



## Caffeinated sugar-sweetened beverages and common physical complaints in Icelandic children aged 10–12 years



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### ABSTRACT

**Objective.** Consumption of caffeinated sugar-sweetened beverages (CSSBs) among children and adolescents has increased markedly in recent years but the consequence of their consumption is not well understood. The objective of this study was to assess the prevalence of CSSBs in children aged 10–12 years and examine the relationship between CSSBs and common physical complaints.

**Methods.** Data from the 2013 cross-sectional population school survey *Youth in Iceland* (N = 11,267, response rate: 90.1%, girls 49.7%) was used to assess the prevalence of cola and energy drink consumption and associations to headaches, stomachaches, sleeping problems and low appetite.

**Results.** Around 19% of boys and 8% of girls reported consuming cola drinks on a daily basis and 7% of boys and 3% of girls reported consuming energy drinks. A general trend of a dose–response relationship was observed between CSSBs and physical complaints for both types of beverages. These relationships were generally stronger for energy drinks than cola drinks.

**Conclusion.** Our findings call into question the acceptability, availability, and marketing of CSSBs to 10–12 year-old children and adolescents. For validation purposes replications of these analyses are needed in other parts of the world, including studies using prospective longitudinal designs.

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### Introduction

Caffeine consumption among children and adolescents has been reported to have increased about 70% from 1970 to the end of the 20th century (Harnack et al., 1999) and continued to increase through the first decade of the 21st (Arria and O'Brien, 2011; Pomeranz, 2012). This increase in use can primarily be attributed to two factors; 1) a massive expansion of availability of caffeinated sugar-sweetened beverages (CSSBs)<sup>1</sup> such as caffeinated soda and the so called “energy drinks” that are generally both higher in caffeine amount and concentration than caffeinated soda (Heckman et al., 2010); and 2), targeted emphasis in marketing of these products to young people (Oddy and O'Sullivan, 2009; Pomeranz, 2012). As an example, the consumption of energy drinks increased by more than 50% between 2005 and 2009 (Temple, 2009), with more than 500 new energy drinks reported to have been launched worldwide in 2006 alone (Reissig et al., 2009).

CSSBs form a sub-component of a larger group of beverages, generally referred to as “sugar-sweetened beverages” (SSBs), that have been subject to much interest and debate in the contemporary nutrition and public health literature (Weed et al., 2011; York, 2013). This debate has primarily concerned the relationship between SSBs and obesity in the population (Hu, 2013) and associated health outcomes such as hypertension (Sonestedt, 2013) and stroke (Niknam et al., 2013). Studies on SSBs and health outcomes among youth have primarily focused on weight gain and related factors such as metabolic disturbances (Ambrosini et al., 2013), and obesity (Hebden et al., 2013). In a review on child and adolescent consumption of caffeine, Temple (2009) highlighted the relationship between caffeine use and the concomitant consumption of sugar through the provision of CSSBs which may lead to an overall enhancement of preference for foods and beverages that contain high amounts of sugar.

Several studies have reported a prevalence of daily caffeine consumption between 70% and 80% among high-school aged adolescents (James et al., 2011; National Sleep Foundation, 2006), and caffeine use has been reported to be widespread in children as young as five (Warzak et al., 2011). However, recent studies of child and adolescent caffeine use have focused mostly on adolescent consumption of energy drinks (Schneider et al., 2011). Associations have been established between the use of energy drinks and various risk behaviors among

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<sup>1</sup> Caffeinated sugar-sweetened beverages.

older adolescents such as increased alcohol consumption (Arria et al., 2011; Velazquez et al., 2012), smoking (James et al., 2011), cannabis use (Miller, 2008), sleep problems (Calamaro et al., 2012; James et al., 2011), and delinquent behaviors such as violence and conduct disorder (Kristjansson et al., 2013a), without considering the differential effects of early introduction to energy drink consumption. Additionally, recent evidence suggests that gender differences are prevalent in caffeine consumption and relationship with risk behaviors. Boys tend to use more caffeine than girls (e.g., James et al., 2011) but there are indications that the polarization between heavy users is greater in girls than boys resulting in stronger relationships between caffeine consumption and risk behaviors among girls than boys (Kristjansson et al., 2013a). This body of research has predominantly focused on adolescents from the age of 14 and through college, with relatively little attention to date having been given to younger populations or other sources of caffeine such as soda.

Investigating the impact of caffeine consumption on children and early adolescents may be particularly important, because they may be especially vulnerable to the harmful effects of the drug. As a nonselective adenosine receptor antagonist, the actions of caffeine are evident at diverse sites, both centrally and peripherally (Dunwiddie and Masino, 2001). Molecular similarities in the structure of caffeine and adenosine allow caffeine to occupy adenosine receptor sites, which in turn promotes adenosine upregulation and increased functional sensitivity to endogenous adenosine. This process explains the development of caffeine physical dependence, evidenced by the appearance of characteristic behavioral, physiological, and subjective withdrawal effects such as sleepiness, lethargy, and headache (Juliano and Griffiths, 2004). Due to lower body mass, children may be more vulnerable to the effects of caffeine compared to adults consuming equal portions. This may apply to negative effects arising from the direct actions of caffeine, such as chronic headache (Hering-Hanit and Gadoth, 2003), stomachache and low appetite (Juliano et al., 2012), and sleep problems (Kristjansson et al., 2011), as well as physical dependence (Temple, 2009). It is therefore especially important to determine whether children and early adolescent's consumption of caffeine should be reduced, limited or prevented altogether.

The objective of this study was to assess the population prevalence of CSSBs use in children aged 10–12 years as well as to examine the relationship between CSSBs, particularly cola drinks and energy drinks, and common physical complaints (e.g., headaches, stomachaches, sleeping problems, and low appetite) in a population-based sample of 10–12 year boys and girls.

## Methods

### Sample

The present study utilized population-wide cross-sectional data from the 2013 *Youth in Iceland* study, which is a population-based survey that monitors trends in a wide range of demographic and health-related variables in children aged 10–12 years in all primary schools in Iceland (Kristjansson et al., 2013b; Sigfusdottir et al., 2009). The survey was conducted by the Icelandic Center for Social Research and Analysis (ICSRA) in collaboration with the Icelandic Ministry of Education, Science, and Culture. A total of 11,267 students completed the questionnaire (response rate: 90.1% of the national population of Iceland in these age groups, girls: 49.7%). An estimated 90% of the approximately 320,000 inhabitants of Iceland are of Norse–Celtic descent, around 76% of the population belongs to the Lutheran State Church, 5.2% are outside religious institutions, and no other religious sect has more than 3.4% of the population registered in its services (Statistics Iceland, 2013). Because of this homogeneity, exogenous variables such as race and religion, which are often used in research in other countries, were not included in the present analysis.

### Participants

Participants reported in this study were 5th, 6th and 7th grade students who were 10, 11 and 12 years of age. Under ICSRA oversight, teachers at each school

supervised questionnaire completion on-site. All students who attended school on the day of the survey were asked to participate in the survey. The questionnaire was to be completed within their regular classrooms. No identifying information was obtained. All aspects of data collection, including participant involvement based on passive parental consent, were in compliance with Icelandic law on the protection of human subjects. A detailed description of all data collection protocols has been submitted elsewhere (Kristjansson et al., 2013b).

### Measures

#### CSSBs

The consumption of CSSBs was assessed with two questions headed, “how many cans/bottles/or glasses of the following beverages do you typically consume each day”: and the following items: “Cola drinks (e.g., Coca Cola, Pepsi Cola)” and “Energy drinks (e.g., Red Bull, Magic, Burn, Monster, XL)”. Response categories were 1 = “None”, 2 = “Less than one”, 3 = “One”, 4 = “Two to three”, 5 = “Four to five”, and 6 = “Six or more”. For the purpose of this analysis the responses were combined to form three groups with 0 = “none”, 1 = “less than one per day”, and 2 = “one or more per day”.

#### Common physical complaints

Physical complaints were measured with four questions pertaining to the frequency of symptoms during the past 7 days headed, “how often, if ever, have you experienced the following symptoms during the last 7 days”: and the following items: “Headaches”, “Stomachaches”, “Low appetite”, and “Sleeping problems”, and the following response categories: 1 = “never”, 2 = “almost never”, 3 = “seldom”, 4 = “sometimes”, and 5 = “often”. For the purpose of the present analysis the responses were collapsed to form a dichotomous measure with 0 = “never–almost never–seldom”, and 1 = “sometimes–often”.

#### Family structure

Participants were asked which of the following live in their home: father, step- or foster father, mother, step- or foster mother, siblings (if any), grandfather, grandmother, and other relatives. For the purpose of this analysis these variables serve as statistical controls in all predictive models.

#### Statistical analysis

First we report frequencies and percentages of grade, frequency of physical complaints, and prevalence of CSSB consumption. Second, we use logistic regression with adjusted odds ratios (OR) and 95% confidence intervals (CI) in our predictive analyses. All models were run separately for boys and girls with the reference category set to “none” on both respective beverage categories. To overcome statistical contamination in effects we adjust for the covariance of cola drinks when analyzing the relationship between energy drinks and physical complaints and vice versa. Third, to explore possible gender differences in the relationship between caffeine consumption and the outcome, we also ran all models by including the gender variable and caffeine \* gender interaction term. The software IBM SPSS Statistics, version 20.0, was used to analyze the data.

## Results

Table 1 shows the prevalence of CSSBs and physical complaints among boys and girls in our sample. In short, the use of CSSBs is more common among boys and physical complaints are more common among girls. Almost 19% of boys and close to 8% of girls report consuming cola drinks every day and just over 7% of boys and almost 3% of girls report consuming energy drinks on a daily basis. About one in five girls reported having headaches, stomachaches and/or sleeping problems sometimes or often during last 7 days, but the frequency of these symptoms was less common among boys on all occasions ( $p < .001$ ).

Table 2 shows the cross-tabulations and odds ratios for the relationship between cola drink consumption and physical complaints among boys and girls. For both genders, the prevalence of physical complaints generally increased with greater frequency of cola drink consumption. The adjusted odds ratios show a dose–response relationship between cola drink consumption and physical complaints for both boys and

**Table 1**  
Participants by gender and grade and their frequency of physical complaints and consumption of caffeinated beverages.<sup>a</sup>

Material from the 2013 *Youth in Iceland* school survey among 10–12 year old children.

| Characteristics             | Boys % (n/N)       | Girls % (n/N)      | p ( $\chi^2$ ) |
|-----------------------------|--------------------|--------------------|----------------|
| Participants (N = 11,132)   | 50.3 (5601/11,132) | 49.7 (5531/11,132) |                |
| Grade                       |                    |                    |                |
| 5th (10–11 years, n = 3604) | 31.9 (1779/5585)   | 32.6 (1794/5509)   |                |
| 6th (11–12 years, n = 3663) | 33.3 (1858/5585)   | 32.5 (1790/5509)   |                |
| 7th (12–13 years, n = 3885) | 34.9 (1948/5585)   | 34.9 (1925/5509)   |                |
| Headaches                   |                    |                    |                |
| Never–almost never–seldom   | 84.2 (4565/5420)   | 77.4 (4188/5410)   |                |
| Sometimes–often             | 15.8 (855/5420)    | 22.6 (1222/5410)   | p < .001       |
| Stomachaches                |                    |                    |                |
| Never–almost never–seldom   | 86.8 (4706/5421)   | 79.0 (4282/5419)   |                |
| Sometimes–often             | 13.2 (715/5421)    | 21.0 (1137/5419)   | p < .001       |
| Sleeping problems           |                    |                    |                |
| Never–almost never–seldom   | 81.2 (4398/5418)   | 78.4 (4249/5417)   |                |
| Sometimes–often             | 18.8 (1020/5418)   | 21.6 (1168/5417)   | p < .001       |
| Low appetite                |                    |                    |                |
| Never–almost never–seldom   | 88.4 (4802/5435)   | 85.3 (4632/5429)   |                |
| Sometimes–often             | 11.6 (633/5435)    | 14.7 (797/5429)    | p < .001       |
| Cola drink consumption      |                    |                    |                |
| None                        | 47.0 (2581/5494)   | 64.6 (3530/5464)   |                |
| Less than 1 per day         | 34.5 (1893/5494)   | 27.7 (1516/5464)   |                |
| 1+ per day                  | 18.6 (1020/5494)   | 7.7 (418/5464)     | p < .001       |
| Energy drink consumption    |                    |                    |                |
| None                        | 80.9 (4342/5366)   | 90.8 (4913/5410)   |                |
| Less than 1 per day         | 12.0 (645/5366)    | 6.4 (347/5410)     |                |
| 1+ per day                  | 7.1 (379/5366)     | 2.8 (150/5410)     | p < .001       |

<sup>a</sup> Denominators vary from N as a result of difference in missing information.

girls on 13 out of 16 occasions. The exceptions are in the models for headaches and stomachaches for boys who drink cola drinks less than once per day, and sleeping problems for girls who consume cola drinks less than once per day.

Table 3 shows the cross-tabulations and odds ratios for the relationship between energy drink consumption and physical complaints among boys and girls. For boys and girls the prevalence of physical complaints generally increased with greater energy drink use. The adjusted odds ratio models show a dose–response relationship between energy drink consumption and physical complaints on 12 out of 16 occasions for both sexes, with the exception of low appetite for boys who drink energy drinks less than once per day and headaches, sleeping problems and low appetite for girls who consume energy drinks less than once per day.

Additionally, we ran all models to include gender and an interaction term for gender and caffeine. Only two of 16 models revealed minor

gender differences in this respect (data not shown). First, boys who consume energy drinks less than once per day were a little more likely than girls who consume energy drinks that often to report sometimes or often suffering from headaches (OR: .69,  $p = .031$ ). Second, girls who consume energy drinks once per day or more were more likely than boys who consume energy drinks that often to report sometimes or often having low appetite (OR: 1.69,  $p = .028$ ).

## Discussion

The present analyses are among the first to assess the prevalence of CSSB consumption in a population of children aged 10–12 years (see also Frary et al., 2005), and the first to show a dose–response relationship between cola and energy drink consumption and the frequency of headaches, stomachaches, sleeping problems and low appetite among children of this age span. Increase in consumption of both cola drinks and energy drinks was, for the most part, linearly associated with the prevalence of physical complaints. This finding also holds for those boys and girls who consume cola and energy drinks less than every day. Additionally, the adjusted odds ratio models indicate a dose–response relationship between cola drink consumption and physical complaints while statistically controlling for the consumption of energy drinks, and vice versa. This is particularly noteworthy given the popularity of cola drinks among children of this age. Although we are not able to attribute our observations to cause and effect, the findings indicate a stronger relationship for the consumption of energy drinks and physical complaints than for cola drinks. For example, as shown in Table 3, boys who consume energy drinks every day are 2.45 times more likely than boys who never consume such drinks to report sometimes or often having stomachaches. This same relationship has an adjusted OR of 1.31 for cola drink consumption among boys. Likewise, girls who consume energy drinks on a daily basis are 2.31 times more likely than girls who do not consume such drinks to report sometimes or often suffering from low appetite. The same relationship with cola drinks among girls has an OR of 1.37.

Our findings highlight an urgent need to better understand the effects of regular caffeine consumption on the health and well-being of children and early adolescents. Previous reviews from the pediatric literature have raised concerns related to the impact of children's caffeine use on their physiological development and on their heightened potential risk for physical dependence (Schneider et al., 2011; Seifert et al., 2011). Similarly, recent findings suggest that children in 5th grade who consume caffeine may be at increased risk for withdrawal-related anxiety and depressive affect (Luebbe and Bell, 2009) and that youth

**Table 2**  
Cola drink consumption and frequency of common physical complaints (sometimes/often) in 10–12 year old boys and girls.<sup>a</sup>  
Prevalence rates and adjusted odds ratios from the 2013 *Youth in Iceland* school survey among 10–12 year old children.

| Variables           | Boys            |                  | Girls           |                  |
|---------------------|-----------------|------------------|-----------------|------------------|
|                     | % (n/N)         | OR (95% CI)      | % (n/N)         | OR (95% CI)      |
| Headaches           |                 |                  |                 |                  |
| None                | 13.6 (344/2531) | 1.0              | 20.9 (729/3480) | 1.0              |
| Less than 1 per day | 16.3 (299/1834) | 1.09 (.92–1.30)  | 25.3 (373/1474) | 1.21 (1.05–1.41) |
| 1+ per day          | 20.5 (199/9720) | 1.29 (1.03–1.62) | 26.7 (108/404)  | 1.13 (.87–1.47)  |
| Stomachaches        |                 |                  |                 |                  |
| None                | 11.1 (280/2530) | 1.0              | 19.1 (667/3487) | 1.0              |
| Less than 1 per day | 13.9 (254/1832) | 1.11 (.92–1.34)  | 23.2 (343/1476) | 1.20 (1.03–1.40) |
| 1+ per day          | 17.6 (172/979)  | 1.31 (1.03–1.67) | 27.7 (112/404)  | 1.40 (1.08–1.80) |
| Sleeping problems   |                 |                  |                 |                  |
| None                | 16.0 (405/2528) | 1.0              | 19.9 (693/3480) | 1.0              |
| Less than 1 per day | 20.2 (369/1831) | 1.21 (1.03–1.42) | 23.1 (342/1482) | 1.15 (.99–1.34)  |
| 1+ per day          | 23.2 (227/978)  | 1.34 (1.09–1.66) | 29.2 (118/404)  | 1.55 (1.21–1.98) |
| Low appetite        |                 |                  |                 |                  |
| None                | 9.7 (246/2538)  | 1.0              | 13.1 (458/3488) | 1.0              |
| Less than 1 per day | 12.7 (233/1838) | 1.30 (1.06–1.58) | 17.0 (252/1483) | 1.27 (1.07–1.50) |
| 1+ per day          | 14.4 (141/977)  | 1.44 (1.12–1.86) | 19.9 (81/408)   | 1.37 (1.03–1.83) |

Adjusted odds ratios (OR) with 95% confidence intervals (CI).

<sup>a</sup> Denominators vary from N as a result of difference in missing information.

**Table 3**

Energy drink consumption and frequency of common physical complaints (sometimes/often) in 10–12 year old boys and girls.<sup>a</sup>  
Prevalence rates and adjusted odds ratios from the 2013 *Youth in Iceland* school survey among 10–12 year old children.

| Variables           | Boys            |                  | Girls            |                  |
|---------------------|-----------------|------------------|------------------|------------------|
|                     | % (n/N)         | OR (95% CI)      | % (n/N)          | OR (95% CI)      |
| Headaches           |                 |                  |                  |                  |
| None                | 14.0 (596/4267) | 1.0              | 21.7 (1053/4845) | 1.0              |
| Less than 1 per day | 21.7 (135/622)  | 1.61 (1.30–2.00) | 25.1 (85/338)    | 1.13 (.87–1.47)  |
| 1+ per day          | 25.7 (95/370)   | 1.87 (1.43–2.46) | 35.6 (52/146)    | 1.68 (1.17–2.41) |
| Stomachaches        |                 |                  |                  |                  |
| None                | 11.3 (484/4271) | 1.0              | 20.0 (974/4858)  | 1.0              |
| Less than 1 per day | 18.3 (114/623)  | 1.61 (1.28–2.04) | 26.3 (89/338)    | 1.31 (1.01–1.70) |
| 1+ per day          | 26.8 (99/370)   | 2.45 (1.86–3.23) | 34.0 (48/141)    | 1.76 (1.21–2.54) |
| Sleeping problems   |                 |                  |                  |                  |
| None                | 16.9 (722/4264) | 1.0              | 20.9 (1013/4853) | 1.0              |
| Less than 1 per day | 24.7 (153/620)  | 1.48 (1.21–1.83) | 25.6 (87/340)    | 1.16 (.89–1.50)  |
| 1+ per day          | 28.6 (106/370)  | 1.63 (1.25–2.12) | 32.4 (46/142)    | 1.56 (1.07–2.25) |
| Low appetite        |                 |                  |                  |                  |
| None                | 10.9 (466/4273) | 1.0              | 13.9 (677/4868)  | 1.0              |
| Less than 1 per day | 13.5 (85/629)   | 1.15 (.88–1.48)  | 18.8 (64/340)    | 1.31 (.98–1.75)  |
| 1+ per day          | 16.9 (63/372)   | 1.30 (.95–1.78)  | 31.0 (44/142)    | 2.31 (1.58–3.39) |

Adjusted odds ratios (OR) with 95% confidence intervals (CI).

<sup>a</sup> Denominators vary from N as a result of difference in missing information.

diagnosed with major depressive disorders report more caffeine use than their healthy counterparts (Whalen et al., 2008). Overall, our findings underline the importance of improving understanding of the relationship between caffeine consumption and physical and emotional symptoms in children aged 10–12 years. Studies are needed that have been designed to understand whether such symptoms are due to the direct effects of caffeine, to withdrawal effects associated with intermittent consumption, or to a purposeful self-mediation with caffeine. Ultimately, prospective study designs would be needed to clarify such associations. Additionally, future studies should aim to account for sugar concentration and other stimulants present in CSSBs in an attempt to isolate “true” caffeine effects more precisely. Two major observations arise from this study: 1) a dose–response relationship was found between the consumption of CSSBs and physical complaints, and 2) a considerably stronger relationship for energy drinks with physical complaints, compared to cola drinks, as reflected in the adjusted odds ratios. In light of the differences in caffeine amount and concentration of these beverage types, these observations serve to partly validate our findings. Previously, we have shown that relationships between adolescent caffeine use and various outcomes are dependent on caffeine amount consumed and that more caffeine increases the likelihood of negative outcomes (Kristjansson et al., 2013a). We would therefore expect an increase in the odds of physical complaints when young people consume energy drinks instead of cola drinks.

#### Study limitations and strengths

This study has several limitations as well as some strengths. First, the cross-sectional nature of the design precludes us from attributing the reported dose–response relationship to cause and effect. Second, our caffeine measures are relatively underdeveloped, consisting of two questions concerning the frequency of use of two types of caffeinated beverages. Further, the current recoding and analyses leave substantial room for variability in caffeine consumption, which future studies should strive to minimize. Ideally, we would have liked to include a more refined measure of caffeine such as a more comprehensive measure scale or a biochemical measure of saliva or blood. Third, we do not include measures of respondent's body mass or sugar consumption, both of which could confound the reported findings (Frery et al., 2005; Temple, 2009). With regard to strengths, the study was conducted as part of the *Youth in Iceland* program, which utilizes a well-established and standardized protocol for data collection and questionnaire design that has been conducted annually by ISCR for 16 years (see Kristjansson et al., 2013b; Sigfusdottir et al., 2009). Furthermore, nearly

a whole population cohort of children participated in the study (response rate was over 90%), rendering problems concerning selection bias and distributions very unlikely.

#### Conclusion

We observed a dose–response relationship between the frequency of consumption of both cola drinks and energy drinks with physical complaints in the form of headaches, stomachaches, sleeping problems and low appetite in a population sample of boys and girls aged 10–12 years. The adjusted odds ratio models indicate a stronger relationship between energy drinks and physical complaints than for cola drinks. This finding, which was consistent across both sexes, supports our concern that due to their higher levels and concentration of caffeine, energy drinks may pose a relatively greater risk to young people than other sources of caffeine. Our findings call into question the acceptability, availability, and marketing of CSSBs to children, specifically those aged 10–12 years, but also younger children and adolescents and supports the *Institute of Medicine's* (2007) recommendation that schools prohibit all energy drink use. For validation purposes replications of these analyses are needed in other parts of the world, including studies that use prospective longitudinal designs.

#### Conflict of interest statement

The authors declare that there are no conflicts of interest.

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