

Daily Caffeine Intake among Osijek High School Students: Questionnaire Study

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Aim. To assess caffeine intake habits of Osijek high school students and identify the most important sources of caffeine intake.

Methods. Adjusted Wisconsin University Caffeine Consumption Questionnaire was administered to 571 high school students (371 boys and 200 girls in the ninth grade) from Osijek, the largest town in eastern Croatia. The level of caffeine in soft drinks was determined by the high pressure liquid chromatography method, and in chocolate and coffee from the literature data.

Results. Only 10% of our participants did not use foodstuffs containing caffeine. The intake of caffeine originated from soft drinks (50%), coffee (37%), and chocolate (13%). The mean caffeine concentration in soft drinks was 100 ± 26.9 mg/L. The mean estimated caffeine intake was 62.8 ± 59.8 mg/day. There was no statistically significant difference between boys and girls in caffeine consumption (1.0 ± 0.9 mg/kg bw for boys vs 1.1 ± 1.4 mg/kg bw for girls). Daily caffeine intake of 50-100 mg was recorded in 32% of girls and 29% of boys, whereas intake greater than 100 mg/day was recorded in 18% of girls and 25% of boys.

Conclusion. Soft drinks containing caffeine were the major source of caffeine intake in high school students. Large-scale public health measures are needed to inform the public on health issues related to excessive intake of caffeine-containing foodstuffs by children and adolescents.

Key words: adolescent; caffeine; Croatia; drinking; eating

Caffeine is a chemical compound belonging to the group of chemicals naturally found in more than 60 plants (1). Caffeine is widely used all over the world, and is said to be the most commonly used psychoactive substance. Caffeine is taken with coffee (the major source), tea, cocoa, and chocolate, as well as with some soft drinks, which contain caffeine derived from the extract of the *Cola acuminata* nut, added to the drink for specific and unique flavor.

Caffeine has a mild stimulating effect on the central nervous system, accompanied by the feeling of strength reinforcement. Adult middle-aged persons, especially those engaged in highly stressful occupations, frequently take more than five cups of coffee daily (1). In 1958, the Food and Drug Administration described caffeine as a generally harmless substance (or GRAS, an abbreviation for "generally recognized as safe"), and the American Medical Association issued a statement in 1984 that moderate caffeine consumption is safe (1). However, high doses of caffeine (1,000 mg and more) can cause restlessness, insomnia, palpitations, and diarrhea.

As caffeine is also found in some foodstuffs traditionally consumed primarily by children, it may cause

sleeping and dietary disturbances in children (2,3). In adolescents, drinking caffeinated drinks on a daily basis causes classic symptoms of overdosing or withdrawal (tiredness, slowing down, and headache) (4-11).

The transition from elementary to high school coincides with the initial stage of puberty, when adolescents uncritically imitate various habits they have observed in adults, including coffee consumption. Since adolescents of that age frequently consume large amounts of chocolate and soft drinks, we wanted to estimate the level of caffeine intake among young adolescents. We administered a specific questionnaire to high school students in the ninth grade during their regular medical checkups.

Participants and Methods

Participants

The study included high school students of both sexes, aged 14-15 years, living in Osijek, Croatia. There were 121 students from a vocational catering school, 214 from two high schools, and 236 from a vocational engineering school, to assure that students from different social backgrounds and with different educational ambitions and dietary habits are represented in the sample.

Questionnaire

We used an anonymous questionnaire to collect the data on age, sex, and body weight, as well as the frequency of consuming and amount of consumed soft drinks containing caffeine, energy stimulating drinks, chocolate, and coffee. The questions on the intake of caffeine-containing tea and medications (e.g., some analgesics and antipyretics) were not included, because the habit of taking tea is not widely spread in the area and the probability of using this type of medications by the study population was low. The questionnaire was administered during regular medical checkups of high school students at the Department of School Health, Osijek-Baranja County Institute of Public Health. The questionnaire was based on Landrum's Caffeine Consumption Questionnaire (12) and modified according to the local circumstances and age of the subjects.

Concentration of Caffeine in Soft Drinks.

The concentration of caffeine in 26 domestic and imported caffeinated soft drinks was measured by the method of high-pressure liquid chromatography on a Varian device (Varian Inc., Harbor City, CA, USA; 1996) with a UV/VIS 9050 detector and Varian 9012 pump, in the following conditions: Supelcosil LC-18 column, dimensions 10 cm x 4.6 cm x 5 µm; mobile phase was water:methanol (50:50; v:v); flow rate 2 mL/min; detector 274 nm; injected volume 20 µL; and column temperature 22 ± 3 °C.

Caffeine standard was prepared by dissolving 25 mg of caffeine in 50 mL redistilled water, followed by 10 times dilution of 1 mL of the solution with the addition of mobile phase. Soft drink samples were prepared by diluting 5 mL sample with an equal amount of mobile phase. All determinations were performed in triplicate.

The mean amount of caffeine per gram of chocolate milk and a cup (60 mL) of coffee was determined from the literature data (13), and the data published by the National Coffee Association, USA (<http://www.ncausa.org/public/pages/index.cfm?pageid=1>) and National Soft Drink Association, USA (<http://www.nsd.org>).

Statistical Analysis

The mean daily intake of caffeine was presented as the amount of caffeine consumed per day (mg/day), as this is the most common form to express daily intake, and also as the amount of caffeine per kilogram of body weight (mg/kg bw), which is a better indicator of caffeine exposure. The proportion of particular foodstuffs in the overall daily intake of caffeine was determined from the questionnaire data. Sex differences in daily caffeine consumption were statistically analyzed with student t-test. All statistical analyses were performed with Microsoft Excel 2000 (Microsoft Corporation, Redmond, WA, USA).

Results

Out of 571 Osijek high school students included in the study, 58 (10%) who did not consume any of the tested foodstuffs containing caffeine were excluded from further analyses. These children did not like chocolate (or ate it in negligible quantities, ie, less than 1 mg/day), and preferred to drink juices over sodas containing caffeine. The remaining sample of 513 participants (90%) who did consume caffeine included 317 boys (62%) and 196 girls (38%). The mean body weight was 65 ± 12 kg for boys and 57 ± 10 kg for girls. The questionnaire analysis showed that 30% of the study participants consumed coffee, 40% soft drinks, and 78% chocolate.

The mean concentration of caffeine measured in 26 different brands of soft drinks was 100 ± 26.9 mg/L (range, 36-145) and was consistent with the values stated in the national regulations (14-16) (Table 1). The average caffeine content varied with the origin of soft drink. The lowest was in soft drinks from local manufactures. The mean concentration of caffeine in a single cup of coffee was estimated considering the

Table 1. Average caffeine content in soft drinks of different origins in the Osijek-Baranja County, Croatia

Origin (No. of samples)	Caffeine content (mean ± SD; mg/L)
National industry (n = 6)	115.7 ± 25.9
Local manufacture (n = 14)	82.8 ± 29.7
Imported (n = 6)	124.3 ± 11.4
Total (n = 26)	100.0 ± 26.9

most common mode of preparing coffee in the cafes from the area. One cup of coffee (60 mL) prepared in a local cafe contained 32 mg of caffeine on average. A single gram of chocolate was estimated to contain 0.2 mg of caffeine on average, and 1 mL of soft drink with the addition of caffeine contained 0.1 mg of caffeine on average. Thus, the mean daily intake of caffeine, irrespective of the caffeine origin and sex, was 62.8 ± 59.8 mg/day (range 2-572). The mean daily intake of caffeine was slightly but not significantly greater in boys than in girls (Table 2).

Table 2. Daily caffeine intake and daily caffeine intake per body weight among high school first-graders in Osijek-Baranja County*

Sex	Daily caffeine intake (mg; mean ± SD)	Daily caffeine intake per body weight (mg/kg bw; mean ± SD)
Boys	64.6 ± 57.2	1.0 ± 0.9
Girls	59.8 ± 63.9	1.1 ± 1.4

*No statistical difference between boys and girls for daily caffeine intake (t=0.383; p=0.05) and daily caffeine per body weight (t=0.4999, p=0.05).

The minimum mean daily intake of caffeine was identical in both sexes (2.0 mg/day). The maximum mean daily intake of caffeine recorded in boys and girls was 440.00 and 572.00 mg/day, respectively. Each individual's daily intake of caffeine was also calculated per kg of body weight. The mean intake of caffeine was 1.0 ± 0.9 mg/kg bw among the boys and 1.1 ± 1.4 mg/kg bw among the girls. The difference was not statistically significant (Table 2).

Half of the caffeine consumed by our participants came from soft drinks, 37% from coffee, and 13% from chocolate, without any significant sex differences. The maximum measured intakes of caffeine originating from chocolate, soft drinks, and coffee were 50.0, 200.0, and 512.0 mg/day, respectively. The lowest daily intake of 2.0 mg/day was recorded in students taking moderate amounts of chocolate, without any additional caffeine intake from other foodstuffs.

Discussion

In the confusion of daily living, tradition, and consumer society, adolescents adopt some habits that may represent a health risk. One of these habits is the consumption of foodstuffs containing caffeine. The vast majority of the high school students included in our study consumed caffeine on daily basis. Mean daily intake of caffeine was 63 mg/day. Soft drinks were found to be the major source of caffeine, followed by coffee and chocolate. In spite of our concerns, we found that caffeinated soft drinks produced by the small manufacturers in the region had the lowest concentration of caffeine when compared with soft drinks from other origins. In the last few years, nu-

merous small companies for manufacture and distribution of soft drinks appeared in the Osijek-Baranja County, and these drinks found a large-scale use in many households, mostly because of their low price. Therefore, a drive was launched to test the quality and safety of these products, with special reference to the caffeine content.

The issue of uncontrolled intake of caffeine by adolescents has attracted the interest of medical and other professionals aware that caffeine is a psychoactive substance, which may induce different consequences, especially in case of uncontrolled and excessive intake. In addition, caffeine is a common additive found in foodstuffs widely consumed by this age group, e.g., soft and energy drinks, coffee, or chewing gums (2,3,6,7,10). Gallay et al (11) described an epidemic characterized by headache, vertigo, nausea, and vomiting in several schools in Belgium, which was, at least in the first few cases, explained as being due to intoxication with caffeinated soft drinks. Griffiths et al (17) believed that it was of utmost importance for both the professionals and the public to realize that the huge consumption of soft drinks resulted from pharmacological properties of caffeine (mood change, psychoactive effects) rather than their rich flavor. According to Lee et al (3), boys more than girls drink soft drinks that contain caffeine. However, we found no statistically significant differences among sexes.

According to some authors, caffeine intake of ≥ 50 mg/day is quite high and potentially associated with withdrawal symptoms (5), while others state that these symptoms will occur at a caffeine intake of 100 mg/day, potentially leading to caffeine dependence (10). In our study, a daily caffeine intake of 50-100 mg was recorded in 32% of the girls and 29% of boys, whereas the intake greater than 100 mg/day was recorded in 18% of the girls and 25% of boys. Thus, caffeine induced transient behaviors could be expected in about 50% of the study participants.

We found no statistically significant difference among sexes in the daily caffeine intake, which is consistent with the report of Kristi (12). As daily caffeine intake was almost identical in boys and girls, the latter had a higher caffeine intake per kg bw (1.1 mg/kg/day) due to their lower body weight, but the difference from boys (1.03 mg/kg/day) was not statistically significant. In 1999, the European Commission on Food Safety issued a statement according to which intake of 5.3 mg of caffeine per kilogram of body weight per day in a 10-year-old child can cause transient behavioral disturbances, such as excitability, irritability, nervousness, or anxiety (18). Nawrot et al (19) argued that a child's intake of caffeine should not exceed 2.5 mg/kg bw/day. Accordingly, 34 participants (6.5%) from our study sample belonged to the risk group with a caffeine intake exceeding 2.5 mg caffeine/kg bw/day. However, if our results are interpreted in accordance with Rojo Camargo et al (20), who defined a heavy consumption of caffeine as the daily intake of more than 1.5 mg/kg bw, 24% of our participants were "heavy consumers".

In addition to providing the data on caffeine consumption, level of daily caffeine intake, and origin of caffeine ingested, the results of our study shed new light on this considerable public health problem. Caffeine intake in adolescents has not been paid due attention in our setting to date, primarily due to the lack of epidemiologic data, preset cultural and dietary habits, and unfavorable impact of the consumer habits from other settings. We believe that the issue of adolescents' uncontrolled caffeine intake calls for action from the public and professional circles. Appropriate measures of prevention and health education, along with regular quality and safety control of foodstuffs, especially those with the addition of caffeine, are needed to ensure the best development of adolescents into healthy adults.

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