

# Long-term effects of adolescent cannabis use on cognitive function: A review

By Sofia Cervantes

## AUTHOR BIO

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## ABSTRACT

Cannabis use has surged in the U.S. due to increased legalization, with a significant increase during the COVID-19 pandemic in adolescents and young adults. While cannabis use is becoming more widely accepted, there are still lingering concerns about its effects on cognition. This paper aimed to determine the long-term effects of adolescent cannabis use on cognitive function. 41 peer-reviewed research papers were found using ScienceDirect and seven were selected, analyzed, and summarized for this study. 42% of the papers concluded that there are long-term effects due to the use of cannabis. The effects are related to the methylation of genes and the expression of proteins. 22% of papers conclude that there are no significant effects on cortical thickness and volumes after consistent cannabis use. Overall, the research suggests cannabis can influence genetic markers and protein levels but does not appear to impact cortical volumes in the brain, which can lead to cognitive deficits and mental health issues but does not affect intelligence. Future research may focus on exploring the long-term effects of how methylation markers impact mental health and cognitive ability, potentially through continued co-twin control studies with frequent MRI scans and expanded methylome-wide association studies to build on these existing findings.

**Keywords:** *Young adults, teenagers, drug use, brain function, mental health, cortical thickness, cortical volume, cannabis*

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## INTRODUCTION

Cannabis is the dried leaves, flowers, or stems of the cannabis plant, which includes intoxicating chemical compounds such as tetrahydrocannabinol (National Institute on Drug Abuse, 2020). Over the last few years, its use has become widely accessible across the United States with 38 states legalizing cannabis for adult medical use and 24 of these states legalizing for adult non-medical use (Federation of State Medical Boards, 2024). Cannabis can be consumed through edible products, smoking, and other concentrates such as oils or wax (Menke, 2019), and its consumption has reached increasingly high levels with 42% of adults actively using marijuana in the past year (Patrick et al., 2024).

The use of cannabis was especially high during the COVID-19 pandemic of 2020 (Mehra et al., 2023). With a 48% increase in cannabis use from 2020 to 2022 especially in younger age groups, teenagers have faced growing exposure to marijuana and other addictive substances throughout their adolescence (Mehra et al., 2023). While adolescent tobacco and alcohol use has decreased in the past few years, cannabis levels have been climbing due to increased cannabis legalization in the United States (Károly et al., 2019).

Most cannabis use begins during late adolescence and reaches its highest levels during young adulthood (Scheyer et al., 2022) because young adults experience increased independence, find themselves in need of coping mechanisms, and can find themselves under peer influence.

While cannabis is used across the country for both medical reasons and, in some states, for leisure activities, the morality of marijuana use is highly debated throughout the country as many citizens have either preconceived notions or have acquired misinformation through word of mouth or articles on the internet (*Myths and Facts about Marijuana Use*, n.d.). Although many myths have been disproven by research such as the addictiveness of marijuana (*Myths and Facts about Marijuana Use*, n.d.), there are still lingering questions on the effect of cannabis use on cognition, especially among young adults and adolescents as brains have yet to be fully developed. This systematic review aims to analyze the recent literature on the long-term effects of cannabis use during adolescent years.

## METHODOLOGY

For this systematic review, peer-reviewed research papers were searched to understand the effects of cannabis use during teenage years on long-term cognition. ScienceDirect database was chosen, and a set of keywords was used: ‘Cannabis (adolescent OR teenager) “adult brain”’. Because the most recent research will be the most precise or recently updated, articles in the search were limited to research done from 2019 to November 2024. The final search resulted in 41 peer-reviewed research articles. These papers were screened to check whether the articles’ research was relevant to the topic.

Many articles were considered improper for this review since they focused on the effects of other substances and only briefly mentioned cannabis use or solely researched cannabis use during

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adulthood. Post-screening, the final number of papers was seven. These articles were reviewed, and their findings were analyzed and compared based on methodologies, results, and biases found while reading papers.

### RESULTS

Seven studies were identified, reviewed, and categorized based on the findings related to the presence or absence of long-term effects due to cannabis use (Table 1).

**Table 1**  
*Selected studies*

Authors	Year	Title	Long-term Effects
Clark et al.	2021	Methylomic investigation of problematic adolescent cannabis use and its negative mental health consequences	Yes
Harper et al.	2021	The effects of alcohol and cannabis use on the cortical thickness of cognitive control and salience brain networks in emerging adulthood: A co-twin control study	No
Hawke & Henderson	2021	Legalization of cannabis use in Canada: Impacts on the cannabis use profiles of youth seeking services for substance use	N/A
Johnson et al.	2020	A large-scale genome-wide association study meta-analysis of cannabis use disorder.	Yes
Karoly et al.	2019	Investigating a novel fMRI cannabis cue reactivity task in youth	N/A
Loch et al.	2023	Plasma levels of neurotrophin 4/5, NGF, and pro-BDNF influence transition to mental disorders in a sample of individuals at ultra-high risk for psychosis	Yes
Meier et al.	2019	Associations between adolescent cannabis use frequency and adult brain structure: A prospective study of boys followed to adulthood.	No

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*Note: This table lists, for each article, the author's name, year of publication, title of publication, and whether there are long-term effects of cannabis use during adolescence presented in the results of each paper. "N/A" indicates that the article was inconclusive regarding the long-term effect of cannabis use during adolescence.*

This study aimed to review the literature to find the long-term effects of cannabis use during adolescence. Three out of the seven papers stated that there are long-term effects of cannabis use during adolescence. According to Clark et al. (2021), frequent cannabis use during teenage years causes changes within methylation markers, regulating neuronal differentiation and protein expression in neurons. The different methylation markers would directly turn genes "on" and "off" by the addition and removal of methyl groups in the DNA. After interviewing participants aged 9 to 16 and having them complete a Psychiatric Assessment, researchers used methylome-wide association studies to assess each individual's methylation score calculation. They discovered that CLMN, an acid regulated gene, known as the CALMIN gene in humans, regulates cell cycle exit and neurite growth in murine neuroblastoma and is impacted by problematic cannabis use during adolescence (Clark et al., 2021). SENP7, which encodes regulatory proteases of SUMO proteins and is linked to neuronal functions. Clark's evidence links adolescent cannabis use to deficits in cognition and effects on DNA repair genes.

Loch et al. (2023) also discovered a significant imbalance in Pro-BDNF and NT-4/5 protein levels, which are essential for neuronal growth and survival, in ultra-high-risk patients (patients who exhibit risk factors that place them at a significantly elevated likelihood of psychosis) who use cannabis. After similar screening processes, the participants' bloodwork was collected to perform statistical analyses. Neurotrophin levels were evaluated by absorbance in 450, using optical density values based on the standard curve values. Logistic regression models and path analyses were used to control for confounders. Cannabis was found to be an important contributor to transition to mental disorders and was also related to low scores on dysphoric mood, which are feelings of dissatisfaction, unease, or discontent (Loch et al., 2023).

Johnson et al. (2020) tests the genetic correlation between cannabis use and cannabis use disorder. After a genome-wide association study, Johnson and others examined the genetic overlap between cannabis use disorder and 22 other traits. Their findings suggest that factors that influence one's curiosity, sociability, or predisposition to risk-taking to use cannabis may not be the same as the genetic factors that make someone more likely to develop an addiction or dependence disorder. So, their research shows that cannabis use disorder positively correlates with a higher likelihood of genetic disorders such as schizophrenia, psychopathology, and severe depression.

On the other hand, research by Meier et al. (2019) and Harper et al. (2021) shows that cortical thickness isn't affected by cannabis use during adolescence. Both studies applied cannabis use questionnaires to assess the extent of each participant's cannabis use. Participants in both studies were required to undergo MRI scanning to examine cortical volumes and thickness. Their findings conclude that differences in cortical thickness of individuals who used cannabis aren't statistically significant compared to those who didn't use cannabis. Depending on different brain areas, thicker cortical

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thickness can be related to higher cognitive ability (Menary et al., 2013). The studies conclude that marijuana use during adolescence doesn't affect cortical thickness or volume. Harper's study is particularly intriguing as Harper used co-twin controls to determine differences in cortical volumes. The same-sex co-twin control allowed for greater localization of cannabis effects relative to most previous work in this area.

Hawke & Henderson (2021) and Karoly et al. (2019) did not assess the long-term effects of marijuana use during adolescence. However, they provide information that can help assess our results. Hawke & Henderson (2021) determined that there aren't significant differences between cannabis use before and after legalization. Through many surveys and statistical analyses, Hawke & Henderson (2021) established that cannabis use was safer after legalization as there was a 25% increase in users purchasing cannabis from a government source. Karoly et al. (2019) aimed to measure how cannabis-related images affected teens' reactions and if different types of images (active vs. passive) influenced brain activity in young people who use cannabis but are not seeking treatment. 92% of cannabis-related images were correctly identified as cannabis, and 92% of non-cannabis-related images were also correctly identified as non-cannabis. For 35 out of 36 cannabis images, the participants began to crave cannabis, which demonstrated reward and cognitive control activation in the adolescents.

According to these seven papers, cannabis use can affect genetic markers and protein expression but doesn't have any significant effect on cortical volumes or thickness.

## **DISCUSSION**

Of the seven papers, 42% determined that there were long-term effects of cannabis use. Clark et al. (2021), Loch et al. (2023), and Johnson et al. (2020) show cannabis use during adolescence has long-term effects, altering genetic markers and protein output related to neuronal differentiation, which are commonly associated with mental disorders. These three studies focused on how cannabis use during one's teenage years will affect someone's genetic makeup. When researchers determined differences in methylation patterns and protein regulation, there was a distinct positive correlation between cannabis use and possible future deficits in cognition. It is important to observe that these three studies used similar methodologies and focused on only changed genetic markers, using genome-wide association studies, to determine changes in one's expression of genes or protein regulation.

On the other hand, 29% of papers found no long-term effects. These papers used different methodologies and researched different targets of long-term effects such as cortical thickness and volume. Because in adolescents and young adults cortical thickness is positively correlated with higher intelligence ratings (Menary et al., 2013), it's important to understand how significant cannabis use affects, if any, cortical volumes and thickness. Meier et al. (2019) and Harper et al. (2021) determined that there are no significant correlations between cannabis use and cortical thickness or volume in the brain, specifically in areas such as the temporal lobe and various sections of the prefrontal cortex. Instead of performing genetic evaluations like Clark et al. (2021), Loch et al. (2023), and Johnson et al. (2020), Meier and Harper performed MRI assessments, manually reviewing areas related to cognitive control.

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From the conclusions of this research, cannabis use during adolescence does not have a significant effect on intelligence levels.

Meier and Harper's research does not match Canada's government assessment of cannabis use. According to their cannabis effect assessment, cannabis will affect IQ, especially when beginning cannabis during adolescence (Health Canada, 2018). However, there may be aspects of cognitive function that are affected by cannabis that aren't accounted for in the research of this systematic review.

Harper et al. (2021) is particularly interesting as they aimed to discover the effect of both alcohol and cannabis use on various parts of the brain. The authors show that alcohol consumption significantly reduces cortical thickness and volume, specifically in the prefrontal and parietal medial areas. This suggests that those who consume alcohol in high dosages are more susceptible to decreased performance in cognitive activities, including memory, attention, and executive functions than those who use cannabis. There is a high social stigma that cannabis use is far worse than drinking alcohol (American Addiction Centers, 2022). However, based on Harper et al. (2021), the long-term effects of alcohol use can affect someone far more significantly than cannabis use. Since their research reviewed only cortical volumes and thickness, other effects of marijuana may not be accounted for.

There are some limitations to this systematic review. Because cannabis is only a recently legalized drug worldwide, there isn't significant long-term research available. To properly determine all aspects of adolescent cannabis use in the long term, research studies of 10+ years must be conducted. This lack of research may account for the limited number of papers found. To ameliorate this review, another round of research could have been conducted with a different set of keywords to find other research articles related to the topic. There are limitations within each research article read as well. In all research articles referenced in this review, participants were self-reported cannabis users. Self-reports make it incredibly difficult for researchers to properly assess the extent of each individual's cannabis use. Another limitation in many of the studies is that each sample size was often limited to a very small group of people. For example, Johnson et al. (2020) and Loch et al. (2023) worked with sample sizes of 20 and 81, respectively. To generalize results further and ensure accuracy, a larger pool of participants would be more appropriate.

Future research is needed to understand the effects of methylation markers on cognitive ability and mental health. Future research could continue the Harper et al. (2021) co-twin control studies with frequent MRI scanning and new methylome-wide association studies to further build on Clark et al. (2021).

For now, there isn't sufficient evidence to provide a response for the question of this review. This limitation isn't exclusive to this review. Future long-term research is the only way to answer the main question of what the long-term effects of cannabis use during adolescence may be.

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## CONCLUSION

From the research and data collected, it can be concluded that cannabis use during adolescence may cause long-term effects. However, the effects that were identified are on a small scale, so it is still not possible to understand how consistent cannabis use would affect an adolescent and their future. To evaluate the consequences of cannabis use during adolescence, it is necessary to conduct long-term research since the present studies are testing how cannabis affects individuals in the present and their projections for the future.

## REFERENCES

American Addiction Centers. (2022). *Perceptions of alcohol vs. marijuana: Which substance is viewed as more harmful?* American Addiction Centers. Retrieved December 10, 2024, from <https://americanaddictioncenters.org/blog/perceptions-of-alcohol-vs-marijuana>

Clark, S. L., Chan, R., Zhao, M., Xie, L. Y., Copeland, W. E., Aberg, K. A., & van den Oord, E. J. C. G. (2021). Methylopic Investigation of Problematic Adolescent Cannabis Use and Its Negative Mental Health Consequences. *Journal of the American Academy of Child & Adolescent Psychiatry*. <https://doi.org/10.1016/j.jaac.2021.02.008>

Federation of State Medical Boards. (2024, April). *Medical Marijuana State-by-State Overview*. <https://www.fsmb.org/siteassets/advocacy/key-issues/medical-marijuana-requirements-by-state.pdf>

Harper, J., Malone, S. M., Wilson, S., Hunt, R. H., Thomas, K. M., & Iacono, W. G. (2021). The Effects of Alcohol and Cannabis Use on the Cortical Thickness of Cognitive Control and Salience Brain Networks in Emerging Adulthood: A Co-twin Control Study. *Biological Psychiatry*, 89(10), 1012–1022. <https://doi.org/10.1016/j.biopsych.2021.01.006>

Hawke, L. D., & Henderson, J. (2021). Legalization of cannabis use in Canada: Impacts on the cannabis use profiles of youth seeking services for substance use. *Journal of Substance Abuse Treatment*, 126, 108340. <https://doi.org/10.1016/j.jsat.2021.108340>

Health Canada. (2018). *Health effects of cannabis - Canada.ca*. Canada.ca. <https://www.canada.ca/en/health-canada/services/drugs-medication/cannabis/health-effects/effects.html>

Ibn Lahmar Andaloussi, Z., Taghzouti, K., & Abboussi, O. (2018). Behavioural and epigenetic effects of paternal exposure to cannabinoids during adolescence on offspring vulnerability to stress. *International Journal of Developmental Neuroscience*, 72(1), 48–54. <https://doi.org/10.1016/j.ijdevneu.2018.11.007>

Johnson, E. C., Demontis, D., Thorgeirsson, T. E., Walters, R. K., Polimanti, R., Hatoum, A. S., Sanchez-Roige, S., Paul, S. E., Wendt, F. R., Clarke, T.-K., Lai, D., Reginsson, G. W., Zhou, H., He, J.,

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Baranger, D. A. A., Gudbjartsson, D. F., Wedow, R., Adkins, D. E., Adkins, A. E., & Alexander, J. (2020). A large-scale genome-wide association study meta-analysis of cannabis use disorder. *The Lancet Psychiatry*, 7(12), 1032–1045. [https://doi.org/10.1016/s2215-0366\(20\)30339-4](https://doi.org/10.1016/s2215-0366(20)30339-4)

Karoly, H. C., Schacht, J. P., Meredith, L. R., Jacobus, J., Tapert, S. F., Gray, K. M., & Squeglia, L. M. (2019). Investigating a novel fMRI cannabis cue reactivity task in youth. *Addictive Behaviors*, 89, 20–28. <https://doi.org/10.1016/j.addbeh.2018.09.015>

Loch, A. A., Tavares, M., Andrade, J. C., Peroni, L., Matheus, Haddad, N. M., van, Talib, L. L., & Wagner Farid Gattaz. (2023). Plasma levels of neurotrophin 4/5, NGF and pro-BDNF influence transition to mental disorders in a sample of individuals at ultra-high risk for psychosis. *Psychiatry Research*, 327, 115402–115402. <https://doi.org/10.1016/j.psychres.2023.115402>

Mehra, K., Rup, J., Wiese, J. L., Tara Marie Watson, Bonato, S., & Rueda, S. (2023). Changes in self-reported cannabis use during the COVID-19 pandemic: a scoping review. *BMC Public Health*, 23(1). <https://doi.org/10.1186/s12889-023-17068-7>

Meier, M. H., Schriber, R. A., Beardslee, J., Hanson, J., & Pardini, D. (2019). Associations between adolescent cannabis use frequency and adult brain structure: A prospective study of boys followed to adulthood. *Drug and Alcohol Dependence*, 202, 191–199. <https://doi.org/10.1016/j.drugalcdep.2019.05.012>

Menary, K., Collins, P. F., Porter, J. N., Muetzel, R., Olson, E. A., Kumar, V., Steinbach, M., Lim, K. O., & Luciana, M. (2013). Associations between cortical thickness and general intelligence in children, adolescents and young adults. *Intelligence*, 41(5), 597–606. <https://doi.org/10.1016/j.intell.2013.07.010>

Menke, J. (2019, March 12). *Methods of Use*. Student Health and Counseling Services. <https://shcs.ucdavis.edu/health-and-wellness/alcohol-tobacco-and-other-drugs/marijuana/methods-use>

*Myths and Facts About Marijuana Use*. (n.d.). Sonomacounty.ca.gov. <https://sonomacounty.ca.gov/health-and-human-services/health-services/marijuana-public-health-and-safety/myths-and-facts-about-marijuana-use>

National Center for Drug Abuse Statistics. (2019). *Marijuana Addiction: Rates & Usage Statistics*. National Center for Drug Abuse Statistics. <https://drugabusestatistics.org/marijuana-addiction/>

National Institute on Drug Abuse. (2020, June 15). *Cannabis (Marijuana)*. National Institute on Drug Abuse. <https://nida.nih.gov/research-topics/cannabis-marijuana>

Patrick, M., Miech, R., Johnston, L., & O'malley, P. (2024). *Monitoring the Future Panel Study Annual Report*. <https://monitoringthefuture.org/wp-content/uploads/2024/07/mtfpanel2024.pdf>

Scheyer, A. F., Laviolette, S. R., Pelissier, A.-L., & Manzoni, O. J. J. (2022). Cannabis in Adolescence: Lasting Cognitive Alterations and Underlying Mechanisms. *Cannabis and Cannabinoid Research*, 8(1). <https://doi.org/10.1089/can.2022.0183>