness. Our results are in line with previous evidence on the association of ED with physiological symptoms [3, 7, 18], substance use [2, 6, 10, 23, 27, 35] or aggressive behaviour [19, 24] in

Table 2 The association of regular energy drink consumption with age, gender and family affluence among adolescents; odds ratios (OR) and 95% confidence intervals (CI) in parentheses

		Crude model 1 OR (95%CI)	Adjusted model 2 OR (95%CI)
Gender	Girl	1 (ref)	1 (ref)
	Boy	2.42 (2.17–2.69)***	2.43 (2.17–1.74)***
Age		1.25 (1.20–1.30)***	1.26 (1.20–1.31)***
Family affluence	Low	1 (ref)	1 (ref)
	Medium	0.87 (0.75–0.99)*	0.84 (0.73–0.97)*
	High	0.95 (0.83–1.08)	0.91 (0.80–1.04)

Crude model 1: crude effect of gender, age and family affluence separately on energy drink consumption. Adjusted model 2: combined effect of gender, age and family affluence on regular energy drink consumption
* $p < 0.05$, *** $p < 0.001$

adolescents. Moreover, we found that adolescents consuming ED on a regular basis were more vulnerable to have problems in school. They reported school dislike, low academic achievement and truancy more frequently than their peers. Taken together, the results of the present study based on the large and representative sample of adolescents point out that regular ED consumption in adolescence is associated with a

higher risk for several negative outcomes ranging from health problems to problems in school.

Given the cross-sectional design of the present study, we cannot make causal inferences regarding the association of ED consumption with health and behavioural problems in adolescents. Three explanations may hold. Firstly, there is growing evidence that ED consumption in childhood and adolescence may have adverse physiological effects [13] due to the high amount of caffeine [34]. Other substances, such as sugar (glucose and fructose), have also been identified as the metabolically deleterious ingredients. In combination with caffeine, it has the greatest metabolic impact and potential influence on overall health [32]. A recent study on adolescents' consumption of sugary and caffeinated drinks suggested the possible explanation that adolescents reporting regular consumption of these drinks are more likely to report mood deviations and subsequently aggressive behaviour [15]. This can be caused by fluctuations in blood glucose levels, which has been found to be related to behavioural deviations.

A second explanation is that ED consumption might be a part of a broader cluster of adverse behaviours [37]. According to this hypothesis, adolescents vulnerable to behave in a risky manner might prefer these beverages. More specifically, previous research has found that a significant number of young adults mix energy drinks with alcohol [16,

Table 3 The association of regular energy drink consumption in adolescents (independent variable) with a wide range of health and behavioural problems, crude and adjusted for age, gender and family affluence; odds ratios (OR) and 95% confidence intervals (CI) in parentheses

	Crude model OR (95%CI)	Number of cases included in the crude model N (%)	Adjusted model OR (95%CI)	Number of cases included in the adjusted model N (%)
Health complaints (daily)				
Head ache	1.75 (1.55–1.98)***	8889 (99.0)	2.12 (1.85–2.44)***	7865 (87.6)
Stomach-ache	1.66 (1.44–1.91)***	8881 (98.9)	2.00 (1.71–2.35)***	7852 (87.5)
Back ache	1.81 (1.58–2.07)***	8787 (97.9)	1.97 (1.70–2.29)***	7778 (86.6)
Feeling low	1.63 (1.45–1.84)***	8816 (98.2)	2.12 (1.84–2.43)***	7808 (87.0)
Irritability or bad temper	1.59 (1.43–1.78)***	8866 (98.8)	1.84 (1.63–2.08)***	7854 (87.5)
Feeling nervous	1.64 (1.47–1.83)***	8856 (98.7)	1.80 (1.60–2.04)***	7843 (87.4)
Difficulties with sleeping	1.61 (1.41–1.83)***	8843 (98.5)	1.88 (1.63–2.17)***	7834 (87.3)
Feeling dizzy	1.91 (1.64–2.23)***	8875 (98.9)	2.13 (1.79–2.53)***	7861 (87.6)
Self-rated health (fair and poor)	1.63 (1.41–1.90)***	8871 (98.8)	1.80 (1.52–2.12)***	7847 (87.4)
Fighting (three times and more)	3.06 (2.68–3.49)***	8822 (98.3)	2.62 (2.26–3.04)***	7867 (87.6)
Bullying (two or three times a week)	1.93 (1.68–2.21)***	8792 (97.9)	1.78 (1.53–2.07)***	7825 (87.2)
Smoking (more than once a week)	9.92 (7.99–12.32)***	8874 (98.9)	9.07 (7.11–11.58)***	7848 (87.4)
Drunkenness (more than once in last 30 days)	5.25 (4.45–6.19)***	8461 (94.3)	4.71 (3.91–5.68)***	7526 (83.8)
School dislike (not very much or not at all)	2.78 (2.50–3.08)***	8941 (99.6)	2.46 (2.19–2.76)***	7904 (88.0)
Academic achievement (below average)	3.89 (3.12–4.85)***	8911 (99.3)	3.43 (2.67–4.41)***	7890 (87.9)
Truancy (once and more)	2.76 (2.44–3.12)***	8850 (98.6)	2.63 (2.29–3.01)***	7881 (87.8)

Model 1: crude effect of energy drinks consumption on problem behaviour. Model 2: effect of regular energy drinks consumption on each variable separately adjusted for gender, age and family affluence

*** $p < 0.001$

22]. This habit—mixing alcohol with energy drinks—may be a main motivation and a gateway to future alcohol use [28].

Thirdly, ED consumption as part of a broader cluster of adverse behaviours could be determined by other psychosocial factors, such as family background, peers or wider environmental factors. In this case, a common cause of these outcomes exists. Practically, this may also be associated with the second explanation, as such, a common cause might lead to a clustering of the outcomes. This has been documented for a number of causes of adverse health-behaviours in adolescents, with e.g. norms of friend [8] and parenting practices [17] being such common causes.

Strengths and limitations

As far as we know, this is the first study on the prevalence and correlates of ED consumption on a large and representative sample of adolescents 11–15 years old, which represents a major strength. In addition, we used measures which have been well validated and extensively used in a variety of reports and peer-reviewed publications at the cross-national level. A limitation of the present study is its cross-sectional design, which hampers making causal inferences. In addition, the present data were based on self-reports, which can be inaccurate or influenced by social desirability, though previous research has shown them to be valid. Our results might be affected by assessing multiple comparisons which might have caused some associations to spuriously significant. However, we used a level of statistical significance of $p < 0.001$, to avoid this effect.

Implications

The present study provides important evidence related to the patterns of adolescents' ED consumption. Regular ED consumption may serve as a screening indicator to identify adolescents at risk for problem behaviour and for a large number of health problems.

Future studies should explore the causality of the relationship between adolescents' ED consumption and negative health and behavioural outcomes via a longitudinal study or randomized controlled trials. Further research is needed to examine the effect of the ingredients of ED on physiology, health and behaviour of adolescents and the factors entering into this relationship. Finally, the topic of the ease of buying ED should be studied to explore the possibilities of price policies.

Conclusion

In conclusion, ED consumption was very frequent among adolescents, especially among boys and older adolescents. Regular ED consumption was found to be associated with a wide range of negative health and behavioural outcomes and

negative school experience. Our findings provide evidence about the importance of preventive actions aimed at reducing adolescents' consumption of ED. Longitudinal studies are needed to explore the causal relationships between ED consumption and health and behavioural outcomes among adolescents and to explore the possibilities of price policies.

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Authors' contributions Jana Holubcikova drafted the initial manuscript, carried out the initial analyses and revised the final manuscript as submitted. Jitse P van Dijk revised the manuscript and approved the final manuscript as submitted. Andrea Madarasova Geckova, Sijmen A Reijneveld and Peter Kolarcik revised the analyses and the final manuscript and approved the final manuscript as submitted.

Compliance with ethical standards

Ethical standards The study was approved by the Ethics Committee of the Medical Faculty at the Pavol Jozef Safarik University in Kosice and have therefore been performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki and its later amendments. Parents of respondents were informed about the study via the school administration, they gave their informed consent prior to inclusion of their children in the study 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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