

Marijuana and Its Effects on Athletic Performance: A Systematic Review

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Abstract

Objective: To determine the effects of marijuana on athletic performance. **Design:** We searched MEDLINE, EMBASE, CINAHL, PsycINFO, AMED, and SPORTDiscus from their beginning to September 2016. Study quality was assessed using the Cochrane collaboration tool for assessing risk of bias and the Cochrane GRADE scale. No meta-analyses were performed for this review.

Setting: Subjects in a track, gym, or recreational ward. **Participants:** Any primary study which included male and female adults of any athletic background between ages 18 and 65, with no other comorbid conditions. **Interventions:** Any primary study which used marijuana cigarettes and included a control group. **Main Outcome Measures:** Vital signs, pulmonary measures, physical work capacity, grip strength, and exercise duration were determined to be relevant outcomes. **Results:** Three trials examined marijuana and its effects on athletic performance. Two trials had a high risk of bias and 1 trial had an unclear risk of bias. The effect of marijuana on outcomes including heart rate, blood pressure, and exercise duration remains unclear. Low quality evidence suggests that treatment, sham, and inactive control groups do not have a significant difference for grip strength. Low quality evidence suggests that there is an ergogenic effect of treatment demonstrated by increased bronchodilation and FEV₁ compared with inactive control and that there is an ergolytic effect of treatment demonstrated by decreased physical work capacity compared with sham and inactive control groups. **Conclusion:** Because the number and quality of studies was low, the effects of marijuana on athletic performance remain unclear.

Key Words: evidence-based review, exercise, doping, ethics

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INTRODUCTION

Marijuana is reported to induce numerous effects on users. It is most commonly administered into the pulmonary circulation through the inhalation of smoke or vapor, but it can also be ingested. Marijuana is extracted from the cannabis plant and possesses an intended use as an illicit psychoactive drug or a prescribed medication.¹ The psychoactive ingredient in the marijuana is tetrahydrocannabinol (THC), which can bind with a high affinity to specific endogenous cannabinoid receptors, CB1, located throughout the diencephalon, telencephalon, limbic structures, and brain stem.¹ THC in combination with other cannabinoids present in a typical marijuana cigarette is capable of inducing psychological effects to mood, perception, cognition, and dependency, as well as systemic effects to the cardiovascular, respiratory, digestive, immune, and endocrine systems.¹ For instance,

cannabis smoking has been associated with dose-related tachycardia, postural hypotension, bronchitis, and emphysema.¹

The use of marijuana in sport has been implicated in controversy the Olympics; notably, when snowboarding was first introduced as an official Olympic event in 1998 during the 18th Olympic Winter Games held in Nagano, Japan.² The Canadian, Ross Rebagliati gave a crowning performance throughout the snowboarding competition, which won his country a Gold medal.² Three days later, an infamous Olympic doping controversy began when he was stripped of his medal soon after the International Olympic Committee (IOC) recorded a positive urine test for marijuana use.² Specifically, the officials found 17.8 ng/mL of 11-nor-delta-9-tetrahydrocannabinol-9-carboxylic acid, the main metabolite of THC, in Rebagliati's system while the threshold was 15 ng/mL.² Rebagliati insisted that his abnormally high level of THC was attributed to second-hand smoke and that he was not exposed to the substance during the event, and soon after, his claim was appealed and the Gold medal was reinstated.² The occurrence of this event marked a long history of controversy surrounding the doping policies behind marijuana use.

Ongoing pressure from various stakeholders prompts the World Anti-Doping Agency (WADA) and the IOC to address their THC threshold. Several studies have elucidated that passive inhalation of marijuana cigarette smoke can result in a positive indication of cannabinoids and THC in urine or blood.^{3–5} Hence, urine and blood tests are not entirely indicative of active marijuana use especially at that low threshold. In addition, international policy regarding the legalization of marijuana is continuously evolving, which may increase the use and normalization of the drug. The 2012

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D. Diep and H. Robson ran the literature search, analyzed and chose the relevant studies, critiqued their methodology and quality of evidence, and formed relevant conclusions. K. V. Trinh analyzed and chose the relevant studies, critiqued their methodology and quality of evidence, and formed relevant conclusions. All authors proofread the manuscript.

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Canadian Community Health Survey–Mental Health demonstrates the high use of marijuana, as it reports that 12.2% of Canadians aged 15 or older have used marijuana in the past year.⁶ As of 2017, the WADA threshold for THC levels detected in athletes to be considered doping has increased to 150.0 ng/mL as a response to the changing views of marijuana use.⁷

Despite all the change surrounding marijuana policy and sport, the IOC and other organizations have banned the use of any substance that has an ergogenic effect, poses a risk to the user's health and safety, or violates the spirit of sport.⁷ It has been reported that marijuana generates feelings of euphoria, resulting in decreased anxiety and increased sociability.⁸ As a result, athletes may use marijuana to alleviate their stress and anxiety during competitions.⁸ Although athletes may smoke marijuana to improve their performance, its ergogenic potential remains questionable. Instead, marijuana may be considered an ergolytic drug where it impairs rather than enhances one's physical performance, stamina, or recovery.⁹

The ergogenic effects of marijuana recorded in the literature are unclear. Hence, the purpose of this review is to qualitatively consolidate the scientific evidence on marijuana and its effects on athletic performance. We can then assess the validity of its ban from competition attributed to its ergogenic properties.

OBJECTIVE

To determine the effects of marijuana on athletic performance.

CRITERIA FOR CONSIDERING STUDIES FOR THIS REVIEW

Types of Studies

Any published primary study of any design consisting of any clinically and/or laboratory-relevant outcomes on athletic performance was included in this review. Because of the minimal amount of studies in this area, the authors included any published study that illustrated clinically and/or laboratory-relevant outcomes to optimize the amount of data retrieved.

Types of Participants

Participants were male and female adults of any athletic background between ages 18 and 65, with no other comorbid conditions.

Types of Interventions

Studies must have used marijuana cigarettes for the intervention group. In addition, the presence of a control group that was not given marijuana cigarettes was necessary for inclusion.

Types of Outcome Measures

Outcomes measured included any enhancement in sport above baseline such as timing, strength, time to fatigue, vital signs, physical work capacity, and/or respiratory enhancement.

METHODS

Search Strategy

Computerized bibliographic databases were searched by 2 research librarians independently without year and language restrictions for medical literature. The following databases were searched from their beginning to September 2016: MEDLINE, EMBASE, CINAHL, PsycINFO, AMED, and SPORTDiscus. We thoroughly screened references and contacted identified content experts. They were adapted as necessary for the different databases. Refer to Table 1 for the selection of studies depicted in the PRISMA diagram.

Study Selection

At least 2 authors independently conducted citation identification, study selection, and data abstraction. Disagreements were resolved through a third assessor. Refer to Table 2 for the Summary of Included Studies chart.

Methodological Assessment

Two authors independently assessed each selected study for methodological quality based on the Cochrane collaboration tool for assessing risk of bias and the Cochrane GRADE scale.^{10,11} Disagreements were resolved through a third assessor. Refer to Table 3 for the Cochrane Risk of Bias chart and Table 4 for the Summary of Findings chart.

Data Extraction

Two authors independently extracted raw data for the descriptions of the participants, methods, interventions, and outcomes from the full-text manuscripts to predesigned forms.

Data Analysis

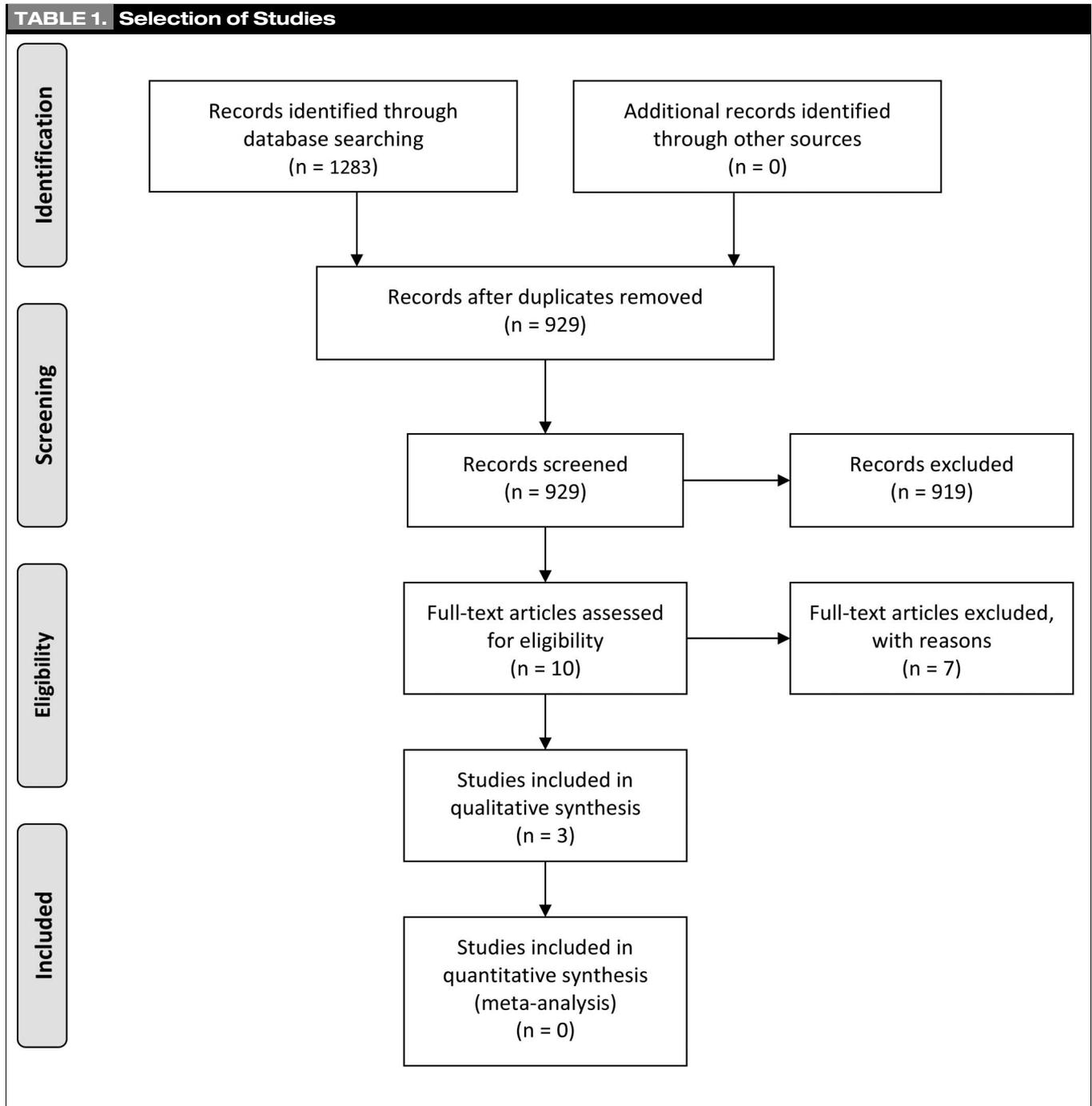
Clinical judgment was used to determine if the similarity of the participants, methods, interventions, duration of the study, and outcomes was adequate to allow pooling of results. Because the 3 trials were too heterogeneous in clinical features, no meta-analyses were performed.^{12–14} Instead, a qualitative analysis for combining evidence was performed, using the Cochrane GRADE table.¹¹ Refer to Table 4 for the Summary of Findings chart.

DESCRIPTION OF STUDIES/STUDY SELECTION

In consultation with 2 research librarians, we developed search strategies to identify potentially relevant studies from the MEDLINE, EMBASE, CINAHL, PsycINFO, AMED, and SPORTDiscus databases. **Supplemental Digital Content** (see **Appendix 1**, <http://links.lww.com/JSM/A146>) for the search strategies. We sought reports of any published trial in relation to marijuana use for its ergogenic effect. Clinical judgment was used to review the search and to retrieve potentially relevant studies.

We identified and screened 929 citation postings and retrieved 10 articles for further evaluation.^{12–21} Of these 10 articles, only 3 studies met the selection criteria.^{12–14} We included 3 marijuana trials on athletic performance, all of which lasted less than or equal to 4-week duration.^{12–14}

During the full-text review, we excluded 7 studies after reviewing their full manuscripts.^{15–21} One study was excluded



because its main outcome of daily physical activity was deemed irrelevant to athletic performance.¹⁵ Three studies were excluded based on the type of participants.^{16–18} Of these studies, 2 included participants with angina pectoris^{16,17} and the another used animal models.¹⁸ We excluded 2 reviews based on their study type (ie, not primary studies).^{19,20} We excluded 1 study as there was no suitable control.²¹

METHODOLOGICAL QUALITY

Methodological quality was graded using 2 sets of criteria:

1. Risk of bias: based on selection, performance, detection, attrition, reporting, and other biases¹⁰

2. Cochrane GRADE table: began with highest quality rating for randomized trial evidence with downgrades to moderate, low, or very low depending on the presence of limitations in design, indirectness of evidence, inconsistency of results, imprecision of results, and high probability of publication bias.¹¹ Alternatively, began with a low quality rating for observational trial evidence with upgrades to moderate or high depending on the presence of a large magnitude of effect, all possible plausible confounding being able to reduce a demonstrated effect when results show no effect, and a dose–response gradient.¹¹ The quality of evidence could also be downgraded depending on similar limitations listed.¹¹

TABLE 2. Characteristics of Included Studies

| Study | Design | Sample Size | Participants | Intervention | Outcomes |
|----------------------------------|---|----------------------------------|---|---|--|
| Maksud and Baron ¹² | Cross-sectional observational study design with 4 arms: cigarette and marijuana users (n = 18), marijuana users (n = 13), cigarette users (n = 17), inactive control (n = 17) | 65 total | Adult industrial male workers aged 19-34 | Not applicable (N/A) | \dot{V}_{O_2} max, physical work capacity, minute ventilation (VE), perceived exertion, working heart rate, percent body fat, lean body weight, hematocrit, hemoglobin levels |
| Renaud and Cormier ¹³ | Crossover RCT with 2 arms: marijuana group (n = 12), inactive control group (n = 12) | 12 total | Healthy, nonsmoking young men (n = 9) and women (n = 3) aged 20-24. No history of cardiovascular, respiratory, psychiatric, or orthopedic disorder. All participants smoked marijuana at least once without any ill effects and have not smoked 1 mo before the study period. | Marijuana group smoked marijuana cigarette containing 7 mg marijuana with a THC content of 1.7% before testing. Inhalation technique was standardized for participants to hold breath for at least 10 s. There was a 7-day washout period before crossover. | \dot{V}_{O_2} max, carbon dioxide output (\dot{V}_{CO_2}), maximum work capacity, forced expiratory volume, minute ventilation (VE), resting heart rate, resting and working blood pressure, breathing frequency, blood carboxyhemoglobin levels |
| Steadward 1975 ¹⁴ | Double-blind crossover RCT with 2 arms: marijuana group (n = 20), sham control group (n = 20), inactive control group (n = 20) | 20 total; 2 unexplained dropouts | 20 participants randomly selected from a larger pool of 80 male volunteer marijuana smokers aged 21-27. | Marijuana group (n = 18) smoked 1.4 g of marijuana with a THC content of 1.3% before testing. Inhalation technique was standardized for participants to hold breath between 7 and 10 s. There was a 3-day washout period before crossover. | Physical work capacity, vital capacity, grip strength, resting blood pressure, resting heart rate, flow rate at 0%-25% and 25%-75% vital capacity |

RESULTS

Of the 3 included studies (Table 2), vital signs (ie, heart rate and blood pressure), pulmonary measures (ie, vital capacity, flow rate, breathing rate, ventilation, oxygen uptake, carbon dioxide output, tidal volume, forced expiratory volume, and hemoglobin level), physical work capacity, grip strength, and exercise duration were determined to be relevant outcomes.¹²⁻¹⁴ Two studies explored the acute effects of marijuana on athletic performance,^{13,14} whereas a single study explored the chronic effects of the intervention on athletic performance.¹²

Vital Signs

Heart Rate

There are 3 studies in this category.¹²⁻¹⁴ Two studies reported increased heart rate before the exercise regimen in the marijuana group in comparison with the sham and inactive control groups.^{13,14} In one study, it was also reported persistence of tachycardia during the exercise regimen and recovery period in the marijuana group relative to the inactive control group.¹³ By contrast, one study reported similar heart rate during various levels of the exercise regimen for all groups.¹² Although this discrepancy may be attributed to the differences between acute and chronic effects of marijuana, there is very low quality evidence (3 trials, 95 participants) suggesting that marijuana smoking increases heart rate before, during, and after exercise relative to the sham and/or inactive control groups.¹²⁻¹⁴

Blood Pressure

There are 2 studies in this category.^{13,14} One study reported a significant increase in blood pressure before the exercise

regimen in the marijuana group relative to the sham and inactive control groups.¹⁴ Thus, this may explain a significant drop in physical work capacity.¹⁴ During the exercise and recovery period, another study reported a significant decrease in blood pressure in the marijuana group relative to the inactive control group.¹³ The authors offered no explanation for this finding.¹³ There is very low quality evidence (2 trials, 30 participants) suggesting that marijuana smoking increases blood pressure before exercise and decreases blood pressure during and after exercise relative to sham and/or inactive control groups.^{13,14}

Pulmonary Measures

There are 3 studies in this category.¹²⁻¹⁴ Each study has various measurements for pulmonary function, including vital capacity, expiratory flow rate, oxygen consumption, minute ventilation, breathing rate, oxygen uptake, carboxyhemoglobin level, carbon dioxide output, tidal volume, and forced expiratory output.

One study reported no significant differences in vital capacity and expiratory flow rate for marijuana compared with the sham and inactive control groups.¹⁴

Another study reported no significant differences in oxygen consumption between all groups.¹² Overall, there was no significant difference in hemoglobin levels between all groups.¹²

At peak exercise performance, one study reported no significant differences in minute ventilation, breathing rate, oxygen uptake, carboxyhemoglobin level, carbon dioxide output, and tidal volume between the marijuana group and the inactive control group.¹³ However, marijuana-induced bronchodilation and significantly higher forced expiratory volume at 1 second (FEV₁) was still present after exercise compared with the inactive control group.¹³ However, there is

TABLE 3. Risk of Bias Chart

| Bias | Maksud and Baron ¹² | Renaud and Cormier ¹³ | Steadward and Singh ¹⁴ |
|--|---|--|---|
| Random sequence generation (selection bias) | High risk | Low risk | Unclear risk |
| | Allocation based on questionnaire responses | "Randomized" | Not addressed |
| Allocation concealment (selection bias) | High risk | Unclear risk | Unclear risk |
| | Allocation based on questionnaire responses | Not addressed | Not addressed |
| Blinding (performance bias and detection bias) | Unclear risk | High risk | High risk |
| All outcomes—patients? | Not addressed | No sham intervention | Likely that blinding could have been broken |
| Blinding (performance bias and detection bias) | Unclear risk | High risk | Low risk |
| All outcomes—providers? | Not addressed | No sham intervention | "Double blind" |
| Blinding (performance bias and detection bias) | Unclear risk | Unclear risk | Unclear risk |
| All outcomes—outcome assessors? | Not addressed | Not addressed | Not addressed |
| Incomplete outcome data (attrition bias) | Low risk | Low risk | Unclear risk |
| All outcomes—dropouts? | No dropouts | No dropouts | 2 dropouts, addressed but not justified |
| Incomplete outcome data (attrition bias) | Low risk | Low risk | Low risk |
| All outcomes—Intention-to-treat analysis? | All prespecified outcomes reported | All prespecified outcomes reported | All prespecified outcomes reported |
| Selective reporting (reporting bias) | Low risk | Low risk | Low risk |
| | All prespecified outcomes reported | All prespecified outcomes reported | All prespecified outcomes reported |
| Similarity of baseline characteristics? | Low risk | Unclear risk | Low risk |
| | No significant differences among baseline characteristics | Not addressed | No significant differences among baseline characteristics |
| Cointervention avoided or similar? | Not applicable (N/A) | Low risk | Low risk |
| | No interventions due to study design | No cointerventions | No cointerventions |
| Compliance acceptable? | Not applicable (N/A) | Low risk | Low risk |
| | No interventions due to study design | Compliance with interventions acceptable | Compliance with interventions acceptable |
| Timing outcome assessments similar? | Not applicable (N/A) | Low risk | Low risk |
| | No interventions due to study design | Outcomes measured at same time across groups | Outcomes measured at same time across groups |
| Overall impression | High risk | High risk | Unclear risk |

low quality evidence (1 trial, 12 participants) suggesting that marijuana smoking significantly increases FEV₁ relative to inactive control.¹³

Physical Work Capacity

There are 2 studies in this category.^{12,14} One study reported a significant drop in physical work capacity in the marijuana group in comparison with the sham and inactive control groups.¹⁴ By contrast, another study reported no significant differences in physical work capacity between all groups.¹² This discrepancy may be attributed to the differences between acute and chronic effects of marijuana. However, there is still low quality evidence (2 trials, 83 participants) suggesting that

smoking marijuana significantly decreases physical work capacity in comparison with the sham and inactive control groups.^{12,14}

Grip Strength

There is one study in this category.¹⁴ There is low quality evidence (1 trial, 20 participants) suggesting no significant differences between the marijuana, sham, and inactive control groups for grip strength.¹⁴

Exercise Duration

There is one study in this category.¹³ The study reported a significant reduction in exercise duration in the marijuana

TABLE 4. Summary of Findings

| Outcomes | Intervention | | | No. of Participants (Studies) | Quality of the Evidence (GRADE) *† | Comments |
|------------------------------|--|--|---|-----------------------------------|---------------------------------------|----------|
| | No Treatment | Sham Marijuana (No Active Ingredients) | Marijuana, 50-150 g, 7 mg/kg (1.3%-2.3% THC) | | | |
| Heart rate | No statistically significant changes (NS) ¹²⁻¹⁴ | NS ¹⁴ | Significantly increased resting heart rate by 43.5% ¹⁴ and 26.2%. ¹³ Observed tachycardia during exercise regimen. ¹³ NS during all intervals of exercise regimen. ¹² | 95 (3) | ⊕○○○ Very low | |
| | | | | Maksud and Baron ¹² | Limitations 1‡ | |
| | | | | Renaud and Cormier ¹³ | Imprecision 0 | |
| | | | | Steadward and Singh ¹⁴ | Inconsistency 1 | |
| | | | | | Indirectness 1§ | |
| | | | | | Other 0 | |
| Blood pressure | NS ^{13,14} | NS ¹⁴ | Significantly increased resting blood pressure ($P < 0.05$). ¹⁴ Significantly decreased blood pressure during exercise regimen and resting period ($P < 0.05$). ¹³ | 30 (2) | ⊕○○○ Very low | |
| | | | | Renaud and Cormier ¹³ | Limitations 1‡ | |
| | | | | Steadward and Singh ¹⁴ | Imprecision 1 | |
| | | | | | Inconsistency 1 | |
| | | | | | Indirectness 1§ | |
| | | | | | Other 0 | |
| Pulmonary measures | NS ¹²⁻¹⁴ | NS ¹³ | Statistically significant improvement of FEV ₁ after exercise ($P < 0.001$). ¹³ | 95 (3) | ⊕⊕○○ Low | |
| | | | | Maksud and Baron ¹² | Limitations 1‡ | |
| | | | | Renaud and Cormier ¹³ | Imprecision 0 | |
| | | | | Steadward and Singh ¹⁴ | Inconsistency 0 | |
| | | | | | Indirectness 1§ | |
| | | | | | Other 0 | |
| Physical work capacity (PWC) | NS ^{12,14} | NS ¹⁴ | Significantly decreased PWC ($P < 0.05$). ¹⁴ | 83 (2) | ⊕⊕○○ Low | |
| | | | | Maksud and Baron ¹² | Limitations 1‡ | |
| | | | | Steadward and Singh ¹⁴ | Imprecision 0 | |
| | | | | | Inconsistency 0 | |
| | | | | | Indirectness 1§ | |
| | | | | | Other 0 | |
| Grip strength | NS ¹⁴ | NS ¹⁴ | NS ¹⁴ | 18 (1) | ⊕⊕○○ Low | |
| | | | | Steadward ¹⁴ | Limitations 1‡ | |

| TABLE 4. Summary of Findings (Continued) | | | | | | |
|--|------------------|--|---|----------------------------------|------------------------------------|----------|
| Outcomes | Intervention | | | No. of Participants (Studies) | Quality of the Evidence (GRADE) *† | Comments |
| | No Treatment | Sham Marijuana (No Active Ingredients) | Marijuana, 50-150 g, 7 mg/kg (1.3%-2.3% THC) | | | |
| | | | | | Imprecision 1¶ | |
| | | | | | Inconsistency 0 | |
| | | | | | Indirectness 0 | |
| | | | | | Other 0 | |
| Exercise duration | NS ¹³ | Not applicable (N/A) | Significantly decreased exercise duration by 6.2% ($P < 0.05$) in study ¹³ | 12 (1) | ⊕○○○ Very low | |
| | | | | Renaud and Cormier ¹³ | Limitations 2 # | |
| | | | | | Imprecision 1 | |
| | | | | | Inconsistency 0 | |
| | | | | | Indirectness 0 | |
| | | | | | Other 0 | |
| <p><i>Marijuana versus Control.</i> Patient or population: male and female participants aged 18 to 65 with no comorbidities. Settings: track, gym, or recreational ward. Intervention: marijuana cigarette. Comparison: sham marijuana cigarette or no treatment.</p> <p><i>GRADE Working Group Grades of Evidence.</i> High quality: further research is very unlikely to change our confidence in the estimate of effect. Moderate quality: further research is likely to have an important impact on our confidence in the estimate of effect and may change the estimate. Low quality: further research is very likely to have an important impact on our confidence in the estimate of effect and is likely to change the estimate. Very low quality: we are very uncertain about the estimate.</p> <p>* Evidence from RCTs is initially classified as high quality and then downgraded based on 5 criteria: limitations in design, imprecision of results, inconsistency of results, indirectness of evidence, and high probability of publication bias. † Evidence from observational studies is initially classified as low quality and then upgraded based on 3 criteria: large magnitude of effect, all plausible confounding would reduce a demonstrated effect when results show no effect, and dose-response gradient. ‡ Evidence obtained from study designs with a high risk of bias. § Surrogate outcome measures used. ¶ Small study group. No direct comparison of therapeutic dose with sham therapy. # Lack of allocation concealment and blinding.</p> <p><i>New Findings:</i></p> <ul style="list-style-type: none"> • Outcomes of marijuana on heart rate, blood pressure, and exercise duration remain unclear. • Sham, inactive control, and treatment groups had no significant difference on grip strength. • Ergogenic effect of treatment demonstrated by increased FEV₁, although there is low quality evidence that supports it. • Ergolytic effect of treatment demonstrated by decreased physical work capacity, although there is low quality evidence that supports it. | | | | | | |

group relative to the inactive control group.¹³ There is very low quality evidence (1 trial, 12 participants) suggesting that marijuana smoking significantly reduces exercise duration relative to the inactive control group.¹³

DISCUSSION

The results of this review found that marijuana and its effects on athletic performance remain unclear. There is very low quality evidence suggesting that marijuana significantly decreases exercise duration compared with inactive control.¹³ In addition, there is very low quality evidence suggesting that marijuana significantly alters heart rate¹²⁻¹⁴ and blood pressure.^{13,14} There is low quality evidence suggesting that marijuana induces bronchodilation and significantly increases FEV₁ after exercise compared with inactive control.¹³ There is low quality evidence suggesting that marijuana significantly decreases physical work capacity compared with the sham and inactive control groups.^{12,14} Taken as a whole, these results suggest that marijuana and its effects on athletic performance remain inconclusive (Table 4).

There were several challenges faced in this review. After identifying and screening 929 citation postings, only 3 trials met the inclusion criteria. It is clear that there are few studies in this area of research. In addition, heterogeneity between the 3 trials appeared at several levels, including study type, sample size, duration of the study, intervention, and outcome measures.¹²⁻¹⁴ As a result of heterogeneity, no meta-analyses were performed for this review. Instead, a qualitative method of combining evidence was used. However, this method is limited, as it is sensitive to how studies are categorized because meeting the criterion of a certain level of evidence depends on the number of studies present in a category. Overall, the weaknesses of this review rest with the 3 included trials. Because none of the trials had a low risk of bias, we were unable to make conclusive statements about the strength of evidence. One trial was an observational study,¹² one trial was described as a crossover study,¹⁴ and another was described as a crossover randomized controlled trial (RCT).¹³

All studies were assessed to have a high or unclear risk of bias¹²⁻¹⁴ (Table 3). We believe that high quality of evidence should be reserved for conclusions in which the likelihood

of making an incorrect reference is small, that is, having consistent findings in multiple sampled studies with low risk of bias. Thus, for their quality of evidence, outcomes derived from at least 1 RCT or crossover study were downgraded from high level of evidence to moderate, low, or very low depending on the presence of limitations in design, indirectness of evidence, inconsistency of results, imprecision of results, and probability of publication bias with the Cochrane GRADE scale¹¹ (Table 4). Alternatively, outcomes derived from only observational studies were upgraded from a low level of evidence to moderate or high depending on the presence of a large magnitude of effect, all plausible confounding being able to reduce a demonstrated effect when results show no effect, and a dose–response gradient. The quality of evidence could also be downgraded depending on similar limitations listed.

Our approach in screening and identifying the literature had several strengths. We had 2 comprehensive and independent librarian-assisted searches of multiple databases. In addition, references were screened, and content experts contacted. We had at least 2 people to decide on article relevance and assess quality. Disagreements were resolved through a third assessor.

CONCLUSIONS

This review found that marijuana and its effects on athletic performance remain unclear because the number and quality of the studies was low; hence, we could only draw limited conclusions. The effect of marijuana on outcomes including heart rate, blood pressure, and exercise duration remains unclear. There is low quality evidence that suggests that there is no significant difference for grip strength between treatment, sham, and inactive control groups.¹⁴ There is low quality evidence that suggests that there is an ergogenic effect of marijuana demonstrated by induced bronchodilation and increased FEV₁ after exercise compared with inactive control, and that there is an ergolytic effect of treatment demonstrated by decreased physical work capacity compared with the sham and inactive control groups.^{12–14}

As a result of its illegal nature, there is a lack of current research on marijuana and its effects on athletic performance. However, there are evolving political and social views on the legalization of marijuana, although the banning of substances in competition is a highly debated and continually changing field. Therefore, there is a high precedent for more high-quality RCTs on this topic to justify current and future doping policy based on the effects of marijuana on athletic performance.

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