Comments on "Caffeine intake and cognitive functions in children by Zhang, Lee and Qiu"

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Introduction

Zhang, Lee and Qiu (2020) examined associations between caffeine consumption and cognitive functioning in 9-10 year old children (N= 11,7180) from the Adolescent Brain Cognitive Development (ABCD) study. The results showed that after adjustment for age, gender, sleep and socioeconomic status, caffeine intake was negatively associated with vocabulary comprehension, working memory, cognitive flexibility, processing speed and episodic memory. These results support suggestions from earlier reviews of caffeine and behaviour (Smith, 2002, 2011, 2013, 2014, 2019; Doepker et al., 2016; Poole et al., 2017) where effects in adults are largely beneficial but sensitive individuals, such as children, may show negative effects.

Most of the effects of caffeine on behaviour have been obtained in laboratory studies. There is some research that has used cognitive tests in field studies (Jarvis, 1993; Lieberman et al., 2002; Smith, 2005) and also epidemiological research with samples of working age (Smith, 2009) and the elderly (Santos et al., 2010). Epidemiological studies often have potential problems that need to be controlled for in the design and analysis. The next section considers such issues in the Zhang, Lee and Qiu (2020) study and recent research on energy drinks and academic attainment of children (Smith & Richards, 2018).

The Design of the ABCD Study

The ABCD study is longitudinal but only cross-sectional research was reported by Zhang, Lee and Qiu (2020). Other cross-sectional research does initially support the results of Zhang, Lee and Qiu (2020) and extends them to other sources of caffeine, age groups and outcomes. Smith and Richards (2018) examined associations between energy drink consumption and academic attainment of secondary school pupils. This differed from Zhang, Lee and Qiu (2020) who used basic cognitive functions as outcomes, had 9-10 year old pupils as the sample with soda as their main source of caffeine. Smith and Richards (2018) also presented longitudinal data, but discussion here will focus on their initial cross-sectional analyses which showed that energy group consumers had lower academic attainment scores.

Possible confounders: School data

A key feature of epidemiological research is to control for other factors that may be correlated with independent and dependent variables. This usually starts with demographic variables, and these were adjusted for in the analyses conducted by Zhang, Lee and Qiu (2020). Smith and Richards (2018) found that academic outcomes were influenced by a number of factors that were obtained from the School Information Management System (SIMS). These included attendance, behavioural problems (detentions and other sanctions), and special educational needs. These variables are associated with both children's academic attainment and their caffeine consumption (Richards et al, 2015; Richards and Smith, 2016a). These factors were not controlled for in the analyses presented by Zhang, Lee and Qiu (2020).

Possible confounders: Health and Health-related behaviours

Zhang, Lee and Qiu (2020) adjusted for the effects of sleep but not health or other health-related behaviours such as exercise. Smith and Richards (2018) showed that frequent mild exercise was a strong predictor of better academic attainment. As well as including health-related behaviours, it is important to include state of health. Smith and Richards (2018), in their longitudinal analyses, found that depression was a significant predictor of poor attainment. Caffeine intake is also associated with both health-related behaviours (e.g. sleep, Richards and Smith, 2016b) and health (Richards & Smith, 2016, b, c, d)

Possible confounders: Diet

There is now extensive evidence that consumption of junk food (refined sugars and saturated fats) is associated with cognitive impairment (Boitard et al., 2012, 2014, 2015; Reichelt et al., 2015). Consumption of caffeinated beverages is often associated with an unhealthy diet (Littlecott et al., 2015; Poulos and Pasch, 2016). Research has shown that diet influences academic attainment, and there are plausible mechanisms for such effects. Yeomans (2017) concluded that consumption of high sugar/high fat diets leads to specific impairments of the hippocampus, which leads to cognitive impairments. Reichelt (2016) suggests that behavioural changes associated with consumption of junk food reflect changes in the pre-frontal cortex and mesocortical dopamine signalling.

The ABCD study does not appear to have data on diet and this may lead to problems interpreting effects on cognition. Smith and Richards (2018) confirmed that energy drink consumption was associated with increased frequency of consuming junk food. They included consumption of junk food in the final model of their cross-sectional regression analysis. There was not only a significant effect of junk food on academic attainment but the effect of energy drink consumption was no longer significant when junk food was included in the model. As well as consumption of an unhealthy diet, it is also important to consider the absence of important parts of the diet. Richards and Smith (2016d) found that it was the combination of energy drink consumption and missing breakfast that was associated with more behavioural problems. Smith and Richards (2018) found in their longitudinal analyses that frequent consumption of breakfast was associated with better academic attainment.

Sources of caffeine

It is important to examine different sources of caffeine for two main reasons. First, they differ in the amount of caffeine, with coffee and energy drinks having higher levels than tea or cola. Secondly, these beverages differ in the other possible psychoactive compounds that may be in the product (e.g. coffee: chlorogenic acid; tea: theanine; energy drinks: taurine; and cola: sugar). The main source of caffeine in the Zhang, Lee and Qiu (2020) study was soda. Smith and Richards (2018) focused on energy drink and put the variable “other sources of caffeine” in the regressions. This summed caffeine from coffee, tea and colas but did not distinguish the individual sources. A re-analysis is shown below which examined individual sources of caffeine in the cross-sectional regressions examining predictor of lower academic attainment. In a univariate analysis, consumption of cola predicted poorer academic attainment (OR = 1.28 CI 1.09-1.52). However, like the effect of energy drinks, this was no longer significant in the final model of the regression including junk food. However, another source of caffeine, coffee, was significant in the final model, with higher coffee consumption being associated with better academic attainment (OR= 0.79 CI 0.64 0.98).

Conclusion

The comments made in this article are intended to increase awareness of potential problems in epidemiological analyses of the effects of caffeine. Some of these can be removed by moving to a longitudinal design and including the relevant confounders outlined above. The paper by Zhang, Lee and Qiu (2020) led to re-examination of the effects of caffeine from cola, which initially looked negative but were no longer significant when junk food was included in the model. The detailed re-analysis of sources of caffeine did show a beneficial effect of consuming coffee on academic attainment. Further analyses and data collection is now required to determine whether this is a robust effect or specific to the sample studied.

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