Patterns and Perceptions of Cannabis Use with Physical Activity

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ABSTRACT

Past research has shown that cannabis use is common among adults in the U.S. Similarly, physical activity (PA), such as exercise, is often a component of many American's daily routines. Anecdotal information suggests that a subset of individuals use cannabis in conjunction with PA, but evidence is lacking. The purpose of this study was to assess the frequency, methods of ingestion, strain types, and timing (before, during or after) of cannabis use in combination with PA. We also sought to better understand the types of PA that cannabis is being used with and reasons why individuals may use cannabis with PA. A brief survey was developed and administered online to participants (N = 105) who reported use of cannabis with PA. Analysis of survey responses revealed that participants were using cannabis in combination with a wide range of physical activities. While use of cannabis was reported within 1-hour before, during, and within 1-hour after PA, the majority of participants (92%) reported using cannabis prior to PA. Over three-fourths of all participants reported feeling that the use of cannabis with their PA had a positive effect on their performance. The majority of participants (60%) reported using multiple strains (i.e. Indica, Sativa, or hybrid) before, during, or after their PA. Although participants reported a range of reasons for using cannabis before, during, or after PA, pain management was the only reason reported across all time periods. Findings from this study suggest that there is a population of physically active individuals using cannabis with PA, many who believe that cannabis use has a positive effect on their performance. Future research should explore these perceptions of cannabis use and performance to provide scientific data to support or refute these anecdotal claims.

Key words: marijuana, exercise, fitness, supplement, timing

Cannabis products, also commonly referred to as marijuana, are derived from the flower, stems and leaves of the hemp plant. The legal status of recreational products derived from cannabis in the U.S. varies by state. Legalization of cannabis for recreational purposes began in 2012, and today, eleven states allow recreational consumption. In direct contrast, cannabis is still federally classified as a Schedule I drug. With nearly 9% of the population reporting use of cannabis products in 2016, cannabis remains the most commonly used federally illegal drug in the U.S. (Substance Abuse and Mental Health Services Administration, 2017).

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Phytocannabinoids, the active components in cannabis, mimic the effects of the endogenous cannabinoids in the body (McCoy, 2016). Delta-9-tetrahydrocannabinol (THC) and cannabidiol (CBD) are the two most abundant phytocannabinoids present in cannabis products and have received the most attention from the scientific community. However, THC and CBD are just two of more than 100 known phytocannabinoids (Radwan et al., 2009) and the effects of these compounds have yet to be fully elucidated. Products of the cannabis plant can further be described by their cultivar, or strain, and are often separated into two general categories: *Cannabis Indica* (Indica) and *Cannabis Sativa* (Sativa) (Leghissa, Hildenbrand, & Schug, 2017), with varying hybrids of the two strains. Among medical cannabis users, common reasons for the use of Indica include pain management and as an aid in sedation and sleep, while Sativa users often prefer this strain for its perceived induction of euphoria and energy enhancement (Pearce, Mitsouras, & Irizarry, 2014). While the psychoactive and medicinal properties of cannabis have been explored for centuries, there is now both pressing interest and need for research related to cannabis use with physical activity (PA).

The proportion of U.S. adults over the age of 18 that met the federal guidelines for aerobic activity and muscular strengthening has increased from 14.3% in 1998 to 21.6% in 2015 (National Center for Health Statistics, 2017). Over half (51.7%) of U.S. adults over the age of 18 years self-reported meeting the federal PA guidelines of at least 150-minutes of moderate or 75-minutes of vigorous activity per week (National Center for Health Statistics, 2017). With the current gap in knowledge in cannabis use with PA, researchers must rely on studies performed decades ago to receive any insight as to how cannabis use might affect PA. It was previously observed that moderate (greater than 5 uses per month but less than daily use over the past year) and heavy users (daily use for at least the past year) of cannabis were less active the day after heavy cannabis use (Babor, Mendelson, & Kuehnle, 1976). Researchers speculated these findings may have been associated with social reasons rather than the pharmacological effects of cannabis (Babor et al., 1976).

The limited availability of research pertaining to cannabis use and PA within the general population has also forced researchers to rely instead on data collected from elite athletes. Among male and female Division 1 National Collegiate Athletic Association (NCAA) athletes surveyed about their personal use of cannabis, 36.8% reported use within the past year (LaBrie, Grossbard, & Hummer, 2009). Thirty-eight percent of the athletes reporting cannabis use within the past year reported using on average once per month, with male athletes more likely to report use compared to their female counterparts (LaBrie et al., 2009). A more recent study found that athletes are more likely to use cannabis if they are male, Caucasian, or using performance enhancing drugs (Brisola-Santos et al., 2016). While these studies do provide novel insight into describing cannabis use among athletic populations, more research is needed to truly assess whether similar trends exist among the average physically active individual and provide insight as to why and how these individuals are using cannabis with PA.

New evidence suggests that the euphoric effects experienced during exercise, also termed as "runner's high," may be the result of the actions of endogenous cannabinoid release during exercise rather than endorphins (Gillman, Hutchison, & Bryan, 2015). The G-protein coupled cannabinoid 1 receptors (CB1) in the brain have been observed to be closely linked to opioid receptors, and the dopaminergic reward pathways suggesting endogenous cannabinoid release with PA could be a major reason why regular exercise is perceived as highly rewarding (Ashton & Moore, 2011; Garland et al., 2011). It is possible that using cannabis products high in CB1 agonists, such as THC (Matsuda, Lolait, Brownstein, Young, & Bonner, 1990), could increase associated pleasure/reward already observed with regular exercise and increase motivation to partake in PA. Conversely, delayed-onset muscle soreness (DOMS) is often associated with muscle damage resulting from acute inflammation from strenuous exercise (Lewis, Ruby, & Bush-Joseph, 2012). Pain associated with DOMS may even result in exercise avoidance (George, Dover, & Fillingim, 2007). Recent evidence suggests that cannabinoids like THC and CBD are associated with pain reduction (Wilsey et al., 2013) and may have anti-

inflammatory effects through their repressive effects on immune tissue (Kozela et al., 2010). As a result, the use of cannabis may be a tempting option to reduce exercise-induced pain and inflammation. Yet, there is little evidence in human populations on how cannabis use combined with PA affects motivation to partake in exercise as well as how cannabis use affects recovery from exercise.

With the growing availability of recreational cannabis products and the need for foundational research in the area of cannabis use with PA, the primary goal of this exploratory study is to describe cannabis use as it relates to PA among the general population. More specifically, this study examines the frequency, method and timing (before, during or after) of cannabis use in combination with PA. Secondary goals include characterizing cannabis use as it relates to modes of PA and strain use and the examination of characteristics (e.g., age, gender) associated with participants' cannabis use in conjunction with PA. Finally, we aim to better understand reasons that participants use cannabis with PA.

METHOD

Participants and Procedures

During the fall of 2017, 140 adults between the ages of 18 to 66 years across the U.S. were surveyed about their cannabis use habits in combination with their PA. Recruitment of participants was conducted online through social media (e.g., Facebook and Snapchat). Facebook page administrators of cannabis focused/educational pages were contacted and asked to post a brief standardized description of the survey along with a link to the survey on their feed. Participants were also asked to share the link on their feed as well after completion of the survey. Snapchat was used by having administrators of local universities post a link to the survey on their story. All advertising routes contained a link which took participants to a Qualtrics survey titled Cannabis Use and PA Questionnaire (CUPAQ), which they completed online. Recruitment materials specifically sought participants who use cannabis and cannabis products in relation to their exercise and PA habits. Participation was anonymous and took approximately 10 minutes. No external incentive was given for survey completion. This study was approved by the Institutional Review Board at the University of Northern Colorado.

Survey Design and Administration

Initial contact in Qualtrics provided participants with a brief overview of the purpose of the study, emphasized that participation would remain anonymous, and noted the time required for participation (10 minutes). Participants were asked to complete informed consent, confirm their age (18 or older) and confirm U.S. residency prior to beginning the survey. The survey consisted of 39 questions which were divided into three main sections. Section 1 consisted of 9 questions designed to gather general participant cannabis use habits (i.e., frequency and duration of use), age, gender, minutes of PA completed each week, and U.S. state of current residence. Quantification of PA was conducted through participant self-report in response to being prompted: "How many minutes per week are you involved in structured physical activities (going to the gym, swimming running, biking, hiking etc.)?" To limit the length of the survey and focus the majority of the questions around participant use of cannabis with PA, no further questions were asked describing the method, duration, or frequency of participant PA throughout an average week. Section 2 of the survey included 18 questions focused on participants' cannabis use habits as it pertained to their use before, during and after PA. Use of cannabis before PA was defined as: within 1-hour of starting PA, and use after PA was defined as within 1-hour of cessation of PA. The frequency of cannabis use associated with PA over the last year and most recent episode of use were also assessed. Skip logic was programmed into Qualtrics so that participants who did not report cannabis use at one or more of the PA time points (before, during, or after) did not receive those questions. When cannabis was used before, during, and/or after PA, participants were asked to select the most common method of ingestion (e.g., smoking using a joint, inhaling via a vaporizer) and the strain (i.e., Indica, Sativa, or Indica/Sativa hybrid) if known. Participants then indicated the specific activities (e.g., weight lifting, kayaking) where cannabis was used before, during, and after PA. Lastly, three separate open-ended questions assessed reasons

for using cannabis before, during, or after PA. Skip logic built into the survey only allowed participants to provide a response to these questions if they had reported using cannabis before, during or after PA previously in the survey. Section 3 of the survey consisted of 12 questions aimed at describing the amount and percentage of THC and CBD consumed. Using skip logic, questions were further divided into three categories based on participant self-reported primary form of cannabis use, including flower or bud, concentrates (i.e., oils, wax, shatter, dabs), and edibles. In assessing the quantity of the flower or bud, a visual aid and terminology were adapted from the Daily Sessions, Frequency, Age of Onset, and Quantity of Cannabis Use Inventory (DFAQ-CU) (Cuttler & Spradlin, 2017).

Statistical Analysis

A total of 140 survey responses were obtained at the conclusion of the study. Three participants failed to agree to the informed consent, and 32 participants reported never using cannabis products with their PA. These 35 participants were removed from the dataset. The remaining N=105 participants responses were used for data analyses. All analyses were conducted using SPSS version 24 (IBM Corp.; Armonk, NY) and data are reported as frequency, percent or mean ± standard deviation. We present descriptive statistics to summarize the background characteristics of the sample and to examine participant use of cannabis before, during or after PA. To assess whether a range of demographic characteristics (e.g., age, gender) were associated with participant cannabis use during PA, we used a series of chi square, ANOVA, and *t*-test analyses with alpha set at $p \leq 0.05$. Lastly, open-ended questions related to the reasons for using cannabis before, during, or after PA were examined through a content-analysis (Marks & Yardley, 2004) which allowed for the categorization of responses from each question into six or seven different themes. Responses for each of the three questions were coded independently by two coders into each of the theme categories. Agreement on these classifications was reached prior to listing a response under a specific theme category (prior to agreement, interrater reliability [*k*] = .80 – 1.00). The frequency of responses was calculated and reported for each theme. Each response could be coded for multiple themes if necessary.

RESULTS

Background Characteristics and Cannabis Use

Participants (53% male) ranged from 18-66 years of age ($M = 31.4 \pm 11.2$ years) and were from 21 states across the U.S. In total $n = 70$ participants were from states where recreational use of cannabis is legalized. Participants reported an average of 74.5 ± 111.5 months (6.2 ± 9.3 years) in duration of regular cannabis use. Ongoing cannabis use frequency revealed that 1.9% used less than once per month, 6.7% reported using between 1-3 times per month, 22.9% reported using between 1-6 times per week, and 68.6% reported using cannabis products daily.

Physical Activity and Cannabis Use

Survey participants reported engaging in an average of 399.87 ± 543.82 minutes of PA throughout a typical week (57.12 ± 77.69 minutes of PA per day) with a range of 25-3600 weekly minutes. The average age of participants when they first reported using cannabis with PA was 23 ± 8 years. 63.8% of the participants reported that their last use of cannabis with PA was within the past week. Breakdown of average participant frequency of cannabis use in combination with PA was self-reported as: 9.5% of participants using cannabis in combination with PA less than once a month, 12.4% between 1-3 times per month, 41.0% 1-6 times per week, and 37.2% reported using cannabis at least once per day in combination with their PA. Overall, 78.2% of all participants were using cannabis at least once per week on average with PA.

Participants also reported the method and quantity of cannabis used most frequently with PA. Methods/forms of cannabis consumption were grouped into four general categories: inhalation of flower/bud, edible, concentrate (dabbing), and other. The majority ($n = 84$; 80.0%) of participants reported that their primary method of cannabis use with PA was by inhalation of flower/bud. Primary methods of inhalation of those participants that reported the use of flower/bud as their main method of cannabis use are as follows:

hand pipe (n = 23; 27.4%), vaporizer (n = 22; 26.2%), bong (n = 18; 21.4%), joint (n = 11; 13.1%) and blunt (n = 6; 7.1%). Only n = 12 (11.4%) of participants reported primarily using concentrates with PA, n = 6 (5.7%) used edibles, and n = 3 (2.9%) used "other," which included topical/salves, capsules, and fresh, non-decarboxylated).

Timing of Cannabis Use with PA

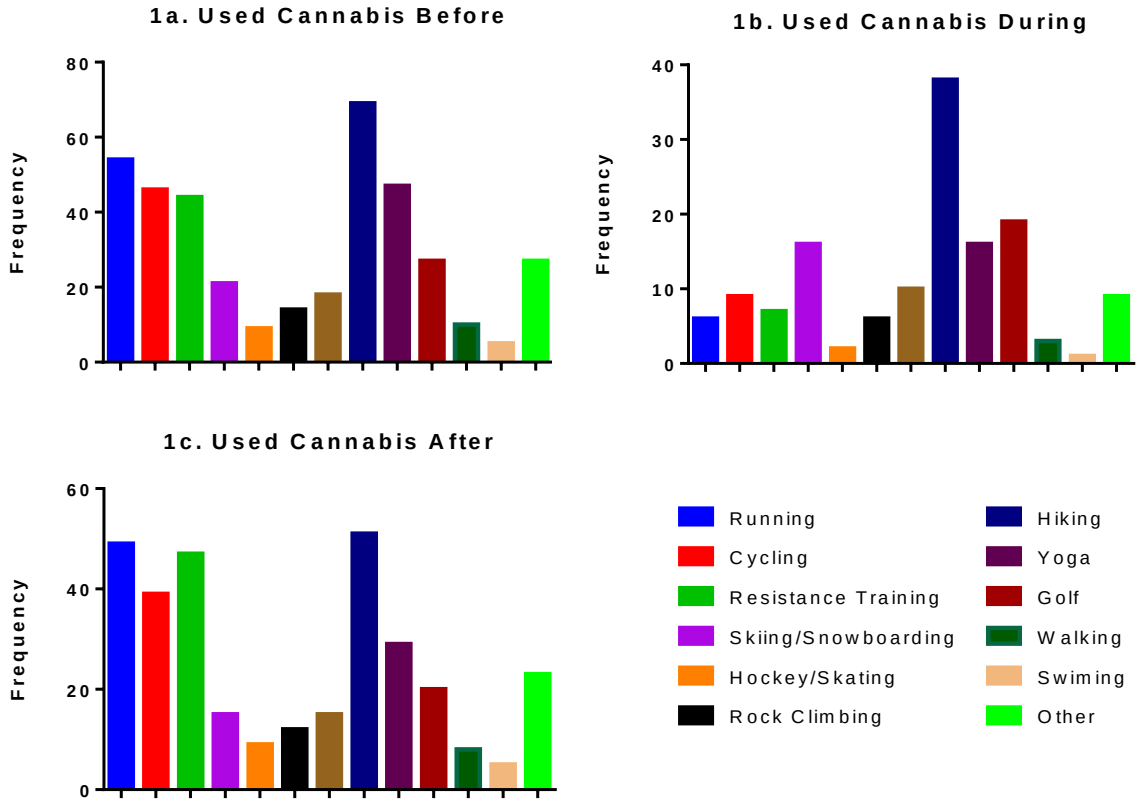
When asked when they had used cannabis in conjunction with PA, 92% (n = 97) of all participants reported having used cannabis before beginning PA, 21% (n = 22) reported having used cannabis during their PA, and 73% (n = 77) reported having used cannabis after PA. When all participants were polled on when they used cannabis with PA most often, 53.3% (n = 56) reported using most often before PA, 4.8% (n = 5) reported using most often during PA, and 41.9% (n = 44) reported using most frequently after their PA. When asked when participants had used cannabis with PA, a total of 23.8% of participants reported using cannabis only before PA, while 48.6% reported using before and after PA, followed by 18.1% reporting using before, during, and after. 6.7% of participants reported using cannabis only after PA, 1.9% using before and during and 1.0% reported using only during. Participants were asked to indicate their primary method of use when they use cannabis before, during or after their PA (Table 1a). Over three-fourths of participants who used cannabis either before, during, or after PA reported their primary method of use was through inhalation. Chi-square analysis showed there was no association between the method of use (Inhalation, Edible, Concentrate, Other) and timing of use before, during or after PA, $\chi^2(6, N = 248) = 7.82$, $p = 0.25$.

Table 1. *Primary Method of Cannabis Consumption & Strain of Cannabis Used Before, During or After Physical Activity*

Table 1a. Category	Method	Frequency Before n (% of total)	Frequency During n (% of total)	Frequency After n (% of total)
Inhalation (flower/bud)	Joint	12 (11.7%)	15 (29.4%)	13 (13.8%)
	Blunt	7 (6.8%)	4 (7.8%)	7 (7.4%)
	Hand pipe	25 (24.3%)	11 (21.6%)	20 (21.3%)
	Bong	21 (20.4%)	1 (2.0%)	17 (18.1%)
	Vaporizer	20 (19.4%)	12 (23.5%)	14 (14.9%)
Edible	Edible	5 (4.9%)	3 (5.9%)	2 (2.1%)
Concentrate	Dabbing	11 (10.7%)	4 (7.8%)	14 (14.9%)
Other	Other*	2 (1.9%)	1 (2.0%)	7 (7.4%)
	Total	103	51	94
Table 1b. Strain		Frequency Before n (% of total)	Frequency During n (% of total)	Frequency After n (% of total)
Indica Only		8 (7.8%)	3 (4.9%)	26 (27.1%)
Sativa Only		34 (33.3%)	15 (24.6%)	7 (7.3%)
Hybrid Only		16 (16.7%)	20 (32.8%)	19 (19.8%)
Didn't Know		6 (5.9%)	6 (9.8%)	6 (6.3%)
Multiple Strains		38 (37.3%)	17 (27.9%)	38 (39.6%)
Total		102	61	96

Note. Frequencies are reported in combination with the percentage of the total number of valid responses (Total (n)). Table 1a: Participants were only allowed to indicate a single method of use that they personally used most often when using cannabis before, during or after PA. *Other forms of use included but were not limited to: topical/salves, capsules, and fresh non-decarboxylated. Table 1b: Participants reported the strain(s) that they had used before, during and after PA. Participants could select as many strain options as applied to them at each time point.

Figure 1. *Frequency of Cannabis Use Before (1a), During (1b), and After (1c) a Variety of Physical Activities*



Participants that reported using flower/bud as their primary method of use ($n = 84$) reported the average amount of flower/bud they personally used in grams using the visual aid from the DFAQ-CU. The average amount of flower/bud used before, during, or after PA were: 0.44 ± 0.45 grams, 0.54 ± 0.49 grams, 0.78 ± 0.86 grams, respectively. There was a statistically significant difference between the amount of flower/bud consumed before, during, and after PA determined by one-way ANOVA, F (2, 221) = 6.274, $p = .002$. Tukey post hoc testing revealed that there was no significant difference in self-reported flower/bud used before and during or during and after PA ($p > 0.05$). However, a significant difference was observed between the amount of flower/bud consumed before and after PA ($p < 0.05$). The frequency of reported strain of use (i.e. only Indica, only Sativa, only hybrid, didn't know or multiple strains) before, during, or after PA are presented in Table 1b. Of the 105 participants, 63 (60%) reported using multiple strains at multiple time points in relation to their PA.

Perception of Cannabis Use on Performance

When participants were asked to report whether cannabis use with PA had a positive, negative, or no effect on their performance, 81 (77%) respondents reported they felt using cannabis in combination with their PA had a positive effect on their performance. Fewer participants ($n = 21$; 20%) reported feeling that the use of cannabis had no effect on their performance, and only 3 participants (3%) reported feeling as though use of cannabis with the PA had a negative impact on their performance.

Table 2. *Categorized Reasons of Cannabis Use Before, During or After PA*

Reasons for Using Cannabis Before PA	Frequency *n* (%)
Pain management/relief	25 (17.1%)
Improve focus, get in the flow, or "get in the zone"	25 (17.1%)
Calm mind and body; relaxation	25 (17.1%)
Improve enjoyment of activity	19 (13.0%)
Improve motivation and state of mind	18 (12.3%)
Other	18 (12.3%)
Enhance performance, decrease fatigue, or to push harder	16 (10.9%)
Reasons for Using Cannabis During PA	**Frequency *n* (%)**
Increase/restore energy, push harder, or to use during a break	12 (21.4%)
Improve enjoyment of activity	11 (19.6%)
Pain management/relief	11 (19.6%)
Other	11 (19.6%)
Improve focus, get back in or stay in the zone	7 (12.5%)
Maintain the high	4 (7.1%)
Reasons for Using Cannabis After PA	**Frequency *n* (%)**
Relaxation	52 (44.4%)
Pain management/relief	25 (21.4%)
Other	18 (15.4%)
Aid in recovery	9 (7.7%)
Stimulate/increase appetite	7 (6.0%)
Aid in sleep	6 (5.1%)

Reported Physical Activities with Cannabis Use

Participants described using cannabis in association with both indoor and outdoor activities, as well as team and individual PA. Participants reported using cannabis before (Figure 1a), during (Figure 1b) and after (Figure 1c) a variety of PA. When participants used cannabis before PA, hiking (n = 69), running (n = 54), yoga (n = 47), cycling (n = 46), and resistance training (n = 44) were the most commonly reported. The most frequent activities reported where cannabis was used during PA were: hiking (n = 38), golf (n = 19), yoga (n = 16) and skiing/snowboarding (n = 16). The most popular activities that participants reported using cannabis after completion of the activity were: hiking (n = 51), running (n = 49), resistance training (n = 47) and cycling (n = 39).

Participant Reasons for using Cannabis with PA

Three separate open-ended questions were presented to participants asking them to describe their reasons for having used cannabis before, during, or after PA. Coded responses can be found in Table 2. Only participants who reported cannabis use during one or more of these times were provided with the respective open-ended questions. The three most common reasons for using cannabis before PA were: pain relief, to improve focus or get in the zone and to calm the mind and/or body or to relax. The most popular reasons for using cannabis during PA was to increase/restore energy, push harder, or use as a break. Participants also described using cannabis during PA to improve their enjoyment of an activity and for pain management/relief. The most frequent theme across participant responses for using cannabis following PA was for relaxation and to decrease pain or soreness, with minor reasons including appetite stimulation, and aid in sleep and recovery (Table 2). The only category that was present as a reason for cannabis use in all three times (before, during and after PA) was pain relief/management.

Demographic Characteristics Associated with Cannabis Use and Performance

To assess whether participant age influenced method of use, perception of use with PA, and

other factors, participants were separated in to two groups: young and older. Participants that were classified as young (≤ 27 years of age; $n = 53$) would have been under the age of 21 when cannabis was first recreationally legalized at the state level, while participants classified as older (≥ 28 years of age; $n = 52$) would have been over the age of 21 at that time. Chi-square analysis revealed a significant difference between younger and older cannabis users with respect to their primary method of cannabis use with PA $\chi^2(2, N = 102) = 7.86$, $p = 0.02$. Older users favored more traditional methods of consumption via inhalation (i.e. joint, bong, pipe, vaporizer, and blunt), while younger users were more likely to use concentrates (dabbing). Younger users started using cannabis with PA at an earlier age (19.3 ± 2.9 years) when compared to older users (26.5 ± 10.5 years; $p = 0.02$). With respect to perceptions of cannabis use on performance, older users were more likely to report feeling that cannabis use had a positive effect on their PA performance. In contrast, younger users were more likely to report feeling that cannabis use had no effect on performance $\chi^2(2, N = 105) = 7.09$, $p = 0.03$. There were no significant differences between younger and older users with respect to the timing of cannabis use with PA (before, during, after; $p = 0.44$) or the frequency of cannabis use with PA ($p = 0.74$).

Participant state of residence was used to classify participants into two separate groups: one group included states in which cannabis was legal for recreational consumption (LG; $n = 70$), and another group included participants from states that recreational use of cannabis was not legal (NL; $n = 35$). Chi-square analysis did not reveal any significant disparities between LG and NL groups pertaining to frequency of cannabis use, frequency of cannabis use with PA, or the primary method of use before, during or after PA. There was no significant difference ($p = 0.06$) in the average age of LG (31.59 ± 12.21 years) or NL (31.17 ± 9.09 years) groups. No significant differences in average age at first use of cannabis ($p = 0.07$; LG = 21.59 ± 7.89 years, NL = 25.09 ± 9.01 years) or average age of first use of cannabis with PA ($p = 0.13$; LG = 23.23 ± 8.08 years, NL = 25.88 ± 8.68 years) were found between the two groups. The LG group had significantly higher ($p = 0.002$) self-reported minutes of PA (466.7 ± 646.7 minutes or 7.8 ± 10.8 hours) per week compared to the NL group (266.2 ± 168.0 minutes or 4.4 ± 2.8 hours) per week. There was also a significant difference ($p = 0.013$) in the duration of regular cannabis use between groups (LG = 83.9 ± 131.3 months or 7.0 ± 10.9 years; NL = 56.1 ± 53.0 months or 4.7 ± 4.4 years). In LG and NL participants that reported flower or bud as their primary method of use (Table 3), 2-way ANOVA with Tukey's multiple comparisons determined that both LG and NL groups consumed significantly more flower/bud after PA compared to before PA, $F(2, 217) = 4.628$, $p = 0.01$. There was no difference in the amount consumed before, during or after PA between LG and NL groups $F(1, 217) = 1.641$, $p = 0.20$.

Table 3. *Reported Typical Amount of Cannabis Flower/Bud Use Before, During or After PA by participants in Recreationally Legal and Non-Legal States*

Group	Amount Used Before Grams ± *SD* (*n*)	Amount Used During Grams ± *SD* (*n*)	Amount Used After Grams ± *SD* (*n*)
Legal	.496 ± .509 (60) *	.578 ± .518 (34)	.797 ± .908 (58) *
Non-Legal	.319 ± .264 (29) +	.442 ± .401 (13)	.732 ± .751 (29) +

Note. Participants were asked to report the typical amount of flower/bud they personally used before, during or after PA using the DFAQ-CU visual aid. *Significant difference between the amount of flower/bud consumed by participants from legal states before and after PA. +Significant difference in the amount of flower/bud used before and after PA of participants from non-legal states.

DISCUSSION

This study provides novel insight into how and why individuals are using cannabis before, during and after PA. While participants responded to using cannabis before, during, and after PA, cannabis use was most often reported before or after PA. Most participants reported that when being physically active they were using cannabis with their PA at least once per week, and largely under the impression that the use of cannabis with their PA had a positive effect on their performance. This could be attributed to the fact that at all three-time points (before, during and after) some participants were reporting the use of cannabis to mediate pain. It is possible that suppression of pain could lead to increased enjoyment of the activity, which was also commonly reported by participants as a reason for using cannabis prior to PA.

Studies assessing cannabis use among elite athletes have found that individuals who were Caucasian, male, or played hockey were the most likely to use cannabis products (Brisola-Santos et al., 2016; LaBrie et al., 2009). In an effort to address the gap in knowledge on recreational use of cannabis with PA in the general population, the present study provides new insight into this topic area. Cannabis use with PA was reported equally among males and females and across a wide range of activities in recreationally physically active individuals. Surprisingly, hiking was the most frequently reported activity where cannabis was used before, during, and after PA. This finding may be attributed to 59 of the participants residing in the state of Colorado at the time of the survey, thus having easier access to both recreational legal cannabis and hiking trails. In addition, the predominance of reported cannabis use with hiking and other outdoor activities (i.e. running, cycling, golf, etc.) could be attributed to the fact that the predominant method of cannabis use with PA was through inhalation of flower/bud. As inhalation is stereotypically done outdoors, the researchers speculate that this could be a reason as to why cannabis was used with so many outdoor activities. These findings should be explored further by future research to fully elucidate as to whether there is a relationship between method of use and type of PA.

Further observation suggests that the timing of cannabis use could also be dependent on the specific type of PA. For example: running, cycling, and resistance training were the 3rd, 4th, and 5th most frequently reported with cannabis use prior to activity, and were the 2nd, 3rd, and 4th most frequently reported activities to use cannabis with after. However, reported prevalence of cannabis use while running, cycling, and resistance training dropped to 6th, 7th and 8th most frequently reported respectively. This could in part be attributed to the inconvenience of having to stop mid run, ride or excuse yourself from the gym to use cannabis. The most popular reported activities to use cannabis during PA were: hiking, golf, skiing/snowboarding, and yoga. These activities are more intermittent rather than continuous and may provide logical breaks in activity to partake in using cannabis.

Data from the present study suggests that the majority of participants felt that the use of cannabis products with their PA had a positive effect on their performance. However, this insight may not be truly representative of physically active individuals' perspective of cannabis use on performance as many participants were recruited through social media pages that presented a positive perspective on cannabis. These numbers may be different if the survey was also distributed on non-pro-cannabis web pages. The perception of improved performance with cannabis use may be purely subjective. The most recent studies which examined this question were conducted 40 years ago and demonstrated that acute use of cannabis containing THC increased resting heart rate (Avakian, Horvath, Michael, & Jacobs, 1979; Steadward & Singh, 1975), systolic and diastolic blood pressure (Steadward & Singh, 1975) as well as reduced time to exhaustion during a cycling bout (Renaud & Cormier, 1986). Yet, no acute effects of THC administration were reported with respect to oxygen uptake or ventilation during submaximal exercise (Avakian et al., 1979). Unfortunately, the concentration of THC in the cannabis used in these studies is no longer reflective of current cannabis products available on the market today, as THC content in cannabis has been steadily increasing over the past several decades (Mehmedic et al., 2010).

While evidence is lacking related to assessing the effects of acute consumption of cannabis on exercise performance, a recent study explored the effects of chronic cannabis use on exercise performance. In this study, participants were

assessed for pulmonary, cardiovascular, anaerobic and strength while at least 12-hours removed from last use of cannabis. When compared to a non-cannabis using control group this cross-sectional study determined that there were no differences with respect to pulmonary, cardiovascular, anaerobic, or strength performance (Lisano et al., 2017). Findings from the present study revealed that a large portion of participants believed that cannabis use had a positive effect on their performance. Further research is needed within this area to truly discern whether the acute use of cannabis has the ability to affect PA performance.

Previous research has shown that adults aged 18-25 have the highest reported percentage of cannabis use, with 20.8% reporting use at least once within the past month Substance Abuse and Mental Health Services Administration, 2017). While the current study did not assess cannabis use rates among age groups of physically active adults, an age-based analysis was done to assess if individuals 18-27 years of age had different perceptions and methods of use compared to adults over 28 years of age. Chi-square analysis revealed that adults ages 18-27 were significantly more likely to report using concentrates as their primary form of cannabis and began using cannabis with PA at a significantly younger age (i.e., 7 years earlier). However, adults over the age of 28 were significantly more likely to report feeling that cannabis use had a positive effect on their performance compared to adults aged 18-27. Emerging research shows that use of concentrates via dabbing may be associated with greater negative consequences, tolerance, and withdrawal compared to flower use (Loflin & Earleywine, 2014). We did not assess negative consequences related to participants' cannabis use, but future research should explore whether those using cannabis with their PA are more likely to have problems related to their use and if they are more likely to use cannabis with PA for specific reasons (e.g., pain management).

Results from this study revealed that 92% of survey participants reported cannabis use before PA, suggesting that more research to ascertain the effects of acute cannabis use on PA performance may be necessary. Conversely, the perceived performance enhancing effect of cannabis on PA performance could be related to the reduced perception of pain. When asked an open-ended question as to why participants used cannabis before, during, and after PA, pain management/relief was the only reason to be reported across all time points. Pain management was the most common reason for cannabis use before PA, and the second most common reason for use during and after PA. This pain control theme is supported by a recent study which found that pain was the most commonly reported reason for seeking use among medicinal cannabis users (Bonn-Miller, Boden, Bucossi, & Babson, 2014; Walsh et al., 2013) with those seeking pain relief preferring Indica (Cohen, Heinz, Ilgen, & Bonn-Miller, 2016; Pearce et al., 2014). Products derived from Indica are typically lower in THC and contain higher quantities of CBD, reducing the perceived psychoactive effects while still maintaining high pain suppressive effects. Mechanistically cannabinoids modify synaptic transduction in the central nervous system and the periphery. THC and CBD are agonists of the two primary cannabinoid receptors, CB1 and CB2 (McCoy, 2016), with CB1 being highly expressed in the central nervous system (Wachtel, ElSohly, Ross, Ambre, & de Wit, 2002) and CB2 more abundant in the periphery (Galiègue et al., 1995). These cannabinoids act on CB1 and CB2 receptors expressed on the pre-and post-synaptic membrane blocking calcium influx, and blocking synaptic vesicle release (Zou & Kumar, 2018). Activation of these receptors blocks synaptic signal transduction and has even been implicated in long-term depotentiation (Xiong et al., 2012).

Conversely, another explanation for the use of cannabis to reduce pain associated with PA is due to the immunosuppressive effects of cannabinoids like CBD (Elliott, Singh, Nagarkatti, & Nagarkatti, 2018; Malfait et al., 2000). While THC has a slight propensity to bind the CB2 receptor, CBD is the primary CB2 agonist within cannabis (Burstein, 2015). The CB2 receptor is highly expressed throughout immune related tissues, including those that are responsible for inflammation (Galiègue et al., 1995). Tissue damage resulting from novel or intense PA has been shown to increase local inflammation at the area of injury and produce cognitive pain often referred to as DOMS (Kanda et al., 2013; Matsuda et al., 2015). It is highly plausible that, especially in participants that reported using cannabis after PA for pain management (n = 25) and recovery (n = 9), they are either consciously or incidentally

utilizing the anti-inflammatory effects of cannabis to help combat pain associated with PA. Interestingly, individuals that utilize cannabis for pain mediation have been found to be at lower risk of development of cannabis use disorders (Cohen et al., 2016).

In conjunction with pain management, the most common reasons reported for cannabis use prior to PA were related to improved focus and to calm or relax the mind and body. This was unexpected, as Sativa strains appear to be used more often prior to PA than following PA. This could be that use of Sativa strains are commonly associated with feelings of euphoria and energy enhancement (Pearce et al., 2014). After PA, using cannabis for relaxation was reported more frequently than any other response. Given the reported perceived effects of Indica related to sedation and pain management (Pearce et al., 2014), it was expected that this strain may be used predominately post-exercise. Findings from the present study indicate that this phenomenon may exist with 27.1% of participants reporting the use of only Indica after PA compared to 7.8% and 4.9% reporting use of only Indica before and during PA, respectively. While the potential disparity of initial findings suggests participants are using sativa before PA and Indica after PA were consistent with our initial hypothesis, the unexpected observation that the majority of participants were using multiple strains regardless of timing of activity may suggest that cannabis strain of use may not only be dependent on timing of activity, but the type of activity. However, there should be caution when interpreting these findings because the survey question in the present study was not designed to ascertain this specific effect.

Although this study provides new information on why and how physically active individuals are using cannabis products with their PA, there are limitations to this study. The design of the study was cross-sectional and conducted as an online survey. As a result, the conclusions of this study are only applicable to individuals who reported using cannabis with their PA. Additionally, as previously mentioned, participants recruited through social media were done so through web pages that had an overall positive view on cannabis use. This limits the results of this study to individuals that have a positive view or experience of cannabis use with PA, as individuals that had a negative experience with cannabis use and PA may have been deterred from participating in the survey. There are limitations associated with self-report data, even though online and in-person administration of surveys has been shown to yield similar results (Weigold, Weigold, & Russell, 2013). Recent findings show that users of cannabis overestimate their use of flower/bud when preparing bowls and joints and that self-report estimates can be inaccurate (Prince, Conner, & Pearson, 2018). While the current study presented participants with a visual aid to help report flower/bud use, it is possible that participants were still overestimating the amount of flower/bud used before, during, or after PA. Reported weekly minutes of PA varied dramatically, with a range of 25 to 3600 minutes of PA per week. The wide range in self-reported PA could be the result of inaccuracy associated with self-report PA (Brenner & DeLamater, 2016) or misinterpretation of the question. It is also possible that the individuals that reported extremely high rates of PA could have highly physically demanding jobs in construction, nursing, fitness, etc. In an effort to allow participants to report any type of PA, participants were not asked if they were physically active for recreational reasons, or if their PA was a part of a structured exercise regimen. Although this approach allows for more broad interpretation of PA, it should be considered a limitation and future work should further examine this question. In addition, the present study did not explore if participants experienced any negative side effects due to their cannabis use, such as those associated with Cannabis Use Disorder. Finally, not all states within the U.S. were represented or dispersed equally within this data set, this could cause regional bias to skew these results.

Future studies exploring the use of cannabis with PA may want to discern whether individuals are consuming cannabis *ad libitum* as they are coincidentally engaging in PA or are intentionally using cannabis in conjunction with structured exercise. With results from the present study revealing that most participants were using cannabis before PA, future research should seek to explore if the use of cannabis before engaging in PA has an effect on that task. This can further be further explored by assessing the specific use of products high in either THC or CBD and how these products, when isolated from each other,

affect performance, enjoyment, pain mediation and recovery. Even though chi-square analysis did not reveal any notable differences between general method of use (Inhalation, Edible, Concentrate, Other) and timing of activity (before, during, or after PA), future research should further examine the relationship between method of use and timing of PA. Further exploration of the specific effects of cannabis use based on specific activity performance, i.e. the effects of cannabis use with PA in golfers or runners, may provide valuable insight in the future.

In summary, this study provides novel insight into cannabis use among individuals that reported using cannabis in combination with their PA. Findings from this study revealed that the most common time to use cannabis in combination with PA was before PA, with the majority of individuals reporting use through traditional inhalation methods of flower/bud. Most participants reported feeling that the use of cannabis with PA had a positive effect on their PA performance. Reasons for cannabis use with PA varied depending on when cannabis was used in combination with PA, with pain management as the only reason reported frequently before, during, and after time points.

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