

The Prevalence of CBD Use in Elite Athletes

Jeena Kinney Fuller, PA-C¹, Luke Counterman, PA-C¹ & Mary Showstark MPAS, PA-C*

¹Physician Assistant Online Program, Yale School of Medicine, 100 Church Street South,
Suite A230, New Haven, 06519, CT

*Corresponding author: mary.showstark@yale.edu (Mary Showstark MPAS, PA-C)

ABSTRACT

Cannabidiol (CBD) is the second most prevalent cannabinoid found in marijuana. Unlike Δ 9-tetrahydrocannabinol (THC), CBD elicits no psychotropic effects and has shown potential therapeutic efficacy in seizure disorders, psychotic symptoms, anxiety, depression, inflammation, cancer, cardiovascular disease, neurodegeneration, multiple sclerosis, and pain. Since research has demonstrated that CBD use has no psychoactive effects, no associated health problems, and does not cause physical or psychological dependence, WADA removed CBD from the Prohibited List in 2018, opening the door for CBD use in athletes. Cannabis use and its ergolytic effects on physical performance have been studied in depth. However, objective data regarding the prevalence of use and the performance effects of CBD is scarce despite its growing popularity in the athletic community. As a result, concerns are being raised anew about whether or not CBD confers an athletic advantage in competition. Our study sought to quantify the prevalence of CBD use among elite athletes, as well as other characteristics surrounding its use in this unique group. Despite growing interest in the general population, only 35% of elite athletes reported having ever used CBD. Of that number, 43% had used CBD within the last two weeks. An elite athlete was more likely to have ever tried CBD if they used other supplements, and if CBD was legal in their country of residence. Most athletes (44%) were unsure if CBD enhanced or hindered their performance, 23% thought CBD probably did not confer an athletic advantage, and 10% believed CBD definitely does not confer an athletic advantage. Though the general population claims that CBD can treat everything from acne to cancer, elite athletes report using CBD to treat and manage muscle recovery, pain, anxiety, and the sleep cycle. Those who reported never using CBD listed rules and regulations of their sport (39.34%) and regulatory concerns (26.23%) as the most frequent reasons for not using CBD. Due to lack of regulation

surrounding production and labeling accuracy, and extreme variation in worldwide legislation, recommending use of CBD to elite athletes is premature, at this point.

INTRODUCTION

The endocannabinoid system (ECS) is the largest neurotransmitter system in the human body and is theorized to be responsible for responding to environmental stimuli resulting in alteration of homeostatic processes including: circulation, emotional state, memory formation, sleep-wake cycles, appetite, inflammation, pain, and metabolism. Its roles in these systems have also led to the ECS being implicated in a wide range of disease states including mood disorders, movement disorders, neuropathic pain, multiple sclerosis, cancer, osteoporosis, epilepsy, myocardial infarctions, stroke, obesity, and many more. A typical chemical synapse system functions by releasing a neurotransmitter from a presynaptic element which then diffuses across the synaptic cleft to a postsynaptic element, binding to and activating its receptors. The ECS, however, works via retrograde neurotransmitter signaling: a diffusible messenger is liberated from the postsynaptic cell, travels upstream across the synaptic cleft, and activates receptors located on the presynaptic nerve terminal allowing it to alter presynaptic transmitter release¹.

The ECS consists of cannabinoid receptors (CB1 and CB2) and lipid-derived endogenous ligands called endocannabinoids [anandamide and 2-arachidonoylglycerol (2-AG)], so named because they were discovered while researching the effects of cannabinoids (the chemical constituents of the *Cannabis* plant) on the human body². CB1, whose active and inactive crystal structures have been elucidated, is widely expressed under physiological conditions and is present at much lower concentrations in the periphery^{2,3}. It is associated with psychoactive, neuromodulatory, and analgesic effects due to its activation by a lipid called

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Δ 9-tetrahydrocannabinol (THC)⁴. CB1 receptors are functionally and physically linked to orexigenic projections in the brain. Orexin projections are found leading to every single part of the mammalian brain and spinal cord, yet only the projections found in the hypothalamus actually produce orexin. In mouse models, increased amounts of orexin demonstrated increased appetite. Decreased amounts of orexin demonstrated a dysregulated sleep-wake cycle. An absence of orexin resulted in narcolepsy-cataplexy (narcolepsy is the inability to stay awake for extended periods of time, and cataplexy is a sudden, brief loss of voluntary muscle control that occurs during waking hours)². Outside of the CNS, CB2 is primarily expressed in the peripheral nervous system in cells of the immune system and the hematopoietic cells, playing an important role in fighting inflammation. It has also been implicated in a variety of modulatory functions including immune suppression, induction of apoptosis, and induction of cell migration. It is also of note that CB2 agonism results in zero psychotropic effects⁵.

The endogenous endocannabinoids Anandamide and 2-AG both act in a dose-dependent manner, whereby they have opposite effects at low versus high concentrations. In addition, they are not stored, but rapidly synthesized and degraded on-demand. Anandamide, a fatty acid neurotransmitter derived from the non-oxidative metabolism of arachidonic acid, is a partial to full agonist of CB1. The name is taken from the Sanskrit word “Ananda” which means “joy, bliss, delight” because this is the molecule credited for eliciting a “runner’s high”⁶. 2-AG is 107 times more prevalent than anandamide in the CNS⁷. It is a full agonist of CB1 and CB2, but it does have a weaker affinity for CB1 than anandamide. The amount of 2-AG increases significantly during orgasm, thus it is postulated to be involved in mediating reward pathways⁸.

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As previously mentioned, exogenous ligands are also capable of binding to endogenous ECS receptors. Despite utilizing the same receptors as endogenous ligands, cannabinoids do not display a 1:1 conversion with endocannabinoids. THC and Cannabidiol (CBD) are the two most prevalent cannabinoids found in *Cannabis sativa L*, respectively. THC is a full agonist of CB1, and responsible for the psychotropic effects of marijuana. THC is degraded within the body to cannabinol (CBN). CBN partially agonizes CB1, but is 75% less potent than THC. CBD, however, is a noncompetitive negative allosteric inhibitor of CB1 and a weak antagonist of CB2. This means that CBD does not have psychoactive effects. In fact, it antagonizes the effects of THC due to its negative allosteric effects on CB1⁹.

CBD was first isolated in 1940 and then structurally characterized in 1963^{10,11}. Since being isolated, CBD has shown potential therapeutic efficacy in seizure disorders, psychotic symptoms, anxiety, depression, inflammation, cancer, cardiovascular disease, neurodegeneration, multiple sclerosis, and pain. CBD-based analgesia is associated with potent immunomodulatory, anti-inflammatory, and antioxidant activity¹²⁻²⁰. In addition, neither abuse nor dependence has been demonstrated²¹. Despite this, CBD continues to have a contentious reputation due to its association with *Cannabis* and, thus, THC.

CBD was effectively made illegal in the United States in 1970 when the Controlled Substances Act (CSA) was signed into law, categorizing marijuana as a schedule I substance (defined as having a high potential for abuse and no accepted medical use). Prior to 1937, hemp was the major industrial fiber when it fell out of favor due to the marijuana tax act, rumored to have been initiated in an attempt to bolster lumber holdings so they would favor lumber over hemp production. This effectively killed the industrial hemp and medical marijuana industries

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due to high taxes. Lack of corporate interest further aided in marijuana's schedule 1 classification at the inception of the CSA in 1970²²⁻²⁷

The medical marijuana revolution began with its legalization in California in 1996. CBD gained public notoriety in 2004 when four-year-old Charlotte Figi, who suffered from a rare intractable form of epilepsy, used cannabis to control her seizures. Her doctor and parents were out of medical and pharmaceutical solutions, so they began to experiment with cannabis. They noticed her seizures abating when she started using a strain that was low in THC and high in CBD. When she went from having over 300 grand mal seizures per week to less than one, she became the face of the medical marijuana and CBD extract movement. Forbes credits Charlotte's success story as being the force that propelled medical and recreational marijuana legalization- especially CBD²⁸. This change in public opinion also led to the eventual legalization of recreational marijuana use in Colorado and Washington in 2012.

In 2014, the Farm Bill provided a legal definition for industrial hemp: the plant species *Cannabis sativa L.* with a THC concentration of not more than 0.3% on a dry weight basis. While hemp remained a schedule I substance under the CSA, the Farm Bill allowed state departments of agriculture and universities to grow and produce hemp as part of research programs investigating the growth, cultivation, and marketing of hemp. In 2018, the Farm Bill was revised and industrial hemp was removed from the CSA, making it legal to grow as a commercial product on the federal level²⁴.

At the time of this writing, CBD is legal in all 50 states, as long as it is hemp-derived. Internationally, the legal status of CBD varies widely and is often vague or not clearly defined. While the general European Union (EU) law permits the consumption of CBD products containing no more than 0.2% THC, individual countries still make their own regulations. For

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example: Croatia and Slovenia have an outright ban on all cannabis and cannabis-derived substances, including CBD. Germany requires a person to obtain a medical marijuana license to purchase or consume CBD. In Austria, CBD extracts containing up to 0.3% THC may be sold, but not as a supplement or medication. China allows the growth of industrial hemp, but products containing CBD are illegal. In France and Japan, CBD is only legal if it contains 0% THC, while Thailand allows up to 0.1% THC. In South Korea, CBD is only legal for licensed medical use²⁹.

The regulatory confusion of CBD carries over to competitive athletics. At the 1998 Olympic Winter Games at Nagano, Canadian snowboarder Regabalti was stripped of his gold medal in the giant slalom event by the International Olympic Committee (IOC) after he tested positive for THC with a urine drug screen. At the time, IOC regulations stated that athletes testing positive for greater than 15 ng/ mL THC “may lead to sanctions.” The IOC stripped Regabalti of his gold medal. This decision was immediately appealed to the Court of Arbitration of Sport by the Canadian Olympic Association (CAS) because the policy was so vague. Regabalti claimed that he had ingested second-hand smoke at a going-away party in Whistler, Canada on January 31, and the specimen collection date was February 8. He claimed that he had not actively used marijuana for 11 months. At the time, THC was not prohibited for the Giant Slalom Snowboard by the International Federation of Skiing. CAS overturned the IOC decision and reinstated Regabalti’s gold medal because there were no clear guidelines for how to handle a positive marijuana test^{30,31}. This debacle led to the formation of the World Anti-Doping Agency (WADA) in 1999 for the purpose of maintaining and enforcing a list of banned substances in international sports competition³².

WADA maintains a list of prohibited substances and methods that are deemed to compromise the integrity of sporting competition. A substance or method is included on the

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Prohibited List if it is a potential masking agent to impede detection of a prohibited substance, or if it meets at least 2 of the following criteria: i) it has the potential to enhance, or enhances, sport performance; ii) it represents an actual or potential health risk to the athlete; iii) it violates the Spirit of Sport. WADA defines the Spirit of Sport as “the intrinsic value... It is the essence of Olympism, the pursuit of human excellence through the dedicated perfection of each person’s talents. It is how we play true. The spirit of sport is the celebration of the human spirit, body and mind, and is reflected in values we find in and through sport, including Ethics, fair play and honesty; health; excellence in performance; character and education; fun and joy; teamwork; dedication and commitment; respect for rules and laws; respect for self and other Participants; courage; community and solidarity.” WADA enforces the Prohibited List through the policy of Strict Liability: the mere presence of a prohibited substance is a sufficient basis for an adverse finding. There is no requirement for actual performance enhancement (or impairment) to be demonstrated³³.

Cannabis (marijuana and all other cannabinoids) has been prohibited by WADA since 2004 under the rule stating, “any pharmacologic substance which is not addressed by any other section and with no current approval by any government regulatory health authority for human therapeutic use.” In 2018, the World Health Organization (WHO) and the Food and Drug Administration (FDA) respectively issued statements affirming that “no public health problems have been associated with CBD use,” and “there is little indication that CBD has abuse potential or presents a significant risk to public health... there is no evidence that CBD causes physical or psychic dependence.” Since research has demonstrated that CBD use has no psychoactive effects, no associated health problems, and does not cause physical or psychological dependence, WADA removed CBD from the Prohibited List in 2018, thus opening the door for CBD use in

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athletes. Cannabis, however, remains a banned substance. While cannabis has not been shown to confer an athletic advantage, it remains banned on the grounds of “spirit of sport” due to its addictive potential and psychotropic effects³⁴.

The limited current literature assessing the impact of Cannabis on physical exercise has focused on the effects of THC. Cannabis is overall ergolytic not ergogenic, so it is not believed to confer an athletic advantage. In fact, THC has been shown to precipitate angina at a lower workload in 100% of subjects, and that overall strength is probably reduced while intoxicated³⁵⁻³⁷. One study demonstrated a positive effect of THC on exercised induced asthma. After inducing bronchospasm with bicycling, THC reduced bronchospasm in both exercise and methacholine induced controls^{38,39}. However, no studies have been performed targeting a population of elite athletes. In addition, no research has been done to determine the efficaciousness of cannabinoids vs currently accepted treatments like albuterol. Despite the literature, 1 in 4 athletes report using Cannabis within the past year⁴⁰. Increased use has also been demonstrated in high-risk sports: skiing, snowboarding, hockey, luge, and bobsled. This may be related to THC’s demonstrated ability to hinder formation of fear memories and its anxiolytic action when used in lower doses⁴¹⁻⁴³.

CBD use among athletes has been analyzed in one study. The Athlete PEACE Survey identified three cannabis user-type clusters in a community-based cohort of self-described adult athletes. The first was characterized by older adults who consume CBD for medical purposes. The second cluster was called a mixed-use cluster because there was variability in the age range and patterns of use of THC and CBD. The third cluster was a long-duration combination use group who used Cannabis the longest with an emphasis on both THC and CBD use together. Out of all cluster groups, 61% reported THC and/ or CBD use for pain⁴⁴. Another survey assessed the

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reasons for CBD use amongst the general population. This survey reported that 62% of CBD users reported using CBD to treat their diagnosed medical conditions of pain, anxiety, and depression⁴⁵.

Cannabis use and its ergolytic effects on physical performance have been studied in depth. However, objective data regarding the prevalence of use and the performance effects of CBD is scarce despite its growing popularity in the athletic community. As a result, concerns are being raised anew about whether or not CBD confers an athletic advantage in competition. To date, claims regarding the prevalence of use in the elite athlete community are subjective and have never been corroborated through objective analysis. This is important because determining the comprehensive effects of a substance on athletic performance is costly and time consuming. The purpose of this study was to determine the relative use of CBD by elite athletes to better assess the need for further evaluation of CBD and potential conferred athletic advantage.

METHODS

We developed a survey in order to assess the prevalence of CBD usage among self-identified current or former elite athletes as well as other characteristics, such as use of other supplements, reasons for use or lack thereof, effects experienced, and whether or not a participant felt CBD use conferred an advantage in sport. The survey was assembled and distributed via Qualtrics online survey software. Prior to distribution, the survey and study protocol were submitted to the Institutional Review Board of Yale University (IRB). Upon the review, the Review Board determined that the study was exempt. Survey respondents consisted of a convenience sample recruited voluntarily through personal contacts, social media posts, and the Yale University Athletics Department. The survey consisted of 28 multiple choice questions,

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with several providing an option to freetext a response. The criteria for inclusion in the study were as follows: ≥ 18 years old, be a self-identified elite athlete (defined as current or former professional, semi-professional, competitive, or college level), agree to informed consent to participate in the survey, and provide an answer to question 13, “Have you ever used CBD?”. Participants were not required to answer 27 out of 28 questions if they did not wish to. Survey responses were collected from April 23rd, 2020 - October 1st, 2020. After the closure of the survey, simple proportions were used to characterize the demographics of respondents, prevalence of CBD use, use of other supplements, reasons for use or lack thereof, effects experienced, and other factors surrounding the use of CBD. JMP Pro 15 software was used to conduct the data analysis. Bivariate comparisons were conducted using Likelihood-ratio and Pearson chi-square tests. Statistical significance was assessed as $P < 0.05$.

RESULTS

DEMOGRAPHICS

A total of 237 survey responses were collected. Of these responses, 199 met the inclusion criteria. The remaining 38 responses were excluded from the analysis. Nearly 50% (49.75%) of respondents were between 18-24 years old. The sample was mostly male (61.62%), white

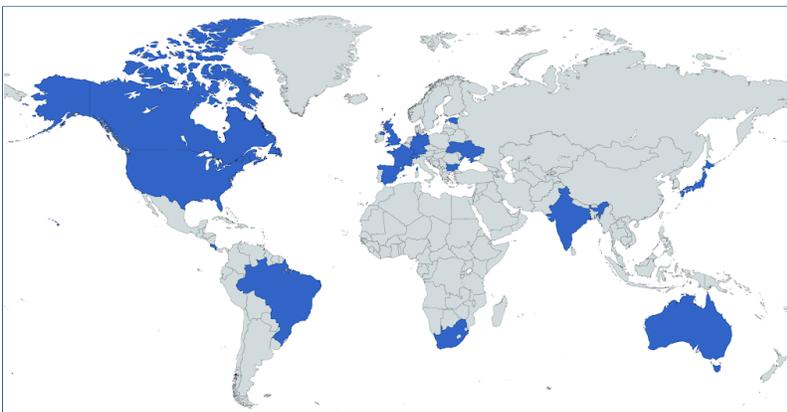


Figure 1. Countries represented

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(87.76%), and non hispanic (90.91%). Responses were received from participants residing in 18 different countries including Brazil, Estonia, India, and Japan, with the majority (73.23%) residing in the United States (Figure 1). All respondents self-identified as elite athletes in their chosen sport with 27 different sports represented including baseball, olympic weight lifting, field hockey, ice climbing, golf, and surfing. Individual and team sports were approximately equally represented in the sample (48.22% individual and 51.78% team). The vast majority of respondents (78.4%) reported being unpaid, while 21.6% reported being compensated for their participation in sport. The sample contained respondents that reported being currently retired from competition (6.51%). The majority of respondents (68.68%) reported spending 10 or more hours per week participating in, or training for, their sport with 28.28% reporting 20+ hours (Table 1).

CBD USE CHARACTERIZATION

Over one third of respondents (35.18%, n=70) reported having ever used CBD, while 42.05% (n=82) of respondents reported using other supplements besides CBD (Figure 2). There was no correlation between sex and CBD use, however men were more likely to report using supplements other than CBD compared to women ($p = 0.0022$). Those reporting CBD use were

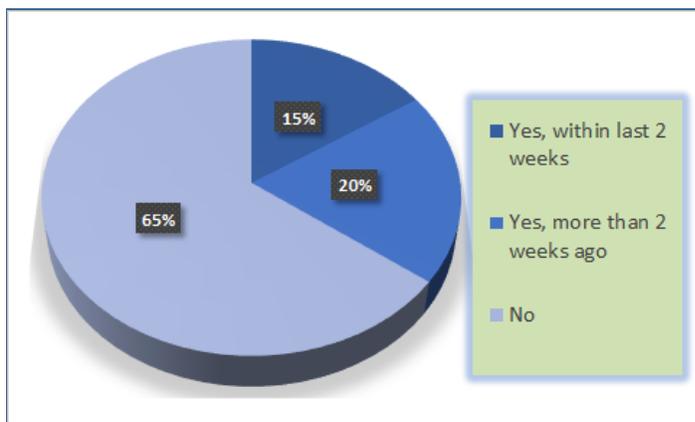


Figure 2. Have you ever used CBD?

Table 1. Demographics of Survey Respondents (n= 199)

	n (%)
Sex	
Male	122 (61.62)
Female	76 (38.38)
Age	
18-24	98 (49.75)
25-29	22 (11.17)
30-39	34 (17.26)
40-49	24 (12.18)
50-59	0
60-69	0
70+	3 (1.52)
Race	
White or Caucasian	172 (87.76)
Asian	12 (6.12)
Black or African American	0
American Indian or Alaskan Native	0
American Indian or Alaskan Native, Caucasian or White	0
Black or African American, White or Caucasian	0
Asian, White or Caucasian	0
Ethnicity	
Hispanic or Latino	0
Not Hispanic or Latino	170 (90.91)
Compensation	
Paid	24 (11.16)
Paid with product	17 (9.91)
Retired paid	6 (2.79)
Retired unpaid	8 (3.72)
Unpaid	160 (74.42)
Hours spent engaged in training/sport per week	
<1 hour	0
1-5 hours	23 (11.62)
5-10 hours	37 (18.69)
10-20 hours	0
20+	56 (28.28)
Have you ever used CBD?	
No	129 (64.82)
Yes	70 (35.18)
Do you use any other supplements besides CBD?	
No	113 (57.95)
Yes	82 (42.05)

also more likely to report use of other supplements ($p < 0.001$). CBD use was more likely when CBD was known to be legal where a respondent resided ($p < 0.001$). The top three reported reasons for using CBD were for muscle recovery (56.52%), anti-inflammatory (42.03%), and sleep (31.88%). Only 11.59% of respondents reported sports performance as a reason for using CBD. When asked if they thought CBD provides an advantage in their sport, 44.92% responded that it might or might not. The next most common responses were probably not (29.95%) and probably yes (11.23%). The absolute responses of definitely not (10.16%) and definitely yes (3.74%) were the least frequent (Figure 3). No correlation was found between reported use of CBD and the belief that it provides an advantage in sport. Among effects experienced from CBD use, anti-inflammatory (48.53%) and better sleep (45.59%) were the most reported, followed by decreased anxiety (38.24%) and faster muscle recovery (38.24%). Very few of those reporting CBD use had used it to replace a medication (10.45%). Medications replaced were primarily related to either pain (e.g. NSAIDs) or sleep (e.g. melatonin). Interestingly, among those who reported ever using CBD, more than half (56.94%) had not used any CBD within the past 2 weeks. Respondents reported numerous reasons for no longer using CBD including 33.33% reporting they did not experience any beneficial effects and 2.56% reporting adverse effects as a reason for stopping. Several respondents reported not currently using as they only use CBD when acutely experiencing symptoms. Among the 122 respondents that had never used CBD, rules and regulations of sport (39.34%), possibility of side effects (37.70%), and legal concerns (29.23%) were the most cited reasons for not trying it. Other cited reasons included regulatory concerns (26.23%), simply not interested (18.85%), and social/peer/familial pressure (14.75%) (Figure 3).

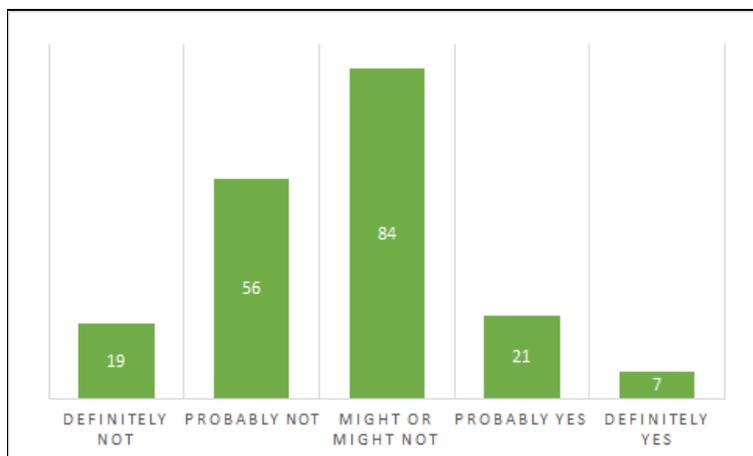


Figure 3. Do you think CBD gives someone an advantage in their sport?

In regards to the route of administration, topical was the most reported (34.33%), followed by edibles (28.36%), and smoking (22.39%). Personal contacts were the most frequently reported source of CBD (44.62%), followed by dispensaries (40.00%). Friends (45.45%), social media (16.67%), and a scholarly article (15.15%) were the most frequently reported initial source of information about CBD. Of the 36 responses to “What brands of CBD have you used?”, 27 unique individual brands were reported.

DISCUSSION

Cannabis use, and use of products made from its constituent parts, have been gaining traction in popular culture since the normalization of medicinal, and now recreational, marijuana use. Piggybacking off of the momentum from the medical marijuana movement, interest in CBD has also been piqued because of its purported uses as a therapeutic agent, which is of great interest to the general public. Sales of CBD products exceeded \$5 billion in 2019, a 706% increase from 2018⁴⁶. Examination of Google searches also demonstrates a large interest in CBD, with 6.4 million unique searchers within the United States in April 2019, alone⁴⁷. Despite inconsistent legislation and institutional rulings around the world, CBD has become an accepted

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training supplement within the elite athletic community. Studies of NCAA athletes have suggested that cannabis use is most influenced by social norms and the risk of detection⁴⁸, so it is reasonable to assume that CBD use would follow a similar trend. The prevalence of marijuana use has been studied in active athletes⁴⁴, and the prevalence of CBD use has been studied in the general population⁴⁵. However, the prevalence of CBD use in the elite athlete population has previously not been evaluated. Our study sought to identify the prevalence of CBD use within this specific population, as well as describe some of the characteristics surrounding its use.

Among our survey respondents, 35.18% reported having ever used CBD, which is similar to 38% of the general population⁴⁵. Corroon and Philips conducted a cross-sectional study on a cohort that consisted only of CBD users residing primarily within the US to characterize their use of CBD. When compared to our cohort, Corroon and Philips' cohort was primarily female (50.87% compared to our 38.38%) and significantly older (93.7% > 24 yo compared to our 49.75% 18-24 yo). Despite these differences, and our population consisting of only self-identified elite athletes, similarities emerged regarding the use of CBD. In both populations, pain, anxiety, and sleep were among the top 4 reasons for CBD use. Each of these uses also aligns with the known therapeutic effects of CBD. This finding concurs with the findings of the Corroon study in that the majority of those using CBD are doing so for a specific desired effect instead of simply general well-being⁴⁵. It is notable that among the elite athlete population, the most frequently reported reason for CBD use was specifically muscle recovery. The pharmacology of this should be the subject of further pharmacological study. In addition, respondents to both surveys reported learning about CBD primarily from friends and internet

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sources, suggesting that clinicians and field experts should take a more active role in education (Figure 4).

Our results differed from the Corroon study in the most frequent routes of administration. Corroon reported sublingual as the most common route (21%), while the elite athlete population

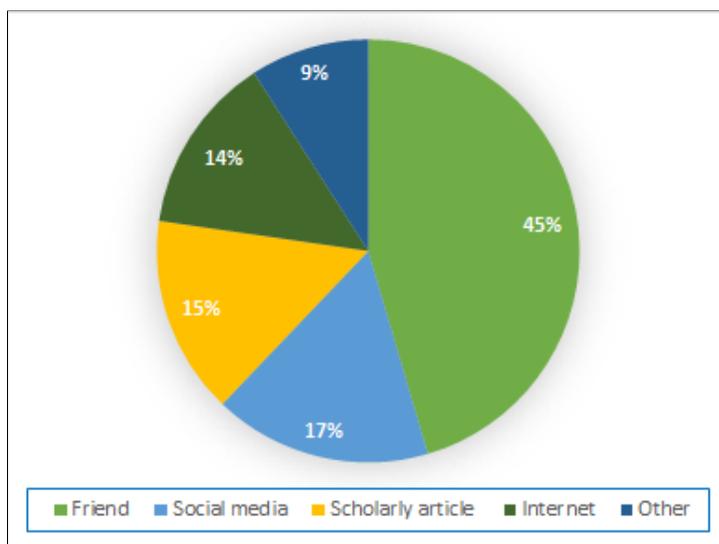
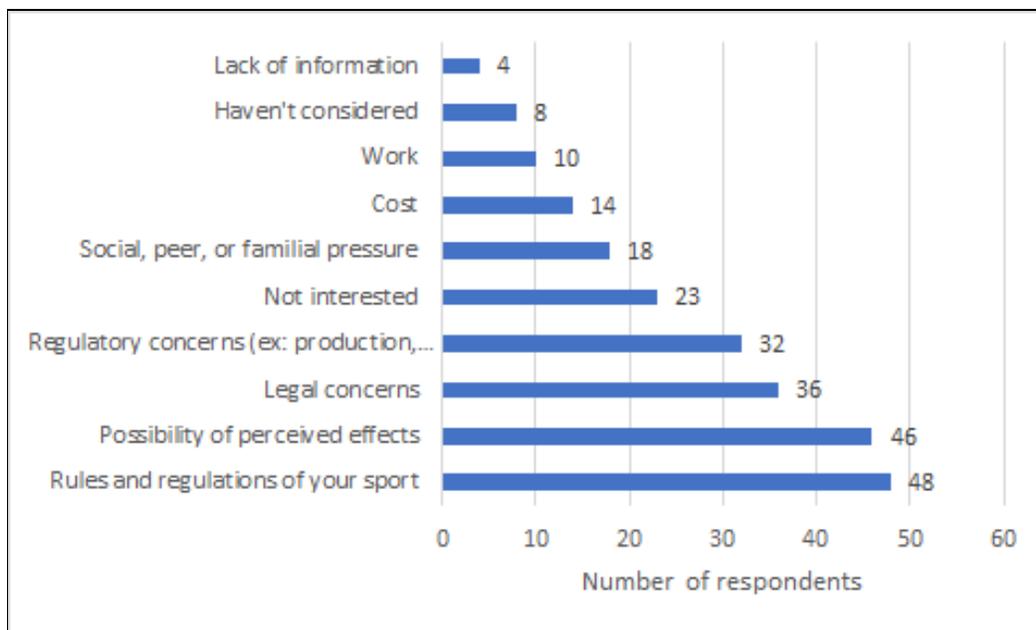


Figure 4. How did you find out about CBD?

more frequently reported topicals, edibles, and smoking. This result parallels that of industry-funded studies⁴⁶, likely due to the influence of those using marijuana-derived CBD. This also exposed a weakness of our study because respondents were not specifically asked about concurrent marijuana use. The PEACE survey on marijuana use in athletes reported “having ever used” prevalence of marijuana as 67.6%⁴⁴. However, given the additional scrutiny and regulation an elite athlete faces, it is not surprising that our “having ever used” prevalence of CBD use at 35.81% is much lower. In fact, those who reported never using CBD listed rules and regulations of their sport (39.34%) and regulatory concerns (26.23%) as the first and fourth most frequent reasons for not using CBD (Figure 5). Also among those who had not used any CBD in the last two weeks, 10.26% reported regulatory concerns and 7.69% reported rules and regulations of their sport as their reason for not using CBD. Taken together with Corroon’s finding that 44.8%



of respondents are non-regular cannabis users⁴⁵ suggests that athletes are not using CBD as a perceived legal route to THC consumption.

Figure 5. If you have never used CBD, what has kept you?

In 2018, CBD was removed from the WADA Prohibited List, opening the door for its use in international athletics. Even though the FDA has issued statements saying that CBD has “no evidence that CBD causes physical or psychic dependence” and that “there is little indication that CBD has abuse potential or presents a significant risk to public health”, no evidence has been published revealing the effect CBD has on athletic performance. While CBD is likely ergogenic based on what we currently know about its pharmacology¹²⁻²⁰, this is an area that requires further research.

We are able to glean several insights into the effects of CBD on athletic performance based on our survey responses. 11.59% of respondents reported initiating CBD use for the purpose of sports performance, while only 8.82% reported experiencing enhanced sports performance. One third of respondents reported that they stopped using CBD because they experienced no effects at all. Significantly more respondents reported using CBD either not

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related to sport (49.25%), or after participating in sport (50.75%), rather than before (20.90%) or during participation in their sport (11.94%). In addition, 89.55% of respondents that reported having ever used CBD have not replaced any medications with CBD. Together, these results suggest that elite athletes are not using CBD to enhance sports performance, though future studies should investigate this further. In addition, CBD seems to have a benign safety profile⁴⁹, with no adverse effects⁴⁵. While Corroon and Philips reported adverse effects were relatively common (30.8%), they suggested this may be due to THC contamination and that most effects were non-serious⁴⁵. In our study, only 2.56% of elite athletes reported stopping use of CBD due to adverse effects experienced. This suggests that any negative effects of CBD are non-serious and outweighed by the benefits of its use.

Even though evidence has neither been supportive for or against CBD use in athletics, we do not recommend the use of CBD at the elite athletic level until more uniformity at the regulatory levels is achieved. In addition, pre-clinical studies suggest that CBD may be useful to athletes due to anti-inflammatory, analgesic, anxiolytic, neuroprotective properties, and influencing the sleep-wake cycle. However, almost no clinical data are available on CBD in the context of exercise, which makes its use in this context premature⁵⁰. Gamelin states it well: “Worldwide regulatory status of CBD is complex and constantly changing... Thus, CBD use may be either legal or illegal depending on the laws of the country where the athlete performs, even though WADA removed this compound from the list of prohibited substances and methods⁵⁰.” With the recent increase in interest, CBD needs to be properly classified so further regulatory compliance can be achieved.

CBD is not classified as an illicit substance, pharmaceutical, dietary supplement, or essential oil. Despite being marketed and readily available worldwide as a dietary supplement, it

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is not recognized as a dietary supplement by WHO or FDA. The FDA approved the drug Epidiolex in June 2018 for the treatment of two rare types of pediatric seizure disorders: Dravet and Lennox-Gastaut Syndromes⁵¹. Epidiolex is hemp-derived and may contain up to 0.1% THC. Because it has a recognized therapeutic use, the pharmaceutical industry believes CBD should be classified as a prescription medication only. However, CBD does not meet criteria to be considered as a strictly pharmaceutical entity. WHO stated that “no public health problems have been associated with CBD use⁵².” The FDA stated that “there is little indication that CBD has abuse potential or presents a significant risk to public health,” and that there is “no evidence that CBD causes physical or psychic dependence⁵².” CBD’s status as a recognized therapeutic agent also means it cannot be classified as a dietary supplement⁵³. CBD also cannot be classified as an essential oil because the FDA defines an essential oil as a natural oil obtained by distillation and having the characteristic fragrance of the extraction source⁵². CBD must first be extracted with a hydrocarbon such as butane before it can be distilled. Beyond providing a definition, essential oils and dietary supplements are not FDA regulated. At best, we can currently say that CBD is a plant extract that is incorrectly used and marketed as a dietary supplement.

Due to lack of regulatory oversight, the contents of a CBD product cannot be easily verified. This means labelling of product source and potency are not reliable. Industry-originated studies have found that users are confused about the source of their CBD, concentration, and other contaminating ingredients^{46,54–57}. Bonn-Miller et al. purchased 84 products from a variety of online sources in order to test these products using high-performance liquid chromatography to evaluate the accuracy of the product labels, to include present but unlabeled cannabinoids⁵⁸. They found a wide range of CBD dosages available on the market, consistent with the lack of an accepted therapeutic dose. When testing, an “accurate” label was defined as testing 90-110% of

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the labeled value. 26.19% of products were over-labeled (contained less CBD than advertised), 42.85% were under-labeled, and 30.95% were accurately labeled. Vaporization liquid was most commonly mislabeled, and oils were labeled most accurately. CBD concentration ranged from 0.10-655.27mg/mL with a mean of 9.45mg/mL. The median labeled concentration was 15.00mg/mL. In addition, unlabeled THC was detected in 18/84 products at a highest concentration of 6.43mg/mL. Under-labeling is less-concerning because CBD does not appear to cause abuse liability or serious adverse side effects at high doses^{59,60}, but the unlabeled THC content may be enough to influence urine drug screen results, especially in children⁶¹. This is also a concern for elite athletes because THC remains a prohibited substance per WADA.

Contamination in CBD products is not isolated to unlabeled cannabinoids. The CBD solvent extraction process is also unregulated, opening the door for harmful solvent contamination. In order to be maximally bioavailable, CBD is dissolved into a lipid-rich edible carrier oil (sunflower, hemp, olive, or vitamin E oil) that is then used in this oil form or added to more extensive preparations for use. Solvents can range from innocuous organic solvents like ethanol and isopropyl alcohol, to harmful solvents like butane and carbon dioxide. The extract is then winterized: the extract is frozen, and the contaminants such as waxes and triglycerides that have a higher melting point are removed via evaporation or centrifugation. Terpenes, the volatile compound that gives Cannabis products their characteristic smell, are removed by heating the extract. Solvents used in each step influence the color, taste, smell, and viscosity of the final product. Terpenes may be captured in the evaporate and reintroduced to the final product to fine tune taste and smell^{62,63}. Other unlabeled contaminants found in CBD products include chemicals added to increase yield, weight, and potency, pesticides, metal particles, synthetic cannabinoids, heavy metals, molds, and bacteria^{63,64}. If any of these contaminants are present in

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the hemp or cannabis plants used to make these products, it is likely that they end up in concentrated form in the final extract. Hazekamp explains it best:

Because different countries allow different activities with regard to cultivation, processing, extraction etc. of hemp, entrepreneurs have set up production pipelines that span multiple countries, where hemp is cultivated in one country, while extraction takes place in another, lab testing in a third, and sales takes place in yet another country. This obviously makes it hard to determine where a CBD product comes from, who is responsible for its final quality, and what standard to follow. Thorough analytical testing of final products by certified third-party labs is an essential tool to guarantee the safety and composition of CBD oils⁶³.

Until oversight can be provided for production and label accuracy, we cannot recommend the use of CBD to elite athletes.

CONCLUSION

Despite growing interest in the general population, only 35% of elite athletes report having ever used CBD. Of that number, 43% had used CBD within the last two weeks. An elite athlete was more likely to have ever tried CBD if they used other supplements and if CBD was legal in their country of residence.. Though the general population claims that CBD can treat everything from acne to cancer, elite athletes report using CBD to treat and manage muscle recovery, pain, anxiety, and sleep cycle. Most athletes either are unsure if CBD provides an athletic advantage (44%), or thought CBD probably does not (23%), or definitely does not (10%) confer an athletic advantage (Figure 3) . Those who reported never using CBD listed rules and regulations of their sport (39.34%) and regulatory concerns (26.23%) as the most frequent reasons for not using CBD (Figure 5).

Due to lack of regulatory oversight of production and labeling accuracy, recommending use of CBD to elite athletes is premature. Though pre-clinical studies have shown that CBD has a benign safety profile, to include at high doses, more research needs to be conducted regarding the effects of CBD and its potential contaminants on athletic performance. Because athletes who use CBD are more likely to use other supplements, more research should be conducted to investigate drug-drug interactions of CBD, dietary supplements, and over the counter medications used for analgesia and sleep disturbances. Even though 89% of athletes report that they have not replaced other medications or supplements with CBD, research elucidating the efficaciousness of CBD compared to currently accepted treatments is needed to strengthen the overall body of knowledge surrounding this topic. Finally, due to vast legislative discrepancies worldwide, the removal of CBD from the WADA Prohibited List should remain a topic of continuing reevaluation based on the rapidly changing political climate surrounding cannabis and CBD product regulation. Athletes who choose to use CBD should remain diligent in their personal investigations of the sourcing and validity of their products to avoid regulatory complications with their sporting regulations.

LIMITATIONS OF STUDY

This study was developed and distributed during the height of the COVID19 pandemic. While we cannot directly attribute our low survey response rate to the onset of the global pandemic, we cannot help but speculate that it was contributory to participant willingness. A natural and unavoidable limitation to gathering data via survey is that all data is subjective. In addition, survey distribution promotes a self-selection participation bias.

DISCLOSURE STATEMENT

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