Int J Public Health (2017) 62:379–386
DOI 10.1007/s00038-016-0862-4

ORIGINAL ARTICLE

Young adolescents who combine alcohol and energy drinks have a higher risk of reporting negative behavioural outcomes

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Received: 21 March 2016 / Revised: 8 June 2016 / Accepted: 9 July 2016 / Published online: 21 July 2016
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Abstract
Objectives To explore whether young adolescents consuming alcohol and energy drinks combined were more likely to report negative behavioural outcomes than their peers who drink only one type of these beverages or are abstinent.
Methods We analysed data on a representative sample of Slovak adolescents 8502 adolescents (mean age 13.21, 49.4 % boys) from the 2014 Health Behaviour in School-aged Children cross-sectional study. We assessed the associations of alcohol and energy drinks consumption with negative outcomes and their potential synergy, as measured by the synergy index (SI).
Results Adolescents consuming both alcohol and energy drinks were at higher risk of negative behavioural outcomes than their peers who drank only alcohol or energy drinks or were non-consumers. Consumers of alcohol and energy drinks were highly prone to be involved in fighting—the joint association of alcohol and energy drinks consumption was greater than sum of its associations separately in relation to fighting (SI 1.49; 95 % confidence interval 1.03–2.16).
Conclusions Preventive strategies should aim at increasing awareness of negative behavioural outcomes—especially aggressive behaviour associated with alcohol and energy drinks consumption among young adolescents.

Keywords Young adolescents · Alcohol · Energy drinks · Negative behavioural outcomes

Introduction

Simultaneous use of alcohol and energy drinks (EDs) has become popular among youth, but knowledge about their health effects is limited. General awareness on the

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relationship of combining of ED and alcohol with negative behavioural outcomes is rising, but there is a lack of evidence on this topic in the group of young adolescents. A growing body of research reporting this evidence highlights the harmful effect of combining alcohol and ED, which may lead to several problems, such as increased risk behaviour, injuries, alcohol and drug use, sexual risk behaviour or smoking (Bonar et al. 2015; Flotta et al. 2014; Ilie et al. 2015).

Existing evidence on risks associated with consumption of ED and alcohol separately suggests that consumers of ED are at higher risk to several health and behavioural problems, such as cardiovascular problems, diabetes (Seifert et al. 2011; Grasser et al. 2014), frequent health complaints, sleeping problems (Koivusilta et al. 2016), attention deficit hyperactivity disorder symptoms, delinquency, violent behaviours (Kristjansson et al. 2013; Van Batenburg-Eddes et al. 2014) or substance use (Azagba et al. 2014; Gallimberti et al. 2013; Terry-McElrath et al. 2014). Moreover, adolescents' alcohol consumption was associated with a wide range of negative outcomes, such as future drinking and drug use (Guo et al. 2000), problems in school (Grunbaum et al. 2004), or several physical and emotional problems (Brown et al. 2008). Previous research dealing with the adverse consequences of simultaneous consumption of alcohol and ED has been performed mainly in the USA and Australia. Evidence on European adolescents is rather limited (Flotta et al. 2014; Kristjansson et al. 2015; Magnezi et al. 2015). Moreover, this relationship has mostly been explored among older adolescents (aged 14 years and older).

Simultaneous use of alcohol and ED may lead to negative health and behavioural outcomes for several reasons (Howland and Rohsenow 2013; Vida and Rácz 2015). Consumption of alcohol with ED improves the taste of the drink, thus making high alcohol intake more likely. Furthermore, consumption of alcohol with ED reduces sleepiness and counteracts the sedating effects of alcohol and the sensation of intoxication. This can prolong the drinking session and induce more alcohol consumption, which in turn further impairs judgement and neurocognitive functioning. The combined effect may eventually lead to engagement in other risky behaviours, too. Given the higher caffeine sensitivity of adolescents and their vulnerability to the adverse effects of this beverage (Temple 2009), the impact of consumption of alcohol with ED on negative behavioural outcomes in adolescents might be even greater than in adults.

To the best of our knowledge, evidence is fully lacking on the joint association of alcohol and ED consumption and negative behavioural outcomes among European young adolescents. Thus, the aim of this study was to explore whether young adolescents who combine alcohol and energy drinks are more likely to report problematic behaviour than their peers who drink just one type of these beverages or are non-consumers.

Methods

Sample and procedure

We used data from the Health Behaviour in School-aged Children (HBSC) study conducted in 2014 in Slovakia. The HBSC used two-step sampling to obtain a representative sample. 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 9250 adolescents from the fifth to ninth grades of elementary schools in Slovakia in the target group of young adolescents aged 11–15 years. Due to missing responses on questions about alcohol and/or ED consumption, 748 respondents were excluded. Analyses were thus performed on a final sample of 8502 adolescents (mean age 13.21, 49.4 % boys).

The study was approved by the Ethics Committee of the Medical Faculty at 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.

Measures

Data for the present analyses were collected using questionnaires from the standardised research protocols for the 2014 WHO-collaborative HBSC study. We distinguished (1) adolescents who reported consumption of ED at least once a week and alcohol more than three to five days in last 30 days—combined users, (2) only ED consumers, (3) only alcohol consumers and (4) non-consumers of both alcohol and ED. Tables 1 and 2 provide an overview of the measures used in this study.

Statistical analyses

First, we described the prevalence of each problem behaviour for the total sample and stratified by the categories of ED and alcohol consumption (Table 3). Second, we assessed the odds of being involved in each form of problem behaviour for each category of adolescents—combined users, ED consumers and alcohol consumers, all compared with non-

Table 1 Description of items from the HBSC questionnaire used in this study, with answering categories and dichotomisation; Health Behaviour in School-aged Children study Slovakia, 2013/2014

Variable	Wording of the question	Options	Dichotomisation
Energy drinks consumption	How many times a week do you usually drink energy drinks, for example Red Bull?	Never, less than once a week, once a week, 2–4 days a week, 5–6 days a week, once a day, every day, more than once a day	Energy drinks consumption > more than once a week
Alcohol consumption	On how many days (if any) have you drunk alcohol in the last 30 days?	Never, 1–2 days, 3–5 days, 6–9 days, 10–19 days, 20–29 days, 30 days (or more)	More than 3–5 times vs. other
School dislike	How do you feel about school at present?	I like it a lot, like it a bit, not very much, not at all	Adolescents who liked a school a bit or a lot vs. other
Fighting	During the past 12 months, how many times were you in a physical fight?	Not, 1 time, 2 times, 3 times, 4 times or more	3 times and more in the past 12 months vs. other
Bullying	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 response options	Not, only once or twice, two or three times a month, about once a week, several times a week	Two or three times a month and more often vs. other
Truancy	How many days have you skipped classes or school (without permission) this term?	Never, one, two, three days or four days or more	More than once vs. others
Low academic achievement	In your opinion, what does your class teacher(s) think about your school performance compared to your classmates?	Very good, good, average, below average	Below average vs. others
Family affluence	"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 into a final score, which has a consistent, normal distribution and a range from 0 to 1. Then we created groups of low (0–0.333), middle (0.334–0.666) and high (0.667–1) socioeconomic position (Elgar et al. 2015)	

consumers. Third, we assessed the associations of each drinking category with problem behaviour, crude and adjusted for potential confounders—gender, age and family affluence, using multiple logistic regressions (Table 4).

Finally, we assessed the synergy in the negative effects of combined alcohol and ED consumption by assessing whether the joint association was greater than the sum of associations of ED consumption and alcohol consumption separately (Table 4). We did this using the algorithms of Andersson et al. (2005), using the odds ratios (ORs) per drinking category. We used OR*ij,* where *i* denotes alcohol consumption and *j* denotes ED consumption. In each case, the value 0 stands for no consumption and 1 for consumption of the beverage. If alcohol and ED consumption was present, then we obtained $OR_{11;}$ if alcohol consumption was present without ED consumption, we obtained OR_{10}. In this manner, we calculated three OR representing the exposure category by logistic regression analyses (i.e., OR_{11}, OR_{10} and OR_{01}). Synergy in the joint association of ED and alcohol consumption with negative behavioural outcomes was assessed with the synergy index (SI). The SI was calculated using the formula: $SI = (OR_{11} - 1)/[(OR_{10} + OR_{01}) - 2]$. $SI = 1$ indicates that there is additivity, but no synergy in the association of ED and alcohol consumption with negative behavioural outcomes. A positive synergistic association of alcohol and energy drinks consumption with negative behavioural outcomes is reflected by an $SI > 1$. Statistical analyses were performed using IBM SPSS statistics 20.0 for Windows.

Results

The sociodemographic characteristics of the sample and the prevalence of ED, alcohol consumption, and the examined measures of negative behavioural outcomes are shown in Table 3. Almost 25 % of adolescents reported the consumption of ED, consumption of alcohol or a combination of both on a regular basis. More than 15 % of adolescents were only ED consumers, 3 % of them reported to consume only alcohol regularly, and 3 % of adolescents reported to combine alcohol with ED on a regular basis. The distribution of adolescents' reports of alcohol and energy drinks consumption including the frequency of responses per answer option is shown in Table 2.

Table 2 Distribution of adolescents' reports of alcohol and energy drinks consumption—frequency of responses per answer option; Health Behaviour in School-aged Children study Slovakia, 2013/2014

		N	%
ED consumption	Never	5065	59.6
	Less than once a week	1761	20.7
	Once a week	806	9.5
	2-4 days a week	385	4.5
	5-6 days a week	169	2.0
	Once daily	119	1.4
	More than once daily	197	2.3
Alcohol consumption	Never	6696	78.8
	1-2 days	1211	14.2
	3-5 days	328	3.9
	6-9 days	131	1.5
	10-19 days	60	0,7
	20-29 days	14	0.2
	30 days (or more)	62	0.7

The dichotomisation of the measures of alcohol and ED consumption is indicated by separate colours of the table

Figure 1 shows the distribution of adolescents' consumption of alcohol and ED per drinking group.

Adolescents who combined ED and alcohol were more likely to be involved in each type of problem behaviour than non-consumers. In addition, consumers of alcohol only and ED only were at higher risk to report negative behavioural outcomes but at lower odds than the combined users. When comparing consumers of ED only and alcohol only, both groups of adolescents showed comparable risks to report negative behavioural outcomes. The associations between consumption of ED and alcohol consumption with negative behavioural outcomes remained statistically significant after adjustment for potential confounders—gender, age and family affluence. When exploring the potential synergistic association of alcohol and energy drinks consumption with behavioural problems, we found that the joint association was greater than the sum of the associations of ED consumption and alcohol consumption separately in relation to fighting. After adjustment for gender, age and family affluence this synergistic association became non-significant (Table 4).

Discussion

We explored the associations between consumption of alcohol and ED and behavioural problems, thus becoming the first to conduct such a study in young adolescents. We found that adolescents who consumed both alcohol and ED were at higher risk of behavioural problems than their peers who drank only alcohol or ED, or were non-consumers. We only found a synergy regarding the association of alcohol and ED consumption with fighting, but this synergy became non-significant after considering gender, age and family affluence.

Our finding that young adolescents consuming alcohol and ED were more likely to report negative behavioural outcomes, such as truancy, school dislike, low academic achievement, bullying and fighting, is in line with previous evidence on older adolescents from the USA and Australia (Bonar et al. 2015; Flotta et al. 2014; Kponee et al. 2014). We cannot compare our findings with those on young adolescents in Europe, as this study is the first conducted on that group. However, our findings can be interpreted such that the same mechanisms apply to young European adolescents as to older adolescents in other industrialised countries. Our findings thus highly contribute to the understanding of the onset and initial occurrence of problem behaviour in adolescence. However, these findings need to be confirmed in other countries, in Europe and elsewhere.

Our finding that adolescents reporting consumption of alcohol and ED were at higher risk of negative behavioural outcomes, such as school dislike, truancy, low academic achievement and bullying compared with consumers of alcohol only and ED only, suggests an additivity of the associations. This finding may be explained in two ways. First, the negative behavioural outcomes of these adolescents could be caused by the fact that simultaneous consumption of alcohol and ED may induce more alcohol consumption due to impaired judgement and neurocognitive functioning, which leads to negative behavioural outcomes (Howland and Rohsenow 2013; Vida and Rácz 2015). The potential mechanism behind this causal path was described in a study dealing with adolescents' consumption of soft drinks which contained substances like those in energy drinks. Adolescents reporting consumption of these drinks were found to be more vulnerable to daily mood deviations. This may in turn result in aggressive behaviour (Holubcikova et al. 2015). These findings suggest that the substances contained in these drinks may cause fluctuations in blood glucose levels leading in turn to aggressive behaviour. Previous research supports this potential explanation. (Harris and Munsell 2015; Temple 2009). However, our finding of only an additive association of ED and alcohol with behavioural problems partially disproves this explanation. If the consumption of ED really induces more alcohol consumption, we would expect more than additivity.

A second explanation for the association between adolescents' consumption of alcohol and ED and negative behavioural outcomes is that these associations are due to a general underlying vulnerability to adverse outcomes. Adolescents vulnerable to behave in a risky way may also have a higher tendency to drink alcohol with ED. This explanation is in line with previous findings on the

Table 3 Background characteristics of the sample of 11-to-15-year-old adolescents—gender, family affluence, self-rated health, aggressive behaviour and negative school experiences—overall and by category of energy drinks and alcohol consumers; Health Behaviour in School-aged Children study Slovakia, 2013/2014

	Total $N = 8502$ 100 %	Energy drinks consumers $N = 1386$ (16.3 %)	Alcohol consumers $N = 305$ (3.6 %)	Combined users $N = 290$ (3.4 %)	Non consumers $N = 6521$ (76.7 %)	Overall *P* value
Gender						
Boys	4197 (49.4)	931 (22.2)	153 (3.6)	189 (4.5)	2924 (69.7)	<0.001
Girls	4305 (50.6)	455 (10.6)	152 (3.5)	101 (2.3)	3597 (83.6)	
Family affluence						
Low	2979 (39.4)	507 (17.0)	92 (3.1)	79 (2.7)	2301 (77.2)	<0.01
Middle	2140 (28.3)	305 (14.3)	88 (4.1)	74 (3.5)	1673 (18.2)	
High	2438 (32.3)	378 (15.5)	97 (4.0)	95 (3.9)	1868 (76.6)	
School dislike						
Not very much or not at all	3317 (39.2)	795 (24.0)	166 (5.0)	194 (5.8)	2162 (65.2)	<0.001
Like it	5152 (60.8)	585 (11.4)	138 (2.7)	95 (1.8)	4334 (84.1)	
Truancy						
Once and more	1360 (16.2)	361 (26.5)	94 (6.9)	115 (8.5)	790 (58.1)	<0.001
Never	7034 (83.8)	991 (14.1)	210 (3.0)	169 (2.4)	5664 (80.5)	
Academic achievement						
Below average	306 (3.6)	110 (35.9)	20 (6.5)	32 (10.5)	144 (47.1)	<0.001
Average and better	8138 (96.4)	1266 (15.6)	285 (3.5)	256 (3.1)	6331 (77.8)	
Fighting						
Three times and more	1061 (12.7)	293 (27.6)	68 (6.4)	112 (10.6)	588 (55.4)	<0.001
Less often	7308 (87.3)	1050 (14.4)	236 (3.2)	173 (2.4)	5849 (80.0)	
Bullying						
Two or three times a week	1066 (12.8)	239 (22.4)	56 (5.3)	69 (6.5)	702 (65.9)	<0.001
Less often	7276 (87.2)	1106 (15.2)	248 (3.4)	213 (2.9)	5709 (78.5)	

Only valid percentages are presented; the number (and percentages) of missing values are: gender 0 (0), family affluence 945 (11.1), school dislike 33 (0.3), truancy 108 (1.2), academic achievement 58 (0.6), fighting 133 (1.5) and bullying 160 (1.8)

Overall *P* value—test of differences in proportion between energy drinks consumers, alcohol consumers, combined users and non consumers in gender, family affluence and negative behavioural outcomes

clustering of health-compromising behaviours and delinquency (Dusseldorp et al. 2014; van Nieuwenhuizen et al. 2009). The additivity that we found may be interpreted as support for this second explanation.

We found a synergistic association of alcohol and ED with adolescents' involvement in fighting. This association became non-significant after adding gender, age and family affluence to the model. However, the value of the SI remained unchanged, suggesting that the synergy may not be due to confounding. Thus, our results suggest a substantial association of consumption of alcohol and energy drinks with fighting in adolescents regardless of sociodemographic characteristics, such as gender, age or family affluence. Fighting behaviour has been shown to be strongly associated with adolescents' alcohol consumption (Swahn et al. 2004), and we can hypothesise that ED consumption potentiates this effect of alcohol use. Specific substances, such as the caffeine, taurine and artificial sweeteners contained in energy drinks, may add to the aggressive behaviour of adolescents. In addition, the setting in which young adolescents combined ED and alcohol may add to this. High alcohol use in this young age category is rather deviant, making it more likely that peers taking part in it will come together. In this case, a clustering of young adolescents using both ED and alcohol becomes likely, which may offer an environment promoting mutual aggression and fights. This topic evidently requires particular attention, given its consequences for the health of young adolescents.

Strengths and limitations

This study has several strengths. First, it is the first to deal with the joint association between alcohol and ED

Table 4 The association between regular consumption of energy drinks and alcohol and problematic behaviours among adolescents, crude and adjusted for age, gender and family affluence: odds ratios (ORs) and 95 % confidence interval (CI); and synergy in the joint association of consumption of energy drinks and alcohol with negative behavioural outcomes: synergy index (SI) and 95 % CI; Health Behaviour in School-aged Children study Slovakia, 2013/2014

	Crude model OR (95 % CI)	SI (95 % CI) *P* value	Adjusted model[a] OR (95 % CI)	SI[a] (95 % CI) *P* value
School dislike				
Non-consumer	1 (reference)	0.99 (0.68–1.43)	1 (reference)	1.06 (0.68–1.66)
Energy drinks consumer	2.72 (2.42–3.07)***	0.94	2.43 (2.13–2.76)***	0.79
Alcohol consumer	2.41 (1.91–3.04)***		1.91 (1.50–2.44)***	
Combined user	4.09 (3.19–5.26)***		3.48 (2.64–4.58)***	
Truancy				
Non-consumer	1 (reference)	1.01 (0.70–1.48)	1 (reference)	0.98 (0.65–1.48)
Energy drinks consumer	2.61 (2.27–3.01)***	0.93	2.55 (2.18–2.98)***	0.91
Alcohol consumer	3.21 (2.49–4.14)***		2.65 (2.02–3.48)***	
Combined user	4.88 (3.80–6.25)***		4.13 (3.14–5.43)***	
Low academic achievement				
Non-consumer	1 (reference)	0.92 (0.53–1.59)	1 (reference)	0.87 (0.47–1.61)
Energy drinks consumer	3.82 (2.96–4.93)***	0.76	3.44 (2.57–4.59)***	0.66
Alcohol consumer	3.08 (1.90–5.00)***		3.13 (1.90–5.16)***	
Combined user	5.50 (3.67–8.22)***		4.98 (3.18–7.80)***	
Fighting				
Non-consumer	1 (reference)	1.49 (1.03–2.16)*	1 (reference)	1.49 (0.98–2.27)
Energy drinks consumer	2.78 (2.38–3.24)***	0.03	2.39 (2.02–2.84)***	0.06
Alcohol consumer	2.87 (2.16–3.80)***		3.21 (2.35–4.39)***	
Combined user	6.44 (5.00–8.29)***		6.39 (4.80–8.50)***	
Bullying				
Non-consumer	1 (reference)	1.03 (0.58–1.81)	1 (reference)	0.99 (0.51–1.91)
Energy drinks consumer	1.76 (1.50–2.06)***	0.93	1.65 (1.39–1.97)***	0.979
Alcohol consumer	1.84 (1.36–2.48)***		1.81 (1.31–2.49)***	
Combined user	2.63 (1.99–3.49)***		2.45 (1.80–3.34)***	

* $p < 0.05$, *** $p < 0.001$

[a] The model was adjusted for gender, age and family affluence

consumption with problem behaviour among young European adolescents ranging from 11 to 15 years old. Second, its large and nationally representative sample is a further major strength of this study. Third, we employed well validated and widely used measures. The understanding of the term "energy drink" has been proven in several focus groups by the group of young adolescents (Costa et al. 2014).

Some limitations of the present study should be noted, too. First, its cross-sectional design allows us to make only inferences about associations, and no strong ones about causality. Second, data were based on self-reports, which can be influenced by social desirability. However, this effect will probably be limited, as we guaranteed confidentiality and used well-validated measures. In addition, social desirability probably did not affect reports on energy drinks consumption, since it is legal for adolescents to drink them. Furthermore, the combined consumption of alcohol and ED was measured by two separate questions related to the frequency of alcohol consumption and of ED consumption which can lead to incorrect measurement of the simultaneous consumption of these two beverages.

Implications

Adolescents reporting consumption of alcohol and energy drinks were at higher risk for behavioural problems, which implies a need for preventive strategies aimed at broadening adolescents' knowledge about the adverse effects of combining alcohol with ED. This particularly regards aggressive behaviour in young adolescents who combine these drinks. The adverse effect of ED consumption on behaviour is comparable to that of alcohol consumption, but its

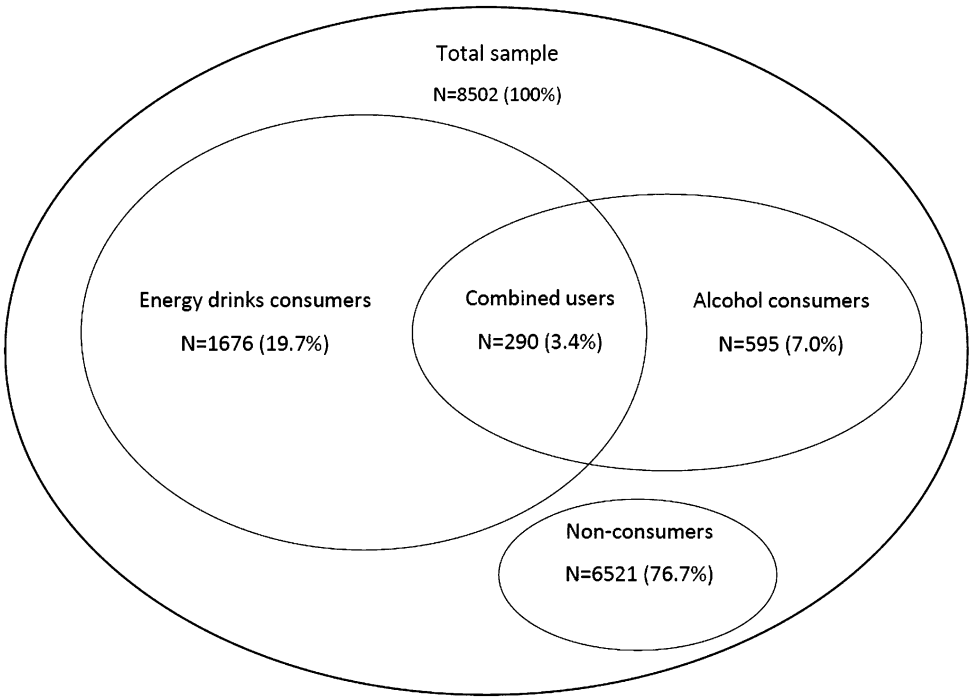

Fig. 1 Distribution of adolescents' consumption of alcohol and energy drinks

prevalence is much higher. Our findings should thus alarm and mobilise public health experts and other stakeholders, who should increase awareness about the adverse effects of ED consumption and implement interventions aimed at reducing the consumption of these beverages by adolescents.

The measures of simultaneous consumption of alcohol with energy drinks should be used in further research to eliminate a potential measurement bias. Moreover, future research should explore the causal pathways between consumption of alcohol and energy drinks and negative behavioural outcomes in adolescents. This may provide more insight regarding the best way to restrain this potential threat for adolescent health.

Conclusion

Adolescents consuming alcohol and energy drinks were more likely to report behaviour problems, such as school dislike, truancy, low academic achievement or bullying, than consumers of alcohol only, and of energy drinks only, as well as non-consumers. Consumers of alcohol and energy drinks were highly prone to be involved in fighting. Preventive strategies should aim at improving public awareness of the negative outcomes associated with alcohol and energy drinks consumption, especially among young adolescents.

Acknowledgements This work was partially supported by the Research and Development Support Agency under Contract No. APVV 0032-11 and APVV-15-0012, by the Scientific Grant Agency of the Ministry of Education, science, research and sport of the Slovak Republic, the Slovak Academy of Sciences, reg. no. 1/0895/14, and was also partially funded within the framework of the project "Social determinants of health in socially and physically disadvantaged and other groups of population" of the Ministry of Education, Youth and Sports in Czech Republic CZ.1.07/2.3.00/20.0063'.

Compliance with ethical standards

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

Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

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