Effects of Adderall in nonclinical student samples

Dane Sherman

Rochester Institute of Technology

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Adderall is a drug that is typically used to treat symptoms of ADHD and narcolepsy, but its ability to create focus over extended periods of time has made it popular among college students. Often termed a 'study drug' and likened to the more commonly used caffeine, Adderall is used by students who wish to perform better academically when either studying for or taking exams. However, there is a good reason why Adderall is not as readily available to college students as caffeine. The larger effects of the drug, especially when taken habitually can lead to addiction, structural changes in the central nervous system, and negative physical side effects.

This literature review focuses on why Adderall is being used to treat ADHD, the effects it has on individuals without ADHD and the motivations behind college student use. Since Adderall was only recently developed and made available for treatment, there is not an abundance of research into the specific effects it has. However, Adderall is composed of amphetamine and dextroamphetamine so looking at the effects that amphetamines have on the central nervous should provide insight into the effects of Adderall. On the social motivations for Adderall use, much of the research into college campus use rely on surveys or social media analysis.

Before looking at the nonmedical effects that Adderall has on students it is worth looking at the intended use for it. While it can be used to treat narcolepsy, the main use for Adderall has been in treating symptoms of ADHD. ADHD is a chronic cognitive disorder characterized by age-inappropriate levels of hyperactivity and inattention. ADHD affects somewhere in the range of 6% of both high school and college students, with similar rates across genders.

Children with ADHD tend to show structural differences in several brain regions. The volume of the putamen, which is involved with coordination of movement, tends to be smaller.

Cortical thinning can also be seen in patients left untreated, and the cerebellar vermis, which is involved with the regulation of posture, also tends to be smaller in children who have been treated with stimulants such as Adderall (Weyandt et al. 2013).

Adderall use in ADHD treatment

There has been a rise in the production of prescription stimulants like Adderall likely from the increased ability of medical professionals to recognize ADHD combined with the increased duration of treatment and possible marketing efforts. With this increased production comes a greater availability and opportunity for Adderall's distribution and misuse (McCabe et al, 2006). Another drug that is typically used in the treatment of ADHD is methamphetamine (also known as Ritalin) with around 90% of its total production being used in ADHD prescriptions (Poulin, 2007). Farone et al. (2002) found that when comparing to placebo effects on individuals with ADHD, both show similar efficacy, but Adderall tends to be more efficient due to its longer-lasting effects. When used in treating ADHD, Adderall has also been shown to increase academic productivity into and above the normal range.

Poulin (2007) found that stimulant medication is the most effective type of medication in the management of ADHD symptoms. Although, perhaps paradoxically, children medicated with stimulants are more likely to develop a substance use disorder later in life. General stimulant usage in both children and adults with ADHD have been linked with improvement in a number of cognitive tasks. Improvements in Response inhibition and working memory tasks are of particular interest as they are linked with greater executive control and focus. Over long periods of time, this leads to better test performance when compared with ADHD controls left untreated (Weyandt et al, 2013). This effect of improving academic productivity and performance also

appears in individuals without ADHD. It is perhaps unsurprising then that the drug has been misused by college students to improve their own productivity far above their normal range.

Amphetamine Usage Effects

Adderall is made up of a combination between amphetamine and dextroamphetamine which are both stimulants that act on the central nervous system. Dextroamphetamine is an enantiomer of amphetamine with a mirrored chemical structure to amphetamine. While they both affect the CNS the same way, dextroamphetamine has stronger effects and makes up about 75% of the Adderall combination.

The brain areas affected by amphetamines are associated with impulse control and hyperactivity. As mentioned earlier, Amphetamine and MPH use have been shown to relieve ADHD symptoms by providing greater attentional control. Like other stimulants, their usage is often associated with increases in positive emotion, physiological arousal. This psychological change is accompanied by related physiological and biological changes. Amphetamines release catecholamines like dopamine and norepinephrine that cause increased alertness, exhilaration, and reduced fatigue. Specifically, the effects to the CNS lead to activation of the sympathetic nervous system.

Long-term usage of Amphetamines can cause the depletion of neurotransmitters, increased receptor sensitivity, and neuron damage. Excessive stimulant use reduced the breakdown of catecholamine neurotransmitters through the inhibition of Monoamine oxidase (MAO). Catecholamines reuptake is also blocked by blocking their respective transporter proteins often leaving dopamine and serotonin stuck in the synaptic cleft. Amphetamines also tend to reduce the production of tryptophan hydroxylase and tyrosine hydroxylase, the rate-limiting enzymes for dopamine and serotonin. This in turn causes a reduction in the amount of

dopamine and serotonin and causes post-synaptic receptors to become hypersensitive to their effects. Receptor hypersensitization combined with a lack of breakdown or transport out of the synaptic cleft is likely what gives amphetamines their powerful effects. Additionally, chronic amphetamine use can change the levels of phosphoproteins which are used to amplify neuron signaling. Increases to the levels of phosphoproteins can cause sustained effects even after the drug is no longer present as they slowly return to their original abundance (Iqbal, 2002).

Long term usage can also lead to physical dependence on the stimulant through attempts to minimize the negative symptoms when drug use ceases. The reduced levels of dopamine and serotonin along with hypersensitization of their respective receptors may lead to mood swings of elated followed by depressive attitudes. Attempts to reduce depressive states by resuming amphetamine use may lead to addiction and sensitization.

Sensitization to amphetamines is concerning because, at higher doses, amphetamines can be toxic to the nervous system. This comes in the form of damage to the dopaminergic and serotonergic systems mainly through their effects on tryptophan hydroxylase and tyrosine hydroxylase. Reduced production of the rate-limiting enzymes for both these neurotransmitters can go on to affect the entire process, creating a buildup of enzymes related to later steps of their production.

In addition to the actions on the central nervous system, long-term amphetamine use can also lead to more physiological changes. Extended use has been shown to cause cardiovascular harm, often by damaging blood vessel walls. This likely comes from a sustained rise in blood pressure during the time of drug action. Iqbal (2002) found that chronic amphetamine-dependent users who had been taking the drug for more than five years also had a chance to develop a noticeable hearing loss that made normal conversation difficult. This effect was often

accompanied by auditory hallucinations as well as Tinnitus (ears ringing) in a few cases. The hearing loss would be alleviated after a week or so without drug use, indicating a likely rebound effect from the higher auditory acuity that is often seen immediately following high stimulant usage.

When given to treat ADHD, long term side effects can be avoided or reduced through professional instruction on dosages and schedules for how often it should be taken. Rather, long term side effects are more likely to appear in nonmedical amphetamine users who are not as informed on these effects, specifically college students.

Adderall Use among College Students

Adderall is the second most used illicit drug used on college campuses, beaten only by marijuana. Specific motivations for Adderall use are discussed later, but it is most perceived to improve academic performance through increased energy with a sustained ability to focus. To see if it actually has that effect, Weyandt et al. (2018) examined and compared the cognitive effects of nonmedical Adderall use in college students on several tasks. While they did show the expected improvement on attentional tasks, they also showed impairment to working memory. This effect is only minor, especially when compared to the benefits of attentional control, and is likely related to the greater executive control and focus when used by individuals with ADHD. The decrease in working memory was also associated with a worsening of students' self-reported ability problem solve and ability to self-regulate. This degradation of students' attitudes about their own cognitive ability may lead to a perceived dependence on Adderall to perform well, particularly during times of high academic stress. Interestingly, when compared to placebo groups, college students given Adderall also did not perform any better on linguistic tasks of

reading performance or story recall. This suggests that while taking Adderall improves the ability to focus, the outcome of such actions on academic performance isn't significantly better.

Looking at changes in physiology, Weyandt et al. (2018) saw a large increase in activation of the autonomic nervous system. This included increased heart rate in addition to increased systolic and diastolic blood pressure. This was consistent with the physiological changes seen in individuals with ADHD, mainly leading to physiological arousal and reduced fatigue.

Motivation for Adderall use

Many surveys have shown that the most common way for students to obtain prescription medication is through their friends or peers. (Weyandt et al, 2013; Poulin 2007). This process by which students sell their own prescription medication is often referred to as 'diversion'. McCabe et al. (2006) found that when looking at the diversion of prescription medication as a whole, 54% of undergraduate students had been approached in some way to sell their medication. One especially troubling finding from that particular survey was that of the general population of illicit drug users are less likely to be aware of the dangers from higher dosages or interaction with other drugs. College students specifically were significantly more likely to engage in larger amounts of drug use with around 80% reporting heavy episodic drinking. As mentioned earlier, not knowing the dangers associated with Adderall use can lead to many negative outcomes.

In a survey targeting illicit drug users, DeSantis and Hale (2010) found that 34% of students had illicitly used ADHD medications. Significant among the group breakdowns were Greek organizations at 48%, Juniors at 49%, and seniors at 55.5%. Prevalence among Greek organizations suggests motivation through social pressure, whereas increasing prevalence with grade-level suggests motivation from academic strain. When examining these theories, Pino et al.

(2017) Showed support for social learning theory, by which a student's drug-taking behavior could be explained by looking at the peer groups they are a part of. This includes factors such as fraternity/sorority groups and living arrangements. They also tested but found no support for general strain theory which views a student's failure to achieve their goals as a source of distress that may then be alleviated through the usage of illicit drugs. In fact, a student's GPA or their perceived academic ability had no significant effect on their drug-taking behavior. Instead, it was through observing the behavior of those around with either positive or negative reinforcement from peer groups that shaped a student's attitudes and then behavior towards illicit drug use. Perhaps the best evidence for this when it comes to Adderall is that only 65% of users actually found the drug to be 'very helpful', indicating the drug may be taken more out of social pressure than the need for a boost in academic performance. As seen earlier, the actual boost in academic performance is not significant and while 65% is still a large portion of students, this is likely due to the perceived benefits that Adderall has.

Attitudes about Adderall may also play a role in both its prevalence and distribution. DeSantis and Hale (2010) also examined the rationale students have behind their attitudes identifying 4 recurring justifications. The most prevalent of these justifications was the comparing and contrasting of 'study drugs' as good and 'party drugs' as bad. Included in this was the moral justification of only using them to do better academically and not to get high. The second most common justification provided was the moderation of stimulant use compared to drugs such as alcohol which is typically used on a weekly basis. Students reported being much more strategic with Adderall use, only taking the drugs during periods of high academic stress. The third justification came from the self-medication of ADHD or partial symptoms making stimulant use morally justifiable as they were just cutting out the 'middleman' and

physiologically justifiable in the relief of symptoms. The final justification came from minimization by framing amphetamines use as harmless, likened to caffeine or carbonated soft drink use to increase energy for a short period of time. The consistency of these justifications for Adderall also indicate that attitudes are perpetuated through the social aspect of college.

Hanson et al. (2013) took to Twitter looking to identify trends in Adderall use across college campuses. By looking examining thousands of tweets for mentions of Adderall and constraining to users that were likely college students they were able to identify a few trends. Mentions of Adderall showed weekly fluctuations, peaking on Wednesdays during the middle of the academic week and then falling to their lowest point by Saturday on the weekend. Rates were also much higher during examination periods in May and December. This confirmed suspicion that Adderall is typically seen as a study aid for difficult academic assignments. These tweets also gave a glimpse into the negative side effects of Adderall abuse with mentions of sleep deprivation and loss of appetite. While these tweets may not be completely accurate to usage on college campuses, they do provide a reflection of the social trends and context for the normalization of Adderall misuse among student populations.

Extension into High School populations

These trends may even start as early as high school. 6.9% of High school seniors reported nonmedical Adderall usage and 7.9% reported Amphetamine use. However, over a quarter (28.7 %) of students who used Adderall did not report general amphetamine use indicating that usage is likely higher. This high rate of discordant response, despite explanations provided in the survey, also points to a lack of understanding of the true effects of the drug (Palmer et al., 2017). When examining high school students and screening them for ADHD, Poulin (2007) found that 9.2% of students with ADHD and 2.4% of students had been prescribed a psychostimulant

amphetamine or methamphetamine. Of those with the medication, regardless of ADHD diagnosis, 26% reported having given or sold their medication to a friend or fellow classmate. While this does appear to be a significant portion of the student population, rates of methamphetamine use were low among students who had not been prescribed the medication. This indicates that the diversion is relatively infrequent, and most students are not consistently selling their medication.

As is now being seen in that given treatment for ADHD at a young age, children medicated with stimulants are more likely to develop a substance use disorder later in life. With illicit Adderall use being seen in high school students, this behavior is likely to carry through into and beyond college, with numerous negative outcomes to their health.

Conclusion

Taken in moderation to treat ADHD, Adderall can help to improve focus back into a normal range, improving academic performance. However, when taken by college students with the expectation of similar effects, the possible negative outcomes and lack of any real improvement make it difficult to justify the improved focus. Social attitudes towards Adderall is the largest contributor towards its continued use, with most students unaware of the negative risks that extended use may cause.

While this literature review looked at the use of Adderall among college students, reports of high school use indicate illicit use may extend later into life. It is possible given their justifications and social acceptability, that college students only use Adderall in moderation and cease use once they have graduated. Additional research on college graduates may examine rates of continued Adderall use to see if concerns associated with long term use are justified.

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