



Caffeine Use in Children: A Comprehensive Review of Pharmacological, Clinical and Public Health Perspectives

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ABSTRACT :

Caffeine, the most consumed mental active substance in the world, is generally observed in free foods, drinks and medicines. The stimulation effects of caffeine adults have been well studied, but the impact on children increases the problem of health care. Depending on the physical and neurological characteristics, children can express themselves as physical and neurological characteristics and can be shown with behavioural changes, sleep, cardiovascular response and potential development. In all these reviews on pharmacokinetic, food sources, physiological and behavioural effects, clinical results and safety guides for the public health of children are taken into account in this review. The initial impact on caffeine is to provide a reasonable position on the evidence of the legislative reform aimed at early exposure and child health protection.

Keywords: Caffeine, Children, Neurodevelopment, Paediatric Pharmacology, Public Health, Behavioural Effects

1. INTRODUCTION

Caffeine (1, 3, 7-trimethylxanthine) is an alkaloid stimulant that impacts the significant fearful device. It certainly happens in coffee beans, tea leaves, cocoa, and numerous smooth beverages, chocolates, and medications. In adults, moderate caffeine consumption is generally related to expanded alertness and advanced intellectual overall performance; however, concerns were raised concerning its outcomes on kids due to physiological variations between age corporations. Extensively, children below 12 aren't necessarily more sensitive to caffeine's stimulating outcomes; however their developing bodies may be more liable to accumulation and unfavorable facet outcomes over the years. The styles and volume of caffeine intake amongst youngsters continue to be insufficiently studied and poorly understood. Beverages containing caffeine are often advertised specifically to kids, leading to improved occurrence within this demographic and elevating recognition of capability fitness outcomes. Over the past 3 decades, caffeine consumption amongst children and teenagers has risen via about 70%. This trend is further amplified by means of the proliferation of recent caffeine-containing power liquids, that may contain as much as 500 mg of caffeine—equivalent to about five cups of espresso—and often consist of excessive degrees of sugar. On account that 2005, sales of energy drinks have grown by using greater than 50%, reflecting fast growth in the beverage industry. These energy drinks are predominantly ate up by means of youth and children and are frequently marketed with slogans inclusive of "purple fires," "wings sown," and "overwhelming wings," regularly related to sports, sex, or more advantageous performance. This example underscores the want for empirical research into the outcomes of caffeine intake in children, concerning collaboration between dad and mom and healthcare professionals. The goal of this evaluate is to synthesize existing literature on caffeine intake and discover the potential links between caffeine consumption in children and adverse fitness results, especially with regards to nutritional behavior and using illicit substances. The evaluate starts off evolved with an analysis of caffeine sources and intake traits, followed by an outline of the physiological mechanisms through which caffeine exerts its consequences.

2. Concerns regarding caffeine consumption in children

The consumption of caffeine among kids and kids provides a range of concerns. First of all, there is a paucity of studies examining the physiological and mental consequences of caffeine within this age organization. Most present studies on adults advocate that caffeine is safe; but, children cannot be truly regarded as smaller versions of adults, because the results of caffeine may fluctuate appreciably in more youthful populations. Secondly, adolescence and formative years are vital intervals characterized by means of rapid increase and mind improvement, making it essential to support most useful bodily and cognitive improvement via ok sleep and right nutrients. Caffeine consumption now not best contributes to minor problems which include weight benefit and a dental problem however also disrupts sleep patterns and encourages excessive intake of soda. Thirdly, setting up healthful nutritional behaviour at some stage in formative years and formative years is vital, as accelerated desire for sweetened drinks and ingredients due to caffeine can elevate strength consumption, doubtlessly leading to obese or weight problems in later tiers. Lastly, animal research suggests that caffeine may also affect mind chemistry, affect the efficacy of certain medications, and make contributions to substance dependence. For the reason that mind

maintains to broaden for the duration of childhood and adolescence, in particular in areas associated with government features, impulse manage, and making plans, these populations may be at heightened threat of unfavourable consequences from caffeine consumption.

3. Sources of Caffeine in Children's Diet

Caffeine is found in a diverse array of food and drink products that are commonly consumed by children. The main dietary sources include various beans, leaves, and fruits, where it is bitter flavor acts as a natural deterrent to pests. It is present in coffee, black tea, and chocolate due to its natural occurrence in the beans and leaves of the plants used to produce these items. Furthermore, caffeine is added as an ingredient in other products such as sodas, energy drinks, and certain over-the-counter medications. The amount of caffeine can vary significantly among these products, affected by factors such as the brewing strength of tea and coffee, or the quantities added to sodas and energy drinks. Approximately 90% of adults report regular caffeine consumption, with an average daily intake of around 227 mg. The primary sources of caffeine for adults consist of coffee (70%), soda (16%), and tea (12%).

The US Food and Drug Administration and the American Medical Association have classified moderate caffeine usage as "generally recognized as safe," however this categorization is primarily based on adult studies. Children and teenagers have really been the subject of relatively little research. Among children and adolescents, caffeine use has increased by 70% since 1977. In 1982, 38 mg of caffeine per day was the average for children aged 5 to 18. The average daily intake of caffeine among a more recent sample of caffeine users aged 12 to 17 is 69.5 mg, which is marginally less than the amount in a single cup of coffee. Compared to the typical adult caffeine intake of about 1.3 mg/kg, children aged 2–11 ingest 0.4 mg/kg and those aged 12–17 consume 0.55 mg/kg when caffeine intake is measured in relation to body weight. As a result, youngsters typically consume half as much caffeine as adults. Despite the fact that this can appear innocuous, there are two things to think about. First, teenagers' caffeine consumption varies widely, with some using significantly more than the norm. According to what will be addressed later, this group may be especially vulnerable to additional high-risk behaviours. Secondly, the limited availability of empirical studies on caffeine consumption among adolescents makes it difficult to determine the minimum level considered safe for this population.

Consumption of soda and other caffeinated beverages in general is concerning due to its known associations with obesity, dental caries, and sleep disturbances, as well as its possible detrimental health impacts. For instance, children between the ages of 2 and 18 who drink more than 9 ounces of soda daily consume around 200 more calories per day and consume less milk and fruit juice than those who drink soda infrequently. According to studies, soda is the most common way for teenagers to get their caffeine fix, but coffee-based beverages and energy drinks, These contain significantly higher amounts of caffeine per serving compared to soda, gaining popularity among this demographic.

Nowadays, consumers may get their caffeine fix from a number of "non-traditional" sources in addition to the conventional ones like coffee, tea, and soda. Caffeine, for instance, has been added to items that people already eat, like sweets, gum, drinks, and mints. You can buy caffeine-containing water (Water Jo eTM) online and at select physical stores. Mints and caffeinated gum (Stay Alert TM and Jolt TM) are likewise becoming more and more popular, and they are marketed to kids like other new caffeine items.

According to the information provided by the Jolt Gum website, the consuming 144 pieces of Gum is equivalent to ingesting the caffeine content of approximately 72 cups of coffee will "make you the most popular kid on the block" and, because of the "greenish speckles," may even help you get an A in art history (Jolt Gum, 2008). Snickers Charged TM, a caffeinated variant of the Snickers™ bar, was recently released by the Mars TM firm (Mars, Mount Olive, NJ). Additionally, there are caffeinated potato chips and oatmeal (Morning Spark Oatmeal; Sturm Foods, Manawa, WI) that you would not find at your neighbourhood grocery store.

- Soft drinks (Colas, flavored sodas): Contain 30–50 mg of caffeine per can (355 ml).
- Energy drinks contain high caffeine levels ranging from 80–300 mg per bottle; not recommended for children.
- Chocolate and cocoa-based products: 5–35 mg of caffeine per serving.
- Tea and coffee: Some children consume tea and coffee in familial or cultural settings.
- OTC medications: Painkillers, cold medications, and weight-loss drugs may contain 30–60 mg of caffeine per dose.

Due to the lack of mandatory labelling in many regions, the actual caffeine intake from these sources is often underestimated by parents and caregivers.

4. Pharmacokinetics of Caffeine in Children

Caffeine is rapidly absorbed in the gastrointestinal tract and reaches peak plasma concentrations within 30–60 minutes post ingestion. In children, however, several pharmacokinetic factors differ significantly:

- Absorption: Similar to adults, but more variable in neonates due to gastric pH and enzymatic immaturity.
- Distribution: Total body water content is higher in children, affecting the distribution volume of hydrophilic compounds like caffeine.
- Metabolism: Primarily metabolized in the liver by cytochrome P450 1A2 (CYP1A2). In neonates, the enzyme is immature, leading to prolonged half-lives (up to 100 hours); reaches adult levels by around 1 year of age.
- Elimination: Renal clearance is slower in younger children.

These pharmacokinetic variances make children more vulnerable to caffeine's toxic effects at lower doses compared to adults.

5. Behavioural and Physiological Effects of Caffeine

5.1 Short-term Effects

- CNS Stimulation: Temporary increase in alertness, wakefulness, and reduced perception of fatigue.

- Mood Elevation: Mild euphoria, although high doses may induce anxiety or restlessness.
- Cognitive Impact: Slight improvements in memory and reaction time; however, inconsistent in children.
- Diuresis: Increased urination due to adenosine receptor antagonism.

5.2 Adverse Effects

- Sleep Disruption: Caffeine can reduce total sleep time, delay sleep onset, and decrease deep sleep duration.
- Hyperactivity and Irritability: Particularly in children with attention-deficit disorders.
- Cardiovascular: Elevated heart rate and blood pressure have been documented, although typically transient.
- Gastrointestinal Disturbance: Stomach pain, nausea, or reflux in sensitive individuals.

5.3 Long-Term Effects

- Neurodevelopmental Impact: Emerging evidence suggests that chronic caffeine exposure may interfere with synaptic pruning and brain maturation during adolescence.
- Caffeine Dependence: Regular consumption can lead to tolerance and withdrawal symptoms (e.g., headache, fatigue, irritability).
- Obesity and Poor Nutrition: Soft drinks high in caffeine also contain sugars and calories, contributing to childhood obesity.

6. Recommended Limits and Safety Guidelines

Several health authorities have proposed safe upper limits for caffeine intake in children. Health Canada's guidelines are frequently cited:

AGE GROUP	MAXIMUM RECOMMENDED INTAKE
4-6 years	45 mg/day
7-9 years	62.5 mg/day
10-12 years	85 mg/day
Adolescents (13-18 years)	2.5 mg/kg/day

The American Academy of Paediatrics advises against caffeine consumption for children under 12 and recommends limiting intake for adolescents.

7. Clinical Implications and Toxicity

High-dose caffeine ingestion in children can lead to acute toxicity, presenting as:

- Nausea and vomiting
- Tachycardia or arrhythmias
- Hypertension
- Seizures (in extreme cases)
- Nervousness, insomnia, and tremors

Emergency room cases due to caffeine overdose, particularly from energy drinks or concentrated supplements, have risen in recent years.

8. Public Health and Regulatory Considerations

8.1 Marketing and Labelling

Many caffeinated products, especially energy drinks, are aggressively marketed to adolescents and young children. Packaging often lacks clear caffeine content labelling, and warnings are rarely included.

8.2 School Environment

Availability of caffeinated beverages in schools through vending machines or nearby convenience stores is a significant contributor to children's caffeine exposure.

8.3 Parental Awareness

Surveys suggest that many parents are unaware of how much caffeine their children are consuming. Public awareness campaigns are necessary to educate caregivers.

9. Recent Research and Emerging Trends

- Neuroimaging Studies: Indicate that caffeine disrupts sleep-related brain processes in adolescents.
- Longitudinal Studies: Link early caffeine use to higher risk of substance abuse and behavioral issues later in life.
- Policy Research: Suggests the need for banning energy drink sales to minors and implementing warning labels.

10. Conclusion

Caffeine is a pervasive component of the modern child's diet, often consumed unknowingly. While moderate intake may not be harmful in older children, excessive and habitual caffeine consumption poses serious risks to neurodevelopment, behaviour, and overall health. Policymakers, healthcare professionals, and caregivers must work together to limit children's exposure and promote safer dietary habits.

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