

Cannabis Use in Adolescent and Young Adult Athletes: A Clinical Review

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Context: Cannabis use among the general population has increased over time, in part due to decriminalization of use and greater social acceptance of cannabis use. These changes have contributed to increased availability of cannabis products, thus raising the likelihood that a subset of adolescent and young adult athletes will use cannabis. Therefore, it is imperative that clinicians and other providers working with young athletes have a thorough understanding of the impact cannabis can have on the athletic performance and overall health of a young athlete.

Evidence Acquisition: PubMed (Medline), CINAHL, PsycINFO, and SportDiscus databases were used to perform a literature search of articles published between January 1, 2010 and December 31, 2022. Additional articles were reviewed based on references obtained from initial articles.

Study Design: Clinical review.

Level of Evidence: Level 4.

Results: Survey studies suggest that up to 1 in 4 athletes have used cannabis at least once in the last year. Age, sex, race, sexual orientation, level of competition, and country of residence of an athlete all contribute to differing rates of cannabis use among athletes. The scientific literature does not support using cannabis for athletic performance, and multiple studies have demonstrated notable impairments in objective athletic performance measures. Cannabis use can also negatively impact an athlete's overall health via cardiovascular, gastrointestinal, and mental health symptoms and disorders.

Conclusion: Cannabis use among adolescent and young adult athletes is common, and rates of use are influenced by many different factors. Current evidence suggests that cannabis use can worsen sport performance, negatively impact an athlete's general health, and contribute to negative mental health outcomes.

Keywords: athlete; cannabis; mental health; sport performance

C*annabis sativa* - a flowering plant - contains over 500 compounds, can be consumed through inhalation or ingestion, and, depending on the preparation, is commonly referred to as cannabis, marijuana, or hemp.³ Among the hundreds of compounds in cannabis, Δ^9 -tetrahydrocannabinol (THC) and cannabidiol (CBD) are the 2 compounds that have received the most attention and have been of greatest clinical interest. THC is largely responsible for the psychoactive effects of cannabis, while the interaction of CBD with the endocannabinoid system, by some reports, may play a role in modulating pain and inflammation.⁴⁶ Increasingly, recreational cannabis products have been found to contain significantly higher concentrations of THC, while CBD levels

have remained relatively constant.^{20,25} The overall increase in both THC levels and the THC:CBD ratio in cannabis products is of notable concern, as the risk of developing cannabis use disorder and cannabis-induced psychosis is believed to be driven primarily by the psychoactive effects of THC.^{16,17,26,31,51} The developing adolescent brain appears to be even more sensitive to the psychoactive effects of THC as those who start using cannabis before adulthood are more likely to develop cannabis use disorder in the future.⁷⁶

Cannabis continues to be on the prohibited substance lists of many elite sports associations including the World Anti-Doping Agency and the National Collegiate Athletic Association (NCAA).^{56,82}

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The authors report no potential conflicts of interest in the development and publication of this article.

DOI: 10.1177/19417381231208661

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However, in recent years, cannabis has undergone decriminalization as well as legalization in many places across the United States (US).⁸ As of May 2023, cannabis can be used legally by adults for recreational purposes in 22 states, 2 US territories, and the District of Columbia. Medicinal use of cannabis preceded these regulatory changes and is more widely available, extending to 38 states, 3 US territories, and the District of Columbia.²⁹ Despite state laws allowing cannabis to be used for medical purposes, there are no current Food and Drug Administration-approved indications for cannabis. There are, however, 3 cannabis-related drug products that have been approved for use in nausea related to chemotherapy and 1 cannabis-derived product for the treatment of Lennox-Gastaut syndrome and Dravet syndrome.²²

Given the ever-increasing availability of cannabis alongside greater social acceptance, it is anticipated that cannabis use among the general population will continue to increase.⁸ Coinciding with this cultural shift, the NCAA recently reduced penalties associated with cannabis use. Positive tests no longer result in suspension from competition; rather, student athletes will be expected to work with their institutions to undergo education about the risks of cannabis misuse.⁶⁴ As the landscape around the legality and medical use of cannabis continues to evolve and athletic associations loosen their restrictions around cannabis use, it may be reasonable to expect a rise in use among athletes. Thus, it is imperative that clinicians working with athletes develop a firm understanding of the impact cannabis has on their athletic performance and overall health. Although previous work already exists in this area,^{78,18} much of the focus has been on older adult athletes. Less is known about the impact cannabis has on the young athlete. This narrative review will focus on the adolescent and young adult athlete using 25 years of age as a cutoff. Due to the rapid evolution of cannabis use, this review focuses primarily on studies published between 2010 and 2022.

EPIDEMIOLOGY

Cannabis use among adolescents and young adults continues to rise despite a concurrent decline in alcohol and tobacco use observed over the last 30 years.³⁷ Many researchers have attempted to elucidate an exact prevalence of cannabis use among young athletes; however, despite many well-designed studies, it remains difficult to quantify. Studies on prevalence often rely on self-report, and the specific words used in survey questions can influence answers and contribute to variability in results.^{5,42} Nonetheless, it is likely that around 25% of athletes, regardless of age, have used cannabis within the last year, as evidenced by a systematic analysis that includes multiple studies and >46,000 athletes aged 13 to 46 years.¹⁸ Among college athletes, data released by the NCAA reports 24% of student athletes have used cannabis within the last year.⁵⁷

To appreciate the interplay between sport and cannabis use among adolescents and young adults, it is essential to understand the use habits of cannabis among athletes and

nonathletes alike. The National Youth Behavior Risk Survey reported that 37% of high-school students in the US have used cannabis in their lifetime, and 21% have used marijuana within the last 30 days.⁶ Among US college students, nearly a third have used cannabis within the last year.²¹

Whether or not sports participation influences cannabis use remains up for debate, and it is likely only one of many factors that needs to be considered when assessing a person's risk of use. In looking exclusively at the interaction between sports participation and cannabis use among high-school students, many studies have found lower rates of cannabis use among athletes compared with their nonathlete peers.^{12,41,45,69,70} Conversely, a longitudinal study of >500 high-school students found no difference in cannabis use between athletes and nonathletes.⁹

Researchers have attempted to further characterize young athlete cannabis use by investigating how demographic factors such as sex, race, and sexuality influence cannabis use. When assessing cannabis use in high-school aged boys, 3 studies reported no difference in cannabis use between athletes and nonathletes,^{2,15,19} while 2 other studies found less cannabis use among male athletes.^{79,80} In female high-school athletes, the data are similarly contradictory. Four studies reported sports participation was associated with decreased use,^{2,15,19,79} 1 study found no difference in use related to sports participation,⁸⁰ and 1 study reported marijuana use was more likely in female athletes compared with their nonathlete peers.³⁹ In addition, 1 study noted that race may influence cannabis use among athletes, reporting that White female athletes were significantly more likely to use cannabis than White female nonathletes, and they also used more cannabis than non-White athletes.¹³ Sexuality may also play a role, as it has been reported that cannabis use is higher in high-school athletes who identify as a sexual minority than their athlete peers who identify as heterosexual.⁷²

Similar contradictions in the interaction between cannabis use and athletic participation exist in studies involving college athletes. Two studies, 1 in Brazil and 1 in Canada, found cannabis consumption to be significantly greater in those participating in varsity athletics than in nonathlete college students,^{47,49} while 3 studies reported sport participation to reduce cannabis use compared with their peers who were not involved in athletics.^{7,54,62} In a survey of >23,000 NCAA athletes, the most commonly reported reason for using cannabis was for socialization, whereas the second most common was for pain management.⁵⁷ Additional factors that appear associated with increased cannabis use in college athletes include identifying as a sexual minority, anxiety related to their sport, a history of using performance enhancing substances, and living in a state where cannabis is legal for medical or recreational use.^{5,36,57,73} The level of competition may also impact cannabis consumption, as Division III athletes (generally representing smaller colleges) reported significantly greater cannabis use, both in season and out of season, than athletes in Division I and Division II.^{57,59}

There is limited research on how different sports influence cannabis use, though the recent NCAA survey reported highest rates of cannabis use in lacrosse, swimming, and wrestling for men, and lacrosse, ice hockey, and field hockey for women.⁵⁷ In addition, 2 studies have reported that high contact sports are associated with greater cannabis use than noncontact sports.^{74,75} Despite these findings, a study of nearly 14,000 high-school student athletes found no association between cannabis use and concussion history.³⁵ Geography may also play a role in cannabis consumption, as multiple studies from European countries have reported lower cannabis consumption in athletes compared with nonathletes.^{30,58,68} Conversely, studies in Lithuania and South Africa found no difference in cannabis consumption between adolescents and young adult athletes compared with their nonathlete peers.^{1,61}

IMPACT ON PERFORMANCE

As the rate of cannabis use increases in adolescents and young adults, there has been more interest in determining how cannabis impacts sport performance, pain control, and recovery. A study among female athletes aged 18 to 26 years assessed whether pretreatment with CBD would alter peak strength and improve strength recovery. No differences between the placebo and CBD groups were seen in either outcome, nor were there any difference in plasma levels of inflammatory markers.¹⁰ Conversely, in a study where CBD was given after an intense exercise session, 72 hours later peak strength was less impacted, and markers of muscle damage were decreased, compared with placebo.³³ A small pilot study recently investigated the impact oral CBD may have on aerobic performance, and, although the study was not powered to assess effect, the authors did not find compelling evidence to suggest CBD would negatively impair aerobic performance and thus recommended further study into how CBD could be used to influence sports performance.⁶⁶

In addition to intentional use of CBD to study sport performance, researchers have also looked into how recreational marijuana use may influence performance. A study assessing routine inflammatory marker levels in healthy and active young adults demonstrated no difference in interleukin-6, cortisol, or C-reactive protein (CRP) between chronic marijuana users and healthy controls.⁴³ A similarly designed study of physically active men in their 20s also demonstrated no difference in cortisol, CRP, and testosterone levels between marijuana users and nonusers, but did note a nonstatistically significant ($P = 0.08$) reduction in strength endurance in marijuana users.⁴⁴ Chronic marijuana users were also noted in 1 study to perform worse on tests involving working memory and psychomotor speed, even after a 3-week abstinence period, suggesting stopping marijuana use right before a sporting event might not alleviate potential negative impacts on performance.⁷⁷ Despite this notable finding related to working memory and psychomotor speed, a study looking at postconcussion cognitive effects found no difference in cognitive recovery in athletes using cannabis versus those who were not, although this study

was done in adults with a mean age of 33 years, so it is unknown if this finding would generalize to adolescents.⁴⁰

GENERAL PHYSICAL HEALTH

When engaged in sport or exercise, the sympathetic nervous system is active, raising heart rate and blood pressure; thus, it is vital for athletes to maintain their cardiovascular health. Although believed to be a rare phenomenon, chronic, heavy marijuana use may result in acute myocardial infarction through cannabis-induced thrombus rupture without identified atherosclerotic disease as evidenced by multiple case reports describing emergent acute coronary syndrome in young athletes immediately after sporting events.^{11,28,32} Reportedly even more rare is acute end organ damage as a result of concentrated THC use via “dabbing,” which may cause a sympathetic storm leading to hyperthermia, cardiotoxicity, and serotonergic toxicity.⁶⁵

Cannabinoid hyperemesis (CHS) is another syndrome with which clinicians working with athletes should be familiar. This syndrome is characterized by abdominal pain, nausea, and resultant intense vomiting, which can have deleterious consequences and is often not relieved by typical antiemetics.⁶⁷ Case reports highlight the need for clinicians to take a detailed substance use history when an athlete develops these symptoms as it can occur at any stage in an athlete’s cannabis use history, and if supportive cares are not pursued, dehydration and subsequent rhabdomyolysis may ensue.⁷¹ Counseling athletes to stop using cannabis when experiencing CHS is of vital importance as the athlete may think that smoking marijuana will help reduce their nausea, when, in reality, continued use will result in worsening of symptoms.²³

MENTAL HEALTH

Surveys used to explore mental health and substance use in athletes and/or in young people are informative. While they may not be able to identify specific causation, identifying associations between cannabis use and mental health can help clinicians better screen and monitor for potential concerns. In addition, although there are limited studies exploring the relationship between cannabis use and mental health in the young athlete, having an understanding of the associations between cannabis use and mental health in adolescents in the general population is helpful. In a sample of nearly 15,000 high-school students, those who were currently using marijuana were significantly more likely to have seriously considered suicide, made a suicide plan, or had attempted suicide in the past.⁵² Another survey study of 10,000 youth in Ireland found a positive association between cannabis use and elevated anxiety, depression, and poor sleep.⁴⁸

In young athletes specifically, 2 studies published recently reported on the relationship between depression and cannabis use. In a pilot study of female college varsity athletes, cannabis use was associated positively with depressive symptoms, and, although this study only included 31 athletes, the effect size was significant.⁸¹ In addition, a protein associated with depression

when brain-derived neurotrophic factor was found to be lower in physically active young adults who identified as chronic cannabis users compared with age-matched peers who did not use cannabis.⁴³

Although the mechanism is not completely understood, cannabis use has been linked to earlier onset of schizophrenia in those with preexisting risk factors and may increase the risk of development of psychotic symptoms in any user.⁶⁰ One case report highlights the risk of cannabis use for the development of psychotic symptoms in a 17-year-old athlete who was admitted to an inpatient psychiatric unit after using synthetic cannabis and acutely developing auditory hallucinations, agitation, and resultant catatonia.⁶³

Multiple studies have looked at the association between pathologic gambling and cannabis use. A study of adolescents aged 14 to 18 years found a positive association between gambling use disorders and cannabis use,⁵³ while another study highlighted impulsivity, gambling, and substance use as interlinked.⁵⁰ While neither of these studies looked exclusively at athletes in assessing gambling behaviors and cannabis use, previous research in this area has noted an increase in gambling behaviors among adult athletes compared with nonathlete peers.¹⁴

DISCUSSION

This literature review identified several studies exploring the relationship between cannabis use and sport participation. Due to discordance among findings from numerous studies, we are unable to conclude the direct impact sports participation has on cannabis use. It is unlikely that sport participation is the sole determining factor in protecting against or facilitating cannabis use. Rather, there appear to be many factors that can ultimately influence a young athlete's use of cannabis. Sex, race, sexual identity, and geography all appeared to influence rates of cannabis use among athletes. Peer pressure and group/team dynamics were not studied robustly among the manuscripts included in this review, though a number of studies did identify a significant increase in binge use of alcohol among various team sports.^{4,24} In addition, college athletes identified socialization as a major reason why they used cannabis. Thus, the dynamic between social acceptance, peer pressure, and desire to be part of the in-group as it relates to team sports and cannabis use should be explored more extensively in the future. Comparing cannabis use among athletes involved in team sports versus athletes participating in individual sports may be another avenue to explore in the future to better understand how sport culture may influence cannabis use. Additional factors that appear to be related to cannabis use rates among athletes include level of competition and physicality of specific sports. Division I and Division II NCAA athletes were less likely to report using cannabis than Division III athletes. While the exact reasons for this discrepancy are unknown, the greater frequency of drug testing and fear of losing athletic scholarships as

punishment for a positive drug test in Division I athletes could be contributing to this finding. Finally, more research is needed to better elucidate how different sports influence cannabis use, especially given the findings that use among athletes who participated in high contact sports were more likely to use than those in noncontact sports, which could be interpreted as a means to control pain.

In relation to sport performance, current existing literature does not support the use of cannabis to improve performance in general, and, more specifically, marijuana use may negatively hinder an athlete's ability to perform at their highest capabilities. Definitive conclusions on CBD are more difficult to make, though outside of 1 study showing a reduction in inflammatory markers with improved strength recovery, there is little evidence that can be used to justify using CBD specifically to improve athletic performance. Further, the lack of regulation of CBD products increases the risk that it may contain nonnegligible levels of THC,³⁴ which could negatively impact performance and/or result in doping policy violations. Finally, there are no head-to-head studies looking at the impact of chronic versus acute (time-limited) use of CBD or marijuana on sports performance. Given the physiological adaptation that occurs over time with chronic versus acute use of many substances, this would be an important aspect for future study.

As use of cannabis is becoming more widespread, and States have both decriminalized and legalized use, some adolescents have begun to believe that cannabis is safe and without negative health implications.²⁷ Thus, it remains imperative that those working with adolescent and young adult athletes continue to provide accurate information related to the health risks associated with cannabis use. Though rare, the development of acute coronary syndrome in otherwise healthy young athletes as a consequence of cannabis use is concerning, and more research on this association is warranted. In addition to cardiovascular risk, young athletes should also be counseled on the mental health implications associated with cannabis use. Whether or not the correlation between depression, suicidality, and cannabis use among adolescent and young adult athletes can be fully explained, there is a growing body of evidence demonstrating the association between major depressive disorder and cannabis use.³⁸ Symptoms of psychosis and earlier onset of schizophrenia in those with familial risk factors have been linked to cannabis use.^{60,55} As recreational cannabis products continue to increase in overall potency, the risk of cannabis induced psychotic symptoms developing in a young athlete may similarly increase. Unfortunately, our review did not identify many studies that looked exclusively at the association between mental health and cannabis in adolescent and young adult athletes and, thus, a major limitation of this review is that our recommendations related to the risks of cannabis and mental health outcomes are built primarily on studies done in the general population. Further research looking exclusively at young athlete mental health will be vital, especially as cannabis continues to become more widely accessible.

CONCLUSION

Cannabis use among adolescent and young adult athletes is common, and rates of use are influenced by many different factors. At the time of this review, there is not compelling evidence to recommend using cannabis to improve athletic performance. Conversely, current evidence suggests that marijuana use may worsen athletic performance, while the impact of CBD supplementation needs further study. Finally, cannabis use is associated with significant negative mental health outcomes and has been implicated in severe cardiovascular and gastrointestinal illness.

REFERENCES

- Asgeirsdottir BB, Kristjansson AL, Sigfusson J, Allegrante JP, Sigfusdottir ID. Trends in substance use and primary prevention variables among adolescents in Lithuania, 2006-19. *Eur J Public Health*. 2020;31(1):7-12.
- Boyes R, O'Sullivan DE, Linden B, McIsaac M, Pickett W. Gender-specific associations between involvement in team sport culture and Canadian adolescents' substance-use behavior. *SSM - Population Health*. 2017;3:663-673.
- Breijyeh Z, Jubeh B, Bufo SA, Karaman R, Scranio L. Cannabis: a toxin-producing plant with potential therapeutic uses. *Toxins*. 2021;13(2):117.
- Brenner J, Swanik K. High-risk drinking characteristics in collegiate athletes. *J Am Coll Health*. 2007;56(3):267-272.
- Buckman JF, Farris SG, Yusko DA. A national study of substance use behaviors among NCAA male athletes who use banned performance enhancing substances. *Drug Alcohol Dependence*. 2013;131(1-2):50-55.
- Centers for Disease Control and Prevention. 2019 Youth Risk Behavior Survey Data. Published 2019. Accessed March 10, 2023. <https://www.cdc.gov/healthyyouth/data/yrbs/index.htm>
- Charest J, Grandner MA, Athey AB, McDuff D, Turner RW. Substance use among collegiate athletes versus non-athletes. *Atlet Train Sports Health Care*. 2021;13(6):16082.
- Connor JP, Stjepanović D, Le Foll B, Hoch E, Budney AJ, Hall WD. Cannabis use and cannabis use disorder. *Nat Rev Dis Primers*. 2021;7(1):16.
- Cristello JV, Trucco EM, Zucker RA. Exploring pathways to substance use: a longitudinal examination of adolescent sport involvement, aggression, and peer substance use. *Addict Behav*. 2020;104:106316.
- Crossland BW, Rigby BR, Duplanty AA, et al. Acute supplementation with cannabidiol does not attenuate inflammation or improve measures of performance following strenuous exercise. *Healthcare (Basel)*. 2022;10(6):1133.
- Deharo P, Massoure PL, Fourcade L. Exercise-induced acute coronary syndrome in a 24-year-old man with massive cannabis consumption. *Acta Cardiol*. 2013;68(4):425-428.
- Delisle TT, Werch CE, Wong AH, Bian H, Weiler R. Relationship between frequency and intensity of physical activity and health behaviors of adolescents. *J Sch Health*. 2010;80(3):134-140.
- Denham BE. Alcohol and marijuana use among American high school seniors: empirical associations with competitive sports participation. *Soc Sport J*. 2011;28(3):362-379.
- Derevensky JL, McDuff D, Reardon CL, Hainline B, Hitchcock ME, Richard J. Problem gambling and associated mental health concerns in elite athletes: a narrative review. *Br J Sports Med*. 2019;53(12):761-766.
- Dever BV, Schulenberg JE, Dworkin JB, O'Malley PM, Kloska DD, Bachman JG. Predicting risk-taking with and without substance use: the effects of parental monitoring, school bonding, and sports participation. *Prev Sci*. 2012;13(6):605-615.
- Di Forti M, Marconi A, Carra E, et al. Proportion of patients in south London with first-episode psychosis attributable to use of high potency cannabis: a case-control study. *Lancet Psychiatry*. 2015;2(3):233-238.
- Di Forti M, Quattrone D, Freeman TP, et al. The contribution of cannabis use to variation in the incidence of psychotic disorder across Europe (EU-GEI): a multicentre case-control study. *Lancet Psychiatry*. 2019;6(5):427-436.
- Docter S, Khan M, Gohal C, et al. Cannabis use and sport: a systematic review. *Sports Health*. 2020;12(2):189-199.
- Dunn MS. Association between physical activity and substance use behaviors among high school students participating in the 2009 Youth Risk Behavior Survey. *Psychol Rep*. 2014;114(3):675-685.
- ElSohly MA, Chandra S, Radwan M, Majumdar CG, Church JC. A comprehensive review of cannabis potency in the united states in the last decade. *Biol Psychiatry Cogn Neurosci Neuroimaging*. 2021;6(6):603-606.
- Evans-Polce R, Lanza S, Maggs J. Heterogeneity of alcohol, tobacco, and other substance use behaviors in U.S. college students: a latent class analysis. *Addict Behav*. 2016;53(53):80-85.
- FDA and Cannabis: Research and Drug Approval Process. US Food and Drug Administration. Published 2019. Accessed March 21, 2023. <https://www.fda.gov/news-events/public-health-focus/fda-and-cannabis-research-and-drug-approval-process>
- Fleshman B, Kaiser K. Cannabinoid hyperemesis syndrome in an athlete. *J Am Board Fam Med*. 2021;34(4):811-813.
- Ford JA. Substance use among college athletes: a comparison based on sport/team affiliation. *J Am Coll Health*. 2007;55(6):367-373.
- Freeman TP, Craft S, Wilson J, et al. Changes in delta-9-tetrahydrocannabinol (THC) and cannabidiol (CBD) concentrations in cannabis over time: systematic review and meta-analysis. *Addiction*. 2021;116(5):1000-1010.
- Freeman TP, Winstock AR. Examining the profile of high-potency cannabis and its association with severity of cannabis dependence. *Psychol Med*. 2015;45(15):3181-3189.
- Friese B. "Is marijuana even a drug?" A qualitative study of how teens view marijuana use and why they use it. *J Psychoactive Drugs*. 2017;49(3):209-216.
- Garza IV, Saleh M, Nguyen BX, Chatila KF. Spontaneous coronary artery dissection and cannabis toxicity in a healthy athletic male. *J Am Coll Cardiol*. 2022;79(9):2174.
- Hartman M. Cannabis Overview. Published May 31, 2022. Accessed March 21, 2023. <https://www.ncsl.org/civil-and-criminal-justice/cannabis-overview>
- Henchoz Y, Dupuis M, Deline S, et al. Associations of physical activity and sport and exercise with at-risk substance use in young men: a longitudinal study. *Prevent Med*. 2014;64(64):27-31.
- Hines LA, Freeman TP, Gage SH, et al. Association of high-potency cannabis use with mental health and substance use in adolescence. *JAMA Psychiatry*. 2020;77(10):1044-1051.
- Hodcroft CJ, Rossiter MC, Buch AN. Cannabis-associated myocardial infarction in a young man with normal coronary arteries. *J Emerg Med*. 2014;47(3):277-281.
- Isemann E, Veit S, Starke L, Flenker U, Diel P. Effects of cannabidiol supplementation on skeletal muscle regeneration after intensive resistance training. *Nutrients*. 2021;13(9):3028.
- Johnson E, Kilgore M, Babalonis S. Cannabidiol (CBD) product contamination: quantitative analysis of Δ^9 -tetrahydrocannabinol (Δ^9 -THC) concentrations found in commercially available CBD products. *Drug Alcohol Depend*. 2022;237:109522.
- Knell G, Burkhardt SO, Caze TJ, Polousky JD, Kohl HW III, Messiah SE. Association between concussion history and factors relating to cognitive, behavioral, and emotional health among American high school athletes: a cross-sectional analysis. *Am J Sports Med*. 2020;48(10):2534-2543.
- Knettel BA, Cherenack EM, Bianchi-Rossi C. Stress, anxiety, binge drinking, and substance use among college student-athletes: a cross-sectional analysis. *J Intercoll Sport*. 2021;14(2):116-135.
- Kreski NT, Cerdá M, Chen Q, et al. Adolescents' use of free time and associations with substance use from 1991 to 2019. *Subst Use Misuse*. 2022;57(13):1-11.
- Langlois C, Potvin S, Khullar A, Tourjman SV. Down and high: reflections regarding depression and cannabis. *Front Psychiatry*. 2021;12:625158.
- Lau EY, Riaz NA, Qian W, Leatherdale ST, Faulkner G. Protective or risky? The longitudinal association of team sports participation and health-related behaviours in Canadian adolescent girls. *Can J Public Health*. 2019;110(5):616-625.
- Lawrence DW, Foster E, Comper P, et al. Cannabis, alcohol and cigarette use during the acute post-concussion period. *Brain Inj*. 2019;34(1):42-51.
- Lee KTH, Vandell DL. Out-of-school time and adolescent substance use. *J Adolesc Health*. 2015;57(5):523-529.
- Lentillon-Kaestner V, Ohl F. Can we measure accurately the prevalence of doping? *Scand J Med Sci Sports*. 2010;21(6):e132-e142.
- Lisano JK, Kisiolek JN, Smoak P, Phillips KT, Stewart LK. Chronic cannabis use and circulating biomarkers of neural health, stress, and inflammation in physically active individuals. *Appl Physiol Nutr Metab*. 2020;45(3):258-263.
- Lisano JK, Smith JD, Mathias AB, et al. Performance and health-related characteristics of physically active males using marijuana. *J Strength Condit Res*. 2019;33(6):1658-1668.
- Lisha NE, Crano WD, Delucchi KL. Participation in team sports and alcohol and marijuana use initiation trajectories. *J Drug Issues*. 2013;44(1):83-93.
- Lu HC, Mackie K. Review of the endocannabinoid system. *Bio Psychiatry Cognit Neurosci Neuroimaging*. 2020;6(6):607-615.
- Mader J, Smith JM, Afzal AR, Szeto ACH, Winters KC. Correlates of lifetime cannabis use and cannabis use severity in a Canadian university sample. *Addict Behav*. 2019;98(98):106015.

48. Mahon C, Howard E, O'Reilly A, Dooley B, Fitzgerald A. A cluster analysis of health behaviours and their relationship to mental health difficulties, life satisfaction and functioning in adolescents. *Prev Med.* 2022;164:107332.
49. Mannes ZL, Hasin DS, Martins SS, et al. Do varsity college athletes have a greater likelihood of risky alcohol and cannabis use than non-athletes? Results from a National Survey in Brazil. *Braz J Psychiatry.* 2022;44(3):289-297.
50. Martínez-Loredo V, Grande-Gosende A, Fernández-Artamendi S, Secades-Villa R, Fernández-Hermida JR. Substance use and gambling patterns among adolescents: differences according to gender and impulsivity. *J Gamb Stud.* 2019;35(1):63-78.
51. Meier MH. Associations between butane hash oil use and cannabis-related problems. *Drug Alcohol Depend.* 2017;179:25-31.
52. Miller GF, DePadilla L, Jones SE, Bartholow BN, Sarmiento K, Breiding MJ. The association between sports- or physical activity-related concussions and suicidality among US high school students, 2017. *Sports Health.* 2020;13(2):194173812093991.
53. Moñino-García M, Ballesta M, Huerta JM, et al. The adolescent problem gambling prevalence associated with leisure-time activities and risky behaviors in Southern Spain. *Int J Ment Health Addict.* Published online November 18, 2022. doi: 10.1007/s11469-022-00950-7
54. Murray RM, Sabiston CM, Doré I, Bélanger M, O'Loughlin JL. Longitudinal associations between team sport participation and substance use in adolescents and young adults. *Addict Behav.* 2020;116:106798.
55. Murrie B, Lappin J, Large M, Sara G. Transition of substance-induced, brief, and atypical psychoses to schizophrenia: a systematic review and meta-analysis. *Schizophr Bull.* 2020;46(3):505-516.
56. National Collegiate Athletic Association. NCAA Banned Drugs. 2022-2023. Accessed March 21, 2023. https://ncaaorg.s3.amazonaws.com/ssi/substance/2022-23NCAA_BannedSubstances.pdf.
57. National Collegiate Athletic Association. NCAA National Study on Substance Use Habits of College Student Athletes. June 2018. Accessed March 21, 2023. https://ncaaorg.s3.amazonaws.com/research/substance/2018RES_SubstanceUseFinalReport.pdf
58. Obradovic Salcin L, Miljanovic Damjanovic V, Jurcev Savicevic A, Ban D, Zenic N. Prospective analysis of prevalence, trajectories of change, and correlates of cannabis misuse in older adolescents from coastal touristic regions in Croatia. *Int J Environ Res Public Health.* 2019;16(16):2924.
59. Orsini MM, Milroy JJ, Wyrick DL, Sanders L. Polysubstance use among first-year NCAA college student-athletes. *J Child Adolesc Substance Abuse.* 2018;27(3):189-195.
60. Ortiz-Medina MB, Perea M, Torales J, et al. Cannabis consumption and psychosis or schizophrenia development. *Int J Social Psychiatry.* 2018;64(7):690-704.
61. Osuafor GN, Okoli CE, Phateng R. Risk and protective factors associated with health risk behaviours among school learners in Western Cape, South Africa. *BMC Public Health.* 2023;23(1):16.
62. Parisi CE, Bugbee BA, Vincent KB, Soong AM, Arria AM. Risks associated with alcohol and marijuana use among college student athletes: the case for involving athletic personnel in prevention and intervention. *J Issues Intercol Athl.* 2019;12:343-364.
63. Pityk O, Lutska O, Sikora A. Spice related catatonia and its treatment: the case study. *Eur Psychiatry.* 2021;64(S1):S578-S578.
64. Radford C. Committee adjusts THC test threshold. Published February 25, 2022. Accessed March 21, 2023. <https://www.ncaa.org/news/2022/2/25/media-center-committee-adjusts-thc-test-threshold.aspx>
65. Rickner SS, Cao D, Kleinschmidt K, Fleming S. A little "dab" will do ya' in: a case report of neuro- and cardiotoxicity following use of cannabis concentrates. *Clin Toxicol.* 2017;55(9):1011-1013.
66. Sahinovic A, Irwin C, Doohan PT, et al. Effects of cannabidiol on exercise physiology and bioenergetics: a randomised controlled pilot trial. *Sports Med Open.* 2022;8(1):27.
67. Sorensen CJ, DeSanto K, Borgelt L, Phillips KT, Monte AA. Cannabinoid hyperemesis syndrome: diagnosis, pathophysiology, and treatment - a systematic review. *J Med Toxicol.* 2016;13(1):71-87.
68. Svensson R, Moeller K, Johnson B, Shannon D. For whom do unstructured activities matters? The interaction between unstructured and structured activities in delinquency and cannabis use: a national self-report study. *Crime Delinquency.* 2023;69(10):2022-2045.
69. Terry-McElrath YM, O'Malley PM. Substance use and exercise participation among young adults: parallel trajectories in a national cohort-sequential study. *Addiction.* 2011;106(10):1855-1865.
70. Terry-McElrath YM, O'Malley PM, Johnston LD. Exercise and substance use among American youth, 1991-2009. *Am J Prev Med.* 2011;40(5):530-540.
71. Trappey BE, Olson APJ. Running out of options: rhabdomyolysis associated with cannabis hyperemesis syndrome. *J Gen Intern Med.* 2017;32(12):1407-1409.
72. Veliz P, Boyd CJ, McCabe SE. Substance use among adolescent sexual minority athletes: a secondary analysis of the youth risk behavior survey. *Addict Behav Rep.* 2016;4:18-23.
73. Veliz P, Epstein-Ngo Q, Zdroik J, Boyd CJ, McCabe SE. Substance use among sexual minority collegiate athletes: a national study. *Substance Use Misuse.* 2016;51(4):517-532.
74. Veliz P, Schulenberg J, Patrick M, Kloska D, McCabe SE, Zarett N. Competitive sports participation in high school and subsequent substance use in young adulthood: assessing differences based on level of contact. *Int Rev Sociol Sport.* 2016;52(2):240-259.
75. Veliz PT, Boyd CJ, McCabe SE. Competitive sport involvement and substance use among adolescents: a nationwide study. *Substance Use Misuse.* 2014;50(2):156-165.
76. Volkow ND, Baler RD, Compton WM, Weiss SRB. Adverse health effects of marijuana use. *New Eng J Med.* 2014;370(23):2219-2227.
77. Wade NE, Wallace AL, Swartz AM, Lisdahl KM. Aerobic fitness level moderates the association between cannabis use and executive functioning and psychomotor speed following abstinence in adolescents and young adults. *J Int Neuropsychol Soc.* 2018;25(2):134-145.
78. Ware MA, Jensen D, Barrette A, Vernec A, Derman W. Cannabis and the health and performance of the elite athlete. *Clin J Sport Medicine.* 2018;28(5):480-484.
79. Williams GC, Burns KE, Battista K, de Groh M, Jiang Y, Leatherdale ST. High school intramural participation and substance use: a longitudinal analysis of COMPASS data. *Substance Use Misuse.* 2021;56(8):1108-1118.
80. Williams GC, Burns KE, Battista K, de Groh M, Jiang Y, Leatherdale ST. High school sport participation and substance use: a cross-sectional analysis of students from the COMPASS study. *Addict Behav Reports.* 2020;12(12):100298.
81. Wilson A, Gicas K, Stevens WD, Sergio L, Wojtowicz M. Substance use is associated with worse mental health and altered resting state functional connectivity in female university athletes at baseline: a pilot study. *PLoS One.* 2021;16(6):e0253261.
82. World Anti-Doping Agency. World Anti-Doping Code International Standard Prohibited List. 2022. Accessed March 21, 2023. https://www.wadaama.org/sites/default/files/resources/files/2022list_final_en.pdf.

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