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The Effects of Rising Caffeine Consumption in Adolescents

Yuli Melamud

[1]Cresskill High School, Cresskill, NJ, USA
#NO Advisor

ABSTRACT

In recent years, the growth of companies selling caffeinated beverages has led to a rise in the caffeine consumption of adolescents. While there are many studies examining the effects of caffeine in adults, there are significantly less findings regarding its effects in adolescents, even though caffeine is likely to affect each demographic differently. This literature review examined the positive and negative effects of caffeine specifically on adolescents. While there could be a few positive effects on athletic and cognitive performance, most of the existing evidence suggests that caffeine is harmful to adolescents' sleep, mood, and physical functioning. Therefore, until more research is available, limiting caffeine intake in adolescents could help prevent potential harmful effects.

Introduction

The world-wide consumption of caffeine among adolescents has increased substantially over the past few years. A major contributor to this rise in caffeine consumption has been the growth of the Energy Drink (ED) industry whose target market is adolescents and young adults (Heckman et al., 2010). The caffeine content for commonly used EDs is 80 mg for 8.5 fluid oz, but the content may vary depending on the brand (Van Dam et al., 2020). Numerous studies have shown that adolescents are indeed attracted to these highly caffeinated drinks. For example, a Norwegian cross-sectional study, which collected data from a sample of 31,091 secondary school students aged 12–19 years, found that 52.3% of the respondents were ED consumers, meaning that they reported consuming EDs on a daily basis to once a month or less (Degirmenci et al., 2018). Furthermore, a study that analyzed trends in ED consumption among U.S. adolescents found that from 2003 to 2016, the prevalence of energy drink consumption increased significantly for adolescents (0.2% to 1.4%, $p=0.028$) and that energy drink consumers had a significantly higher total caffeine intake compared with non-consumers for adolescents (227.0 mg vs 52.1 mg, $p<0.001$) (Vercammen et al., 2019).

This consumption of caffeinated beverages could have numerous effects on adolescents. At its core, caffeine is a psychoactive stimulant, widely known for its ability to increase alertness and energy levels. It works by blocking adenosine receptors. Normally, when adenosine binds to a receptor, it causes a biochemical reaction within the neuron to which it is attached and thus prevents that neuron from conducting a current to other neurons. Therefore, by inhibiting adenosine, caffeine allows neurons to stay active. Areas with adenosine receptors that caffeine helps keep active are related to memory, pain, and wakefulness (Sheth et al., 2014; Van Dort et al., 2009; Ferré et al., 2007). Additionally, caffeine causes the release of stimulating factors such as noradrenaline and dopamine that further contribute to its energizing effects as well as its ability to increase concentration and enhance mood (Cappelletti et al., 2015). This explains why teens may be drawn to the potential benefits of caffeine. However, these positive effects are accompanied by adverse ones, especially in adolescents as some animal-based studies have shown that caffeine affects adolescents differently than adults (Marin et al., 2011). This review aims to examine the positive and negative effects of caffeine on adolescents.

Methods

Searches were made via Google Scholar and PubMed databases using the following keywords: caffeinated drinks or caffeine, adolescent or teen or youth, sleep, physical performance or exercise, mood or mental health or cognitive performance. The earliest papers considered were published in 2005. The majority employed a cross-sectional design, involved participants aged 11–18 years, and were conducted in North America or Europe.

Results

Animal-Based Studies

While most studies focus on adult rodents, there have been some animal-based studies examining the effects of caffeine on adolescents rodents. One such study specifically compared the effects of caffeine on adolescent and adult rats. Both sets of rats were injected with a range of caffeine doses and were then observed in an activity box to measure their locomotor activity. It was found that caffeine increased locomotor activity in adolescent rats at doses 10,30,60, and 120 mg/kg. However, in adult rats locomotor activity only increased at doses of 10 and 30 mg/kg. In fact, at doses of 120 mg/kg, adult rats showed a decrease of locomotor activity (Marin et al., 2011). These findings suggest that caffeine affects adolescents and adults differently. In addition, it's possible that higher doses of caffeine affect adolescents to a greater extent.

Another study examined behavioral and neurochemical alterations triggered by various caffeine doses in adolescent rats. Throughout the study, rats were put through multiple tests, including exposure to an open-field arena in order to evaluate non-associative learning, an object recognition test, and an elevated plus maze task. The results revealed that caffeine at all doses increased anxiety in adolescent rats. At moderate doses, caffeine improved recognition memory. At high doses, caffeine decreased non-associative learning (Ardais et al., 2014). These findings indicate that adolescent caffeine consumption could lead to increased levels of anxiety, though moderate consumption may also have positive effects.

Sleep

Not surprisingly, caffeine tends to have adverse effects on adolescents' sleep as its main function is to elicit greater energy levels and arousement. Numerous studies have found a correlation between caffeine consumption and shorter sleep duration, increased sleep onset latency, and overall poor sleep quality (Koivusilta et al, 2016; Orbeta et al., 2006). In Finland, one study used a classroom survey on 7th graders (73% responded; n = 9446). It was found that those who consumed EDs several times a day exhibited increased odds of having later bedtimes and feeling tiredness/fatigue (Koivusilta et al, 2016). Similarly, another study that analyzed a sample of U.S. adolescents found that a high caffeine intake was associated with difficulty sleeping and feeling tired in the morning (Orbeta et al., 2006). Overall, it is clear that just like in adults, a high caffeine consumption leads to negative effects on sleep in adolescents. Furthermore, poor sleep could then lead to other health, behavioral, and/or cognitive issues.

Mood and Cognitive Performance

Although many may consume caffeine in order to enhance mood, the substance seems to have the opposite effect, especially in adolescents. Currently, it is still unclear whether caffeine has a direct effect on mood. Some

studies have suggested that caffeine's mood-enhancing effects are largely due to the reversal of caffeine withdrawal symptoms (James & Rogers, 2005) while other findings do not support a withdrawal alleviation model (Haskell et al., 2005). However, it is important to keep in mind that the majority of such studies that have found positive effects on mood, whether due to a direct effect or due to the reversal of caffeine withdrawal symptoms, were conducted using adult subjects. Studies examining the effects of caffeine on youth have mainly found adverse effects on mental health. For example, a study examining Korean adolescents found a significant association between energy drink intake and severe stress, depressive mood, suicidal ideation, suicide plan, and suicide attempt. The risk for these detrimental effects on mental health increased with a more frequent use of energy drinks (Park et al., 2016). Other studies have also shown that depressed children and adolescents tend to consume more caffeine relative to healthy individuals. In addition, those suffering from depression reported higher levels of anxiety after consuming caffeine (Whalen et al., 2008). These findings correspond with the results of adolescent rodent studies previously discussed, which reported high levels of anxiety in adolescent rats due to caffeine consumption (Ardais et al., 2014).

In the realm of cognitive performance, caffeine consumption in adolescents has adverse effects as well. A study conducted on middle school students found that those who consumed energy drinks were 66% more likely to be at risk for hyperactivity/inattention (Schwartz et al., 2015). Adolescents who consume energy drinks also report problems in behavior regulation and metacognition (Van Batenburg-Eddes et al., 2014). These results help explain the inverse relationship that has been found between caffeine consumption and academic achievement (James et al., 2011). Essentially, adolescents may begin their caffeine consumption in the hopes of improving alertness, but end up suffering from more anxiety, inattention, and decreased cognitive performance, all of which could undermine academic achievement.

Physical Performance and Symptoms

Caffeine is known for its temporary positive physical effects such as increased physical energy and better physical performance in adults (Pontifex et al., 2010; Glaister et al., 2008; Duncan & Oxford, 2011). However, there is also emerging evidence of its harmful physical effects, especially related to the consumption of EDs. A few studies have demonstrated that drinking EDs before exercising was effective to enhance some aspects of physical performance in junior athletes (Visram et al., 2016; Abian-Vicen et al., 2014; Gallo-Salazar et al., 2015). In a Double-blind, placebo-controlled study in Spain, 16 adolescent basketball players drank either an energy drink that contained 3 mg caffeine per kg or a placebo energy drink. One hour later, the researchers found a significant increase in jump height, mean leg muscle power output, perceived muscle power, and endurance and a decrease in the rate of perceived exhaustion (Abian-Vicen et al., 2014). In a second Double-blind, placebo-controlled study in Spain, 14 elite junior tennis players with the mean age of 16 also drank either an energy drink that contained 3 mg caffeine per kg or a placebo energy drink. Researchers found a significant increase in handgrip force, running pace, and number of sprints per match one hour after the test (Gallo-Salazar et al., 2015). When looking at the cardiovascular effect of caffeine on adolescents, Temple et al., (2010) found an increase in diastolic blood pressure (DBP) and a decrease in heart rate which was dose dependent. In addition, several studies have found that ingesting EDs has various physical health adverse symptoms such as headaches, stomach aches, irritation, fatigue, nausea and vomiting, and heart palpitations (Huhtinen et al., 2013; Koivusilta et al, 2016; Nowak & Jasionowski, 2015; Kristjansson et al., 2014). In a classroom based survey (n=2629) in Poland, 67% of the adolescent participants indicated they drank EDs. The most prevalent adverse health issues reported were stomach ache (46%), heart palpitations (15%), and nausea and vomiting (15%). Additionally, nearly 27% felt hyperactive after drinking an ED (Nowak & Jasionowski, 2015).

Conclusion

In conclusion, the consumption of caffeinated drinks, especially EDs, is associated with a number of adverse outcomes on sleep, mood, cognitive performance, physical performance, and physical functioning in adolescents. Multiple studies have shown that the consumption of caffeine leads to later bedtimes and feelings of tiredness, higher levels of anxiety and problems in behavior regulation, and physical health symptoms, such as headaches and stomach aches. However, there were also studies that indicated caffeine could have positive effects on adolescents, such as improving recognition memory and sports performance. That being said, current literature on effects of caffeine in adolescents is still very limited, as most studies have been conducted on adults. In general, the adverse effects of caffeine seem to outweigh the positive ones in adolescents. In adults, there are more studies highlighting the positive effects of caffeine, so it is unclear whether the lower amount of observed positive effects in adolescents is due to the limited research or the different physiology of teens. Therefore, further research is needed to determine what caffeine dosages adolescents should be consuming (according to the American Academy of Child and Adolescent Psychiatry, the current recommendation for teens is no more than 100 mg per day). Additionally, further study is needed to determine the potential effects of long-term caffeine consumption. Until further research is conducted, it appears that limiting caffeine intake in adolescents may be the best course of action, considering that adolescence is such a critical and vulnerable period in development.

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