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Does CBD affect Delayed onset muscle soreness and performance? A systematic Review.

And

Effects of Topical CBD oil on perceived Delayed Onset Muscle Soreness of the lower limb in athletes and sleep analysis

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Abstract

Delayed onset muscle soreness (DOMS) can occur to anyone. One of the biggest factors in DOMS is muscle soreness. There is a wide range of research into the effects and treatments regarding DOMS, the aim of this literature review and partnering study is to identify how CBD oil can reduce soreness and increase the rate of recovery in athletes. If CBD can affect recovery this indicates a higher performance level on average throughout the training program.

Relevant literature was found using EBSCO search strategy including specific key wording. The literature review was reviewed and assessed using the Downs and Blacks quality assessment checklist. Study participants were recruited through a volunteer sample. Who took part in a series of training sessions with two study groups, one receiving topical CBD oil on the muscles of the lower limb using a randomised control trial study design. The intervention used was a CBD oil with 800 mg concentration per 100 ml and a massage oil used for the placebo. A Visual analog score (VAS) was used to collect a perceived level of soreness, rate of recovery and sleep quality.

Five papers were identified and were critically analysed following a systematic review. Strength and limitations were identified, and emerging themes were drawn together following a data extraction. The study explored perceived soreness and recovery by using a VAS method with a one to ten scoring based on the participant's perceived outcomes from the oil. It was found that CBD oil had positive effects on soreness M= 4.450 compared to placebo of M= 6.300, rate of recovery improved from the CBD oil M= 7.750 compared to placebo M=6.300. sleep quality also showed improvements in the CBD oil group (M= 7.400 placebo compared to the placebo group M= 6.350).

Themes were identified from the data analysis. Two studies showed improvements within DOMS or performance based outcomes from CBD whereas three studies showed no significant differences between placebo and CBD. The effectiveness of CBD was shown at the end of this study to improve soreness and sleep quality and increase the rate of recovery within the participants with statistical analysis of significant differences between study groups of CBD and placebo oils.

From the themes identified, it is clear more research is needed to identify key effects of CBD on recovery. The study suggests that CBD is effective in recovery in a sporting environment.

Does CBD affect Delayed onset muscle soreness and performance? Literature Review

Effects of Topical CBD oil on perceived Delayed Onset Muscle Soreness of the lower limb in athletes and sleep analysis

1. Introduction

Muscle damage, often referred to as delayed onset muscle soreness (DOMS), can be influenced by various factors, either accelerating or alleviating pain levels through various recovery methods (Fedewa et al., 2019). DOMS occurs particularly after engaging in new or strenuous exercise, characterised by an overload of eccentric muscle contractions, impairing day-to-day tasks and exercise efficiency within the first 24 hours (Hotfiel et al., 2018).

DOMS does not discriminate based on athletic level, presenting symptoms such as stiffness, tenderness, and inflammation (Cleary et al., 2006), hindering individuals from completing day to day activities without discomfort. This compromised physical state leads to reduced performance, impacting both daily tasks and workplace tasks, such as manual labour tasks (Smith, 1992). Athletes, likewise, may struggle to achieve optimal performance levels due to lingering pain and discomfort stemming from previous exercise-induced DOMS.
Despite its association with cannabis-derived compounds, cannabidiol (CBD) oil has gained attention for its anti-inflammatory properties.As CBD is no longer banned by the World Anti-Doping Agency, CBD is widely accessible and has demonstrated efficacy in enhancing sleep quality by reducing wake-up intervals and enhancing rapid eye movement (REM) sleep which is where dreaming mainly occurs (Babson et al., 2017). Improved sleep quality, in turn, bolsters recovery by activating protein synthesis pathways, mitigating sleep debt-induced muscle damage, and reducing injury risk by curbing degradation pathway activity (Dattilo et al. 2011).

CBD's relevance to muscle damage lies in its anti-inflammatory properties, demonstrated by studies such as (Hatchett et al. 2020), which observed reduced DOMS effects post-exercise through improvements in visual analog scores (VAS). This highlights CBD's potential in mitigating muscle damage and enhancing recovery.

2. Methods

2.1. Search strategies

A structured systematic search was completed using EBSCO host research platform in December 2023. Records were searched from July 2015. Using a Boolean search strategy, key terms (‘CBD’,’Muscle damage’, ‘performance’) and their alternatives were put into the EBSCO platform (table 1). 111 Articles were screened by title and abstract. After the screening, Full texts were then assessed against the inclusion and exclusion criteria for eligibility (table 2). The full search strategy is shown within a PRISMA (Preferred Reporting Items for Systematic Review and Meta-Analysis) flow diagram outlining the full selection process.

Table 1. Search terms

Key concept	Alternative search terms	Results
Search term 1: CBD	Cannabidiol	85,845
Search term 2: Muscle damage	And or doms or delayed onset muscle soreness or fatigue or inflammation	4,901,180
Search term 3: Performance	Performance	5,811,223
Final search term:	CBD or cannabidiol And or doms or delayed onset muscle soreness or fatigue or inflammation and performance	111

Abbreviations from the data extraction table

- CBD- cannabidiol

2.2. inclusion and exclusion criteria

When extracting the articles that are included in the review, they evaluated against the inclusion and exclusion criteria. The criteria is shown in detail in Table 2. During the screening process only pilot studies and randomised control trials (RCT) were used for this review. Articles included in this review must include post workout supplementation, clear perceived muscle soreness caused by repetitive contraction of the muscle. Studies then became excluded if studies were performed on animals, studies that were not in english, narrative reviews.

Table 2. Inclusion/ exclusion criteria

Inclusion	Exclusion
Population - Human studies, - English studies Intervention -24 hours after exercise use of CBD	Population -Animals Intervention -Studies with no muscle damage -No intervention

Outcome - studies outcome measures measuring performance after use - performance related post intervention exercise Other - RCT, pilot studies - quantitative research-based reviews	Outcome -studies using exercise that do not (something)have a significant muscle damage or perceived muscle soreness Other - systematics reviews , literature reviews, narrative reviews -papers written before 2015

Abbreviations from the data extraction table

- RCT- Randomised controlled trial
- CBD- cannabidiol

2.3. Quality Assessment and Data Collection- downs and blacks

In the evaluation of the papers included in this literature review, a quality assessment tool based on a modified Downs & Blacks checklist was employed, shown in table 3. This modified checklist consists of 27 questions, and was utilised to systematically appraise the methodological rigour of the selected RCT and pilot studies. The assessment encompassed considerations of external validity, internal validity, and the statistical power of the studies. Adhering to a modified Downs & Blacks checklist, the evaluation process incorporated a specific focus on sample size calculation.Simplified criterion, assigning a score of 1 if the calculated sample size was explicitly reported and 0 if this information was absent. Consequently, a maximum total score of 28 was attainable across all five reviewed papers. After this assessment, the data was sorted using a clear structured data extraction template form.The extraction table was made up of the following headings ; Study, Aims, Study Design Intervention, Outcome measures and Results of the reviewed articles. The systematic extraction process facilitated a comprehensive evaluation and identification of recurring themes across the studies, contributing to an understanding of the overall findings.

Table 3. Downs and blacks quality assessment

Questions					
1.	1	1	1	1	1
2.	1	1	1	1	1
3.	1	1	1	1	1
4.	1	1	1	1	1

5.	2	2	1	1	2
6.	1	1	1	1	1
7.	1	1	1	0	0
8.	0	1	1	0	0
9.	1	1	1	1	1
10.	0	1	0	0	1
11.	0	0	1	1	1
12.	0	1	0	0	0
13.	1	1	1	1	1
14.	1	1	1	1	1
15.	1	0	0	1	1
16.	1	1	1	1	1
17.	1	1	1	1	1
18.	1	1	1	1	1
19.	1	1	1	1	1
20.	1	1	1	0	1
21.	1	1	1	1	1
22.	1	0	0	0	0
23.	1	1	0	0	1
24.	1	1	0	0	0
25.	1	1	1	1	1
26.	1	1	1	1	1
27.	1	1	1	1	1
Overall score	24	25	21	20	23

Table 4. Data extraction Table

Study	Aims	Study Design	Population	Intervention	Outcome measures	results
A randomised, double-blind, placebo-controlled, repeated-dose pilot study of the safety, tolerability, and preliminary effects of a cannabidiol (CBD)- and cannabigerol (CBG)-based beverage powder to support recovery from delayed onset muscle soreness (DOMS)	To compare the effects of cannabidiol on recovery, sleep quality, or mood disturbance	RCT	40 exercise trained (3-5 times a week for at least 30 minutes) individuals with BMI 18-35 KG/m2.	8 doses (7 scheduled +1 for lost/missing dose) which participants were randomly assigned (placebo or active) with consumption at home.	Effects of DOMS, and sleep quality post	Repeated dosing of this cannabinoid based formulation over 3.5 days improved the functional aspects of recovery
Effects of Cannabidiol Supplementation on Skeletal Muscle Regeneration after Intensive Resistance Training	The aim of the experiment was to determine the effects of cbd on skeletal regeneration	RCT	16-21 well trained participants	60 mg single application directly after training.	Effects on skeletal regeneration after intensive training	No significant changes but reduced after 24h but no changes. No effects after 48h and 72h. After 72h seven subjects increased their performance.
Topical cannabidiol and the progression rate of delayed onset muscles soreness	Efficacy of topical cannabidiol in reducing inflammation	RCT	(n = 21, age 20.8 ± 1.9 years)	Topical and placebo ointment were applied 30 minutes 24,48 and 72 hours post exercise	Upper arm circumferences were measured and changes in size were	No changes were statistically significant on days between conditions. Soreness

				(DOMS protocol)	recorded.	increased in both the CBD arm and the p arm over time. Therefore the topical ointment had no effect on DOMS.
A Pilot study on cannabidiol and Eccentric Exercise: Impact on Inflammation, performance and pain.	To evaluate the impact of the two doses of CBD oil on inflammation, performance, and pain after an eccentric loading protocol. Handgrip strength and bicep curls in kg	Crossover study	Four eccentric naive (2 male 2 female) were recruited from the local university.	A low dose of 2mg/ kg or a high dose of 10 mg/ kg of CBD which were placed into vegetarian capsules for the placebo to be used as well. Each condition took 72 hours to complete with supplements being taken immediately and 12 hours post exercise.	Performance was measured in two exercises (handgrip strength and Bicep curl in kg) as well as range of motion 24hrs 48hrs and 72hrs. With pain levels measured at the same periods of time as he exercises	There was There were no differences in pain between conditions ($F(2,6) = 0.495$, $p = 0.633$, $np2 = .142$), but there was a difference across time ($F(3,9) = 7.028$, $p = .010$, $np2 = .701$). There were no significant interactions to note. Although there was no statistical significance between conditions and 72 hours (3.12 4.26) post exercise in the placebo condition which was not observed in the low (48: 0.35 2.22; 72: 1.34 5.6) and high dose condition (48: 1.34 1.34; 72: -0.79 5.34).
The Effects of Cannabidol oil on noninvasive measures of muscle damage in men	To investigate the effect of CBD oil on perceived muscle soreness, inflammation, and strength performance	RCT	13 untrained Men (men + SD age 21.85 + 2.73 years) .Noninvasive (perceived soreness.	CBD 150mg post 24h. 6 sets of 10 maximal ECC isokinetic muscle actions of the elbow flexors	To reduce perceived muscle soreness and reduce inflammation in terms of circumference of the arm, hanging joint angle and	The current dose of 150 mg CBD oil at POST, 24 h, and 48 h had no effect on non-invasive markers of muscle damage in the upper extremity. At the current dose and schedule, CBD oil may not be

	after eccentric exercise				peak torque	beneficial for untrained men as a recovery aid after exercise-induced muscle damage.

Abbreviations from the data extraction table

- RCT- Randomised controlled trial
- DOMS- Delayed onset muscle soreness
- CBD- cannabidiol
- ECC- Eccentric
- SD- Standard deviation
- KG- kilogram
- Mg- milligram
- P arm- placebo arm

3. Results

3.1. included studies

Outlined in figure 1 using the PRISMA flow diagram, 111 articles were identified from the main database search strategy. Adhering to the removal of the 28 articles, 83 papers were then screened before assessing them against this review's specific inclusion/exclusion criteria (table 2). Whereas 56 were excluded, leaving 27 for screening. Another 12 not being retrieved due to not being specific to the review title. 15 articles became eligible for final review, however 10 out of the 15 articles were not suitable as they did not meet the inclusion criteria that were specific to this review. Five articles remained, comprised of four RCTs and one pilot study, which can be seen in table 4

Out of the five different papers, 4 papers had a sample size over 10 participants when carrying out their study(Isenmann et al. 2021, Peters et al.2023, Alpy et al. 2023, Cochrane-Snyman et al. 2021). However one paper had a sample size of 4 participants (Stone et al. 2023). All studies showed a DOMS protocol before using their choice of CBD oil, to measure the effect the oil had post exercise. All studies showed performance related and post intervention outcomes at least 24 hours after the initial intervention. Out of the studies, three used trained participants whereas two studies used untrained participants, one of those studies was the pilot study (Stone et al. 2023) .All included CBD post exercise.

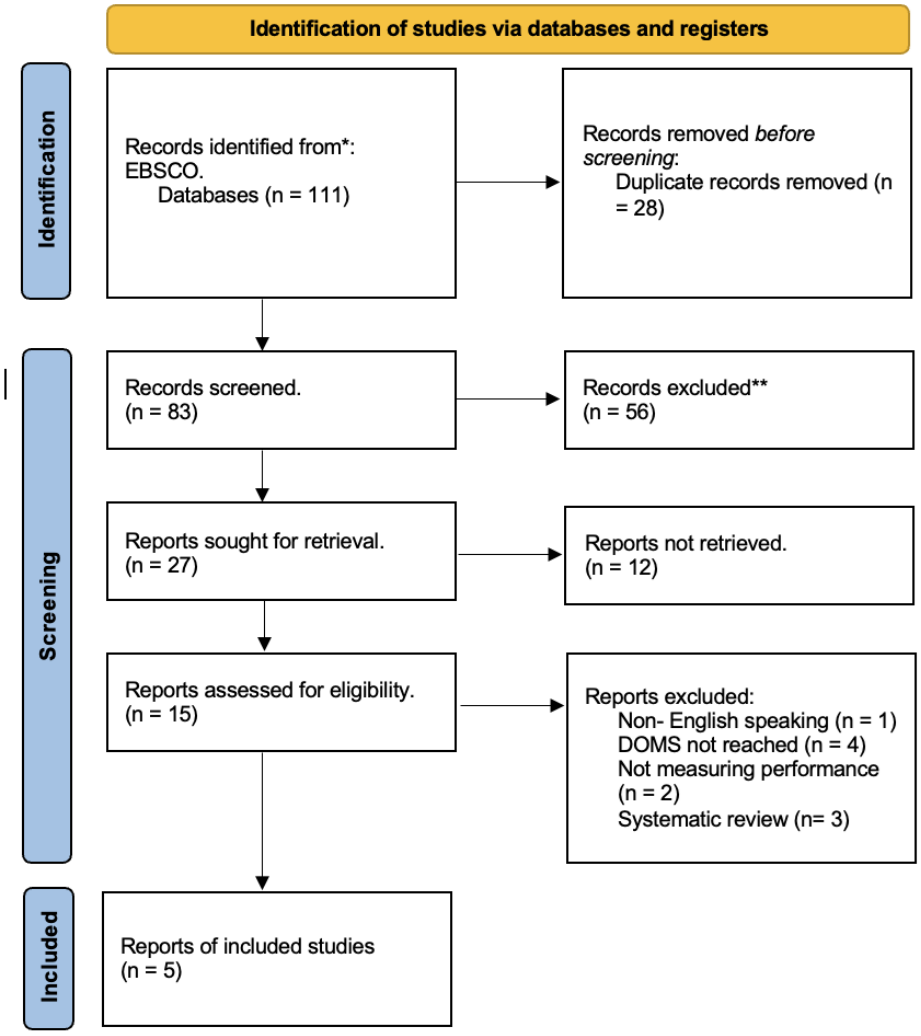

Figure 1. PRISMA flow diagram. The chart outlines the sorting of 111 articles down to the five included in this review

3.2. Quality index

The chosen five papers were analytically evaluated using the modified Downs & Black quality appraisal tool. The overall scores from the 5 studies varied from 20-25. Any paper that scores between 26-28 are excellent, 20-25 is good, 15-19 is fair and below 14 is poor Silverman et al. This means all five critically analysed papers were categorised as good methodological quality (Silverman et al, 2012). Although there

were some common disadvantages across the papers, no papers were eliminated because of poor methodological quality.

3.3. Methodological Analysis

One of the main themes that occurred within these five experiments were attempts to blind both the researcher as well as the participants, as blinding the researcher will have a significant impact on bias reduction in research studies. Blinding the researchers helps mitigate these biases by preventing conscious or unconscious influences on the study outcomes (Day and Altman, 2000). Blinding the researcher will also help prevent data collection bias which is where the researcher will selectively record observations that align with their hypotheses or overlook contradictory evidence. Blinding the researcher helps ensure that the data collection procedures are conducted objectively and consistently across conditions or treatment groups. On the other hand, data analysis bias may occur where the researcher involved in data analysis may unconsciously manipulate or interpret data in a way that supports their hypotheses or desired outcomes. blinding the researcher to study conditions or group assignment minimises the risk of bias during the data analysis, promoting more objective and reliable results (Šimundić, 2013). On the other hand, blinding the participants which the overall theme of the five papers followed will allow the placebo intervention to potentially create an effect on the outcome measures, whereas Alpy et al. (2023) attempted to blind both the researcher and the participants.

Two of the five studies had washout periods between the crossover periods with Isenmann et al. (2021), Cochrane-Snyman et al. (2021) had a two week washout whereas Stone et al. (2023) only has a one week washout which would have an effect on the results as the first treatment may still be within the participant's system Sills and Brodie, (2009) due to a 2-6 week washout period to ensure the treatment has left the participant's system. With crossover studies comparing each participant's response to different treatments within themselves, crossover studies control for individual differences and potential confounding factors that may affect the outcome variable. Statistical analysis of crossover studies requires specialised statistical techniques such as paired T-test to account for within subject correlation and potential crossover effects Wellek and Blettner (2012).

4. Discussion

Results

All five studies exhibited a common focus on exploring the impact of CBD on muscle recovery and inflammation reduction, a trend underscored by the thorough analysis of their findings. Each study employed a DOMS protocol to centre their investigation on post-exercise muscle recovery, capitalising on the induced muscle damage to discern any effects of the interventions. Among these, three studies failed to yield statistically significant differences. (Peters et al. 2023) Notably, one study revealed moderate evidence of CBD's efficacy in reducing perceived soreness 72 hours post-intervention, contrasting with no significant difference observed at the 24-hour mark following the DOMS protocol. However, despite the formulation's lack of substantial

effects on objective outcome measures related to DOMS reduction, participants reported improved ability to perform functional movements without stiffness or soreness interference 48 hours post-intervention. (Isenmann et al. 2021) In contrast, another study reported a significant group difference in muscle damage biomarkers after 72 hours, albeit with a performance decrease observed 24 hours post-intervention, which was resolved by the 48-hour mark. Interestingly, recovery from muscle damage induced by a 1-rep max back squat demonstrated a small yet significant improvement after 72 hours with the intervention. Although no changes were observed in the countermovement jump, the intervention demonstrated effects aligned with the studies' goals of facilitating muscle regeneration within the 72-hour timeframe.

Athletes across all skill levels, from novices to elites, are susceptible to DOMS (Cheung et al., 2012). Consequently, researchers across various studies have incorporated DOMS protocols to assess the impact of CBD interventions on muscle recovery rates and the enhancement of performance post-DOMS onset. Given the variable duration of DOMS, with no precise timeline for its resolution, these studies aim to explore strategies to reduce its duration and enhance an athlete's ability to perform. Whether it's recovering from new exercises, returning to sport after a period of rest, or transitioning from the off-season, understanding and mitigating DOMS is crucial for optimising athletic performance (Cheung et al., 2012). Cochrane-Snymac et al. (2021)found that participants showed no soreness both 24 and 48 hours following the initial DOMS protocol, with no significant difference between the two time points. However, despite the absence of soreness, the intervention demonstrated its efficacy in alleviating DOMS symptoms, indicating its potential benefits for athletes.

Population

All five studies meticulously screened participants to ensure they were not consuming any supplements or medications, with exclusion criteria specifically targeting those using supplementation. This meticulous approach was crucial, as the supplements individuals take could potentially influence the recovery rate from soreness or muscle tenderness.Notably, Pasiakos et al. (2014) highlighted the beneficial effects of protein supplements in reducing muscle soreness, while also noting an increase in muscle damage markers following protein supplementation post-training sessions.
Furthermore, three of the studies exclusively recruited trained athletes, defined as individuals engaged in strength training for a minimum of six months. In contrast, Cochrane-Snymac et al. (2021) opted for untrained participants who had abstained from training for at least one year, while Stone et al. (2023) specifically utilised eccentrically naïve adults for their pilot study. All participants across these studies were adults over 18 years old, with both male and females represented, ensuring a diverse sample
Clarkson and Hubal (2002) emphasised that muscle damage often ensues after unaccustomed exercise, particularly involving a significant number of eccentric contractions. This underscores

the relevance of Stone et al. (2023) pilot study, which focused on the effects of the intervention in untrained athletes performing eccentric bicep curls.
Moreover, four of the studies employed a split-group design, assigning participants to either an active intervention or a placebo group. In contrast, (COCHRANE-SNYMAN et al. 2021) employed a crossover design, with all participants undergoing both active intervention and placebo phases separated by a two-week washout period. Consequently, each study yielded distinct participant cohorts, contributing to variations in mean data collection. Notably, while Stone et al. (2023) conducted a pilot study with four participants, the remaining papers included sample sizes ranging from 13 to 21 participants.

Duration of intervention

All five studies meticulously integrated CBD supplements into their intervention groups, employing rigorous follow-up assessments at key intervals: 24-, 48-, and 72-hours post-baseline testing and having initiated the intervention. Two out of the five studies had a post exercise protocol which was used at the 24, 48 and 72 hours post initial intervention (Alpy et al. 2023; COCHRANE-SNYMAN et al. 2021) compared to the other three studies who implemented performance testing at the different time scales. Within the check in time scales supplements were taken.
Peters et al. (2023) participants were taking two doses with two the first dose of 70 mg and the second dose of 100mg of beverage CBD powder consumed through liquid enhancing the granularity of data collection. The duration of testing allowed the studies to analyse any changes throughout a three-day period enabling a nuanced evaluation of the intervention's efficacy in mitigating DOMS and augmenting performance.
These programmes enable muscle damage to occur within their intervention groups over the time taken to complete testing by ensuring a DOMS protocol is produced. MacIntyre et al. (1995) observed DOMS peaking between 24 hours and 48 hours after exercise.
The alignment of study timelines with the natural progression of DOMS post-exercise suggests a thoughtful and periodised program design. Consequently, all five studies adhered to a meticulously structured and comprehensive research framework, fostering a holistic understanding of CBD's potential impact on both muscle recovery and performance enhancement.

Type of exercise

All five studies undertook rigorous assessments using maximal contractions to establish baseline measures, often calculated as a percentage of the participants' one-repetition maximum (1RM). While Cochrane-Synam et al. (2021) utilised the back squat to gauge maximal strength, the remaining four studies focused on upper limb strength testing. Following the initial assessments, three of these studies delved into discomfort outcomes related to the upper limb.

In Peters et al. (2023) participants' discomfort levels post-DOMS protocol were assessed using visual analog scores (VAS), with the intervention involving a 1RM of elbow flexor concentric contraction paired with 35 mg of CBD beverage powder. This method draws from Delgado et al. (2018) visual representation of pain levels. Alternatively Alpy et al. (2023) examined arm circumference size post-testing, utilising a 1RM preacher curl to activate the bicep brachii muscle, with a topical application of 100mg of CBD oil on the bicep brachii serving as the intervention.

Furthermore, three of the studies homed in on performance outcomes related to DOMS. Isenmann et al. (2021)scrutinised lower limb strength post-DOMS protocol, employing a 1RM back squat regimen at 70% intensity for 12 repetitions over three sets, evaluated at 24, 48, and 72 hours post-initial DOMS protocol. Stone et al. (2023), on the other hand, assessed upper limb performance through maximal force, incorporating six sets of 10 repetitions of bicep curls using a bicep isolator, alongside isometric handgrip strength measurements. Participants in this study consumed CBD via pill form, with doses ranging from 2mg to 10mg, aimed at addressing inflammation and enhancing performance.

These diverse approaches provide comprehensive insights into the interplay between muscle damage, recovery rates, and performance outcomes across various CBD intervention protocols, enriching our understanding of their efficacy in athletic contexts.

5. Limitations

The studies reveal the complexity of studying CBD oil's effects on muscle recovery and performance enhancement. They stress the importance of rigorous methodologies and diverse approaches. Among these studies, variations emerge in their focal points; while some delve into performance outcomes throughout the study period, others concentrate on aspects of recovery, such as inflammation and muscle swelling. Attempting to blind both researchers and participants can be challenging and may introduce complications. Additionally, the inclusion of both trained and untrained individuals in studies can lead to variations in sample size and demographics. Overall, the studies emphasise the need for more thorough methodological and openness to diverse perspectives when investigating CBD's effects in athletic settings.

6. Conclusions

In conclusion, this literature review aimed to delve into the efficacy of CBD oil on muscle recovery and performance enhancement. While the research uncovered notable findings, a

comprehensive picture of CBD's effects remains elusive and warrants further investigation. Among the studies reviewed, one study demonstrated a significant impact of CBD oil on reducing DOMS and improving performance outcomes. However, it also underlines the need for additional research to fully explain CBD's effects in these areas. Interestingly, another study reported no statistically significant differences in performance but noted a reduction in stiffness and tenderness post-intervention. Meanwhile, three studies found no effects on recovery but emphasised the necessity for more robust evidence through further research. Notably, one study highlighted a decrease and reduction in inflammation attributed to CBD's effects. These diverse outcomes show the complexity of CBD's mechanisms and its potential in modulating various aspects of muscle recovery and performance. Through meticulous analysis, it became evident that the duration of testing, spanning 72 hours, including the DOMS protocol alongside a warm-up routine, provided valuable insights into CBD's effects. In light of these findings, it is clear that more thorough research needs to be done, particularly focusing on performance outcomes. It is imperative to unravel the full potential of CBD mechanisms, in optimising muscle recovery and enhancing athletic performance.

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Effects of Topical CBD oil on perceived Delayed Onset Muscle Soreness of the lower limb in athletes and seep analysis

1. Introduction

Cannabidiol (CBD) is a compound derived from the cannabis plant. As CBD is no longer prohibited by the Anti-Doping agency, CBD has become a widely used substance in athletes for recovery. Across the United States (USA) and Canada saw the highest prevalence of CBD use since previous years with the USA having a considerable 50% increase within the past four years of CBD use (Wilson-Poe et al. 2023). CBD can be taken through numerous methods, including CBD vapes, from capsules, patches and topical CBD oils/lotions. CBD topical lotions are used predominantly for inflammation, Jean-Gilles et al (2015) suggests CBD has positive effects of inflammation due to the pro-inflammatory cytokines, inhibits T cell proliferation which induces T cell apoptosis and reduces migration and adhesion of immune cells.

Delayed onset muscle soreness (DOMS) stems from an overuse of eccentric muscle contractions or from participating in new exercises (Heiss et al. 2019). DOMS is the most common muscle injury but is considered a mild injury, common symptoms of DOMS are stiffness and tenderness (Hotfiel et al. 2018). DOMS can have a negative effect on performance or training at optimal levels, due to stiffness and tenderness of muscle groups (Pearcey et al. 2015).

Due to the high demand in various sports, athletes have focused on improving their training plans. A typical athlete training plan has taken the strength and conditioning aspect a lot more serious, strength training in athletes can help reduce the risk of injury during optimal performance levels (Sancese et al. 2023), together with benefits such as maintaining optimal performance levels within matches or sport specific training (Kasprzyk-Kucewicz et al., 2020). With potential external factors pushing athletes to compete at the highest level, athletes have become more demanding on improvements and pushing their training to the limits to reach the highest level. An aspect of their training is strength training, strength training enhances the athlete’s ability to do generic sporting movements (Timothy J et al. 2016). Strength has risks due to its potential to influence an athlete’s ability to perform because of DOMS which stems from overuse of eccentric muscle contractions.

The lower limb covers numerous bones and muscles within the leg, throughout sport the majority of which involve running, running is a closed kinetic chain movement (Nicola and Jewison,

2012) which generates from the foot and activates muscles to produce the running mechanic. Due to the kinetic chain muscles used throughout can have an impact on an athletes fatigue levels with potential injury risks if not conditioned to deal with the demands of their sport.

Sleep plays a role in the rate of recovery due to the body's relaxed state allowing activation of protein synthesis pathways, mitigating sleep debt-induced muscle damage, and reducing injury risk by curbing degradation pathway activity Dattilo et al. (2011). Hirshkowitz et al. (2015) Suggests 7-9 hours sleep for young adults and adults, getting sufficient sleep will help improve daily moods along with reducing daytime sleepiness as well as daily fatigue (Chaput et al. 2018).

Considering the effects of CBD oil on inflammation and muscle soreness, alongside the demands of sport for athletes, as well as their training plans containing strength and conditioning exercises which have potential to inflict DOMS onto the athlete. The hypothesis of this study is topical CBD oil will have a positive effect on perceived soreness alongside a better quality nights sleep due to the relaxant compounds found in CBD.

2. Methods

2.1 study design

Using quantitative research allows the researcher to understand and explain key features of the studies (Watson 2015). Quantitative research is done by researchers generating a hypothesis from an existing theory and then testing their hypothesis against the theory from existing data (Barroga et al. 2023). It also focuses on numerical data as well as convergent reasoning rather than divergent reasoning.

This study focuses on two groups to assess a significant difference between the two intervention groups, one group using a topical CBD substance compared to the controlled group receiving a placebo oil. The testing involved the two study groups to participate in their standard training schedule for their desired sport for two weeks continuing with their daily routines, by applying

the oils directly after their training session had finished as well as answering questions based on their perceived nature of fatigue by using a visual analog score.

2.2 Participants/ recruitment

To enhance the search for appropriate participants, purposive sampling was used. This sampling method allows for better matching of the sample to the aims and objectives of this research project (Campbell et al. 2020). Participants eligible based on the criteria in Table 1 were selected.

Participants were told to carry on their daily routines to assess the difference in which the CBD oil had made on perceived level of soreness as well as sleep analysis. The participants completed two training sessions a week where the oil was applied. During these sessions the participants completed a standardised warm up for their sport before a one hour and 30 minute training session, the time of the session allowed muscle fatigue and soreness to occur. All participants were recruited via social media via Instagram messages to sporting societies at the university. 90 participants were identified but 80 did not respond to initial contact, with zero withdrawals. The final 10 participants were invited to take part in the research shown in figure 1.

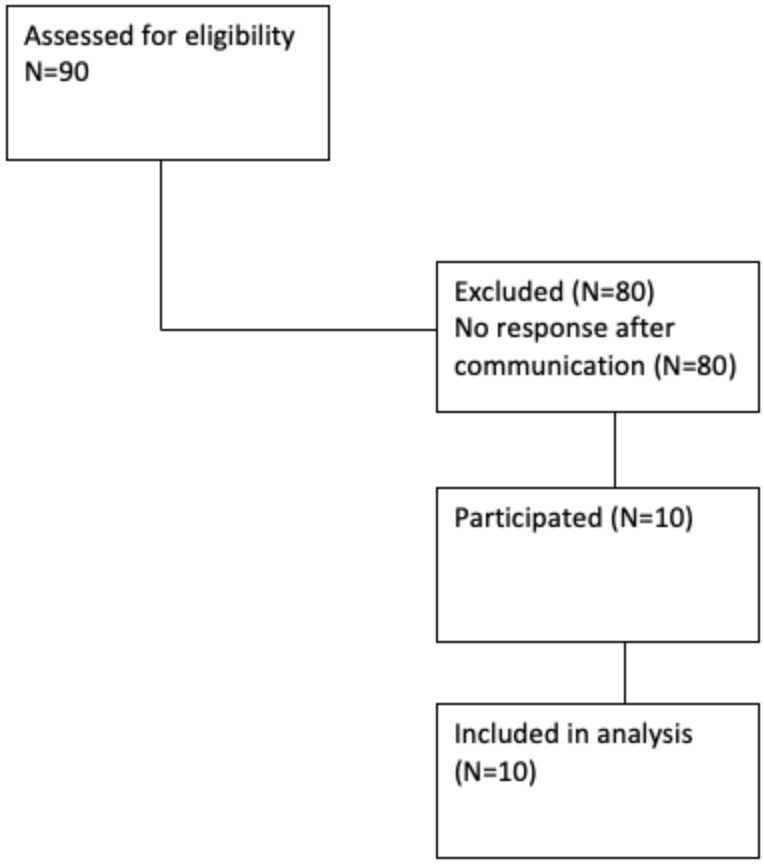

Figure 1. Participant inclusion diagram

2.3 Inclusion and Exclusion criteria

Eligibility criteria is important for the success of a trial, due to the direct effects of the final results. If the eligibility criteria is inappropriate then insufficient recruitment will eventually lead to a failure of the clinical trial (Su et al. 2023). Participants must be over 18 years old, participating in physical activity for a minimum of three times a week for 45 minutes and free from injury or underlying health conditions. Those who did not meet the eligibility requirement included people who did not partake in physical activity three times a week and those under the age of 18. Table 1 lists the full inclusion and exclusion criteria.

Table 1. Inclusion and Exclusion criteria

Inclusion	Exclusion
· Participant must be over the age of 18 · Participant must partake in physical activity for a minimum of three times a week for 45 minute sessions · Participant must be injury free · Participant must have no underlying health conditions	· Not participating in physical activity three times a week for 45 minutes · Participants under the age of 18 years old · Participants carrying injuries · Participants with underlying health conditions.

2.5. Data analysis

Prism 10 version 10.2.2 was used to analyse the data. Parametric assumptions were assessed by Shapiro-wilk normality test to check for normal distribution of data. A two way ANOVA was used to evaluate the difference between experimental (topical CBD oil) and control (topical placebo oil) on perceived muscle soreness and sleep analysis between recovery for the participants' next physical activity. Data is presented as mean and standard deviation to determine between participants who showed a significant difference in response to the CBD treatment. Values of $p < 0.05$ were considered significant differences.

2.6. Ethical Consideration

This study was authorised by Bournemouth University ethics board (ethics ID number; 57193) participants provided permission through signed information and participant agreement forms prior to the first treatment. Data was anonymised and used for results with permission from the participants.

3. RESULTS

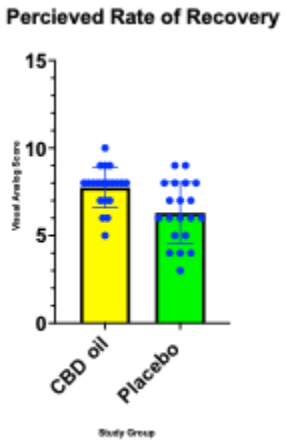

Figure 2. Perceived rate of recovery between training sessions

There was a significant difference in the rate of perceived recovery across the two week study between CBD oil (M=7.750, SD = 1.164) and placebo (M = 6.300, SD = 1.750); t (38) = 3.085) ,p = 0.0835.

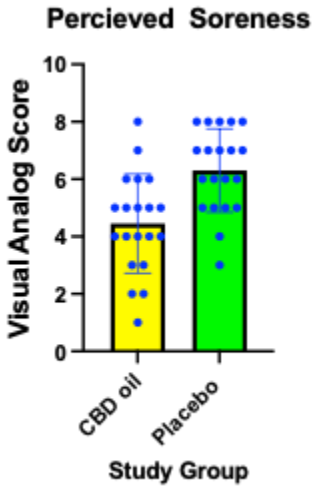

Figure 3. Perceived Soreness 24 hours post training

There was a significant difference in perceived soreness across the two week study between CBD oil (M= 4.450, SD = 1.731) and placebo oil (M = 6.300, SD = 1.455); t (38) = 3.659 ,p = 0.4549.

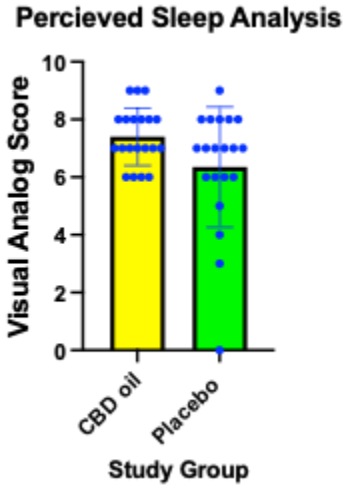

Figure 4. Perceived sleep analysis

There was a significant difference in perceived sleep analysis over the two week study between (CBD oil) (M= 7.400, SD = 0.9947) and placebo oil (M = 6.350, SD = 2.084); t (38) = 2.033 ,p = 0.0023.

4. Discussion

This study aimed to explore the repeated effects of CBD application to affected muscles from a training session in athletes as well as the CBD's ability to affect sleep analysis. The double-blind, randomised control trial was used to reduce the risk of bias and in return and validity.

To assess the recovery of DOMS and muscle soreness the participant took part in a football training session twice a week, soreness is a common side effect within muscle damage known as DOMS (Cheung et al. 2012). In this experiment, topical CBD did significantly increase the perceived rate of recovery as well as reducing perceived soreness as shown by the Paired T-test

data. All were measured for recovery and soreness against the same sessions over the course of the data collection. Soreness comes predominantly from DOMS, which occurs from repeated eccentric muscle contraction (MacIntyre et al. 1995).

The results of this study differ from findings from previous studies, conducted by Peters et al. (2023), regarding the results of ingested CBD beverage based powder on recovery from delayed onset muscle soreness (DOMS). Their results concluded that their chosen dosage of 35 mg of CBD did not show significant changes between placebo and CBD on objective measures of recovery, sleep quality and mood disturbance. However Isenmann et al. 2021 reported a small but significant effect on muscle damage and recovery with a dosage of 60 mg. This dosage is considerably more than the study completed by Peters et al. (2023) And less than the dosage of this study which consisted of 800 mg/100 ml which means both studies used a lower dosage of CBD compared to this study. Due to a higher dosage between Isenmann et al. (2021)(60 mg) with small but not significant difference, and Peters et al. (2023) (10 mg) with no significant difference promoting recovery. The dosage of CBD could be the causing factor in recovery, with a higher dosage the effects of CBD may become higher having a greater effect on muscle recovery (Farinde 2021).

A subjective assessment of DOMS was used for this study, subjective evaluation or a visual analog score (VAS) is often used in analysing the effects of soreness and recovery with DOMS(Lau et al. 2015) and other studies have been seen to use VAS to assess DOMS symptoms. DOMS can have symptoms lasting up to three days and occurs from continuous eccentric contractions and affects the extramuscular connective tissue of the muscle (Wilke and Behringer 2021). Reducing the effect of DOMS from the CBD in favour allows the athletes to perform at a higher level due to the reduce in stiffness and tenderness. These findings vary from some current research produced for the effects of CBD, as there was a significant difference in recovery, soreness and sleep quality between CBD and placebo. This study focused on reducing the symptoms of the mild muscle injury DOMS by reducing the implications which stem from the mild muscle injury, such as stiffness and soreness(Gulick and Kimura 1996), as well as delving into the effects of perceived sleep analysis from the CBD oil. There is moderate evidence

that CBD can improve sleep and fibromyalgia pain which has very similar symptoms to DOMS, as people with fibromyalgia experience pain, aches and stiffness in muscles (Bilodeau 2020).

CBD has limited research into the primary effects on athletes' rate of recovery from DOMS; it is gaining more evidence into its ability to amplify performance properties. CBD has shown evidence to affect the antinociceptive properties in human and animal populations (Ohana et al. 2023). Antinociceptive properties are the body's ability to block or detect pain stimulus by the sensory nervous system (Shaista and Riffat 2020). This study focused on investigating the role of topical CBD oil on the lower limbs muscles rate of recovery with soreness and sleep quality post exercise. CBD oil had a positive effect on reducing perceived soreness 24 hours after training with a mean of 7.750(maybe p value) compared to the placebo group effect of 6.300 using a 1-10 Visual Analog Score shown in figure 2. Therefore, CBD showed a significant improvement on the rate of recovery in terms of DOMS. The VAS of perceived rate of recovery post exercise was considerably higher than the placebo group following the same training session, confirming the effects of the CBD oil within athletes in terms of increasing the rate of recovery.

The results suggest that CBD oil as a lotion has a significant difference in reducing the perceived level of soreness compared to the control study groups between treatments increasing athlete performance throughout the week. Therefore the findings of the study suggest that the CBD oil with a concentration of 800mg is a factor in reduction in soreness post-exercise.

This study suggests CBD has a significant improvement in sleep quality in comparison to the controlled study group which showed no significant difference in sleep quality improvement. Therefore the findings of the study that the CBD oil of 800 mg/100 ml has a positive effect on sleep quality in athletes.

The CBD oil utilised in this study incorporated a natural antioxidant within a carrier of MCT oil. Antioxidants play a crucial role in safeguarding cells from oxidative damage, as explained by Whayne et al. (2016). When subjected to intense exercise, the myofibril filaments within muscles may rupture, resulting in diminished muscle function. Consequently, these occurrences trigger

an inflammatory response and escalate the production of reactive oxygen species, as highlighted by Guglielmo Duranti (2023).

The inclusion of an antioxidant within the CBD oil acts as a potent anti-inflammatory agent, effectively mitigating inflammation within the muscle tissue. This reduction in inflammation serves to alleviate muscle stiffness and soreness, both hallmark symptoms of Delayed Onset Muscle Soreness (DOMS). By improving these discomforts, the CBD oil demonstrates promise as a viable intervention for enhancing post-exercise recovery and overall muscle performance.For the oil to become effective is must get through the outer layer of the skin called corneum, then move through the epidermis and dermis layers beneath the skin. This journey is necessary because the site of inflammation and pain lies deeper within the body and must travel through these layers to make a noticeable effect on the perceived level of pain (Pradal 2020). The concentration levels of the oil must apply within the industry standards for skin applied treatments with the oil used in this study to have a pH of 5-7 for this reason. Concentration levels of NSAIDS in comparison with the CBD concentration requires more thorough research to understand the most effective results.

Monitoring players' fatigued levels allows players to rest and recover, reducing risks of injuries (Halson 2014).The results shown from the study coincides with the hypothesis that CBD has a positive effect in, increasing the rate of recovery and reducing the perceived level of soreness after exercise with an improvement in sleep quality. This means that within an athletic setting, CBD can be beneficial in reducing the effects of soreness and increasing the rate of recovery allowing athletes to continue to perform at their highest level throughout their training plan for the week. With a common factor within football with an increased amount of games being played. With players engaging in two games a week for a number of weeks within a football season, players reported an increase in physical demand (Sioud et al. 2022), with little evidence to show that multiple game weeks increase the risk of injury, perceived level of soreness can play a metal factor on a players rate of intensity within a match or training.

One limitation found within this study was to engage with the participants on a more frequent basis to enhance the accuracy of the participants results regarding recovery and soreness. The reason for this was the participants being university students made it difficult to complete the

study with every participant available as well as their other sporting commitments with various teams meaning being present at each session would be difficult considering the timings and location did not allow for this.

With the training sessions, ensuring everyone covered the same distances in terms of sprint distance as well as covered ground was another limitation due to positions all participants are required to cover different distances meaning intensity was not consistent throughout all participants. Allowing other factors into this study may have caused variation in results, considering athletes would do personal things to help with recovery such as foam roll and stretches as these factors play a role in recovery from DOMS(Pearcey et al. 2015).

To gain a better understanding at the effects of CBD oil in terms of recovery on DOMS more detailed research into different movement patterns and exercises could have been completed which would show a wider understanding on the full outcome effects. As well as an attempt in participants continuing a structured plan throughout the week as participants were left to their own accord after the treatments they may have involved in various activities which may have reduced the rate of recovery such alcohol consumption as this is shown to reduce the rate of recovery by reducing muscle protein synthesis (Lakićević 2019).

5. Conclusion

To summarise what has been said within this study, CBD oil of 800 mg/100 ml has shown to
have a significant difference in effects on perceived soreness and an increase in the rate of
recovery between training sessions. These effects are particularly beneficial for improving performance in sports settings. Additionally, the study found that participants using topical CBD oil experienced improved sleep quality compared to those using a placebo oil. This suggests that CBD oil could be beneficial for enhancing both physical recovery and sleep quality in athletes and individuals engaged in physical training

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