Received: 23 May 2024 | Accepted: 25 November 2024

DOI: 10.1111/add.16746

RESEARCH REPORT

ADDICTION SSA

Visual function and vehicle driving performance under the effects of cannabidiol: A randomized cross-over experiment

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Funding information
Research Projects C-EXP-194-UGR23 funded by FEDER/Junta de Andalucía-Consejería de Transformación Económica, Industria, Conocimiento y Universidades and PID2020-115184RB-I00, funded by MCIN/AEI/10.13039/501100011033

Abstract

Aims: This study aimed to determine the effect of vaporized cannabidiol (CBD) on visual function and vehicle driving performance, given the growing popularity of CBD use worldwide.

Design: Randomized, double-blind, placebo-controlled cross-over experimental study.

Setting: Laboratory of Vision Sciences and Applications, University of Granada, Spain.

Participants: Thirty participants were recruited through advertisements placed in the local newspaper and distributed among the university community. They had a mean age of 26.2 (6.2) years, and 70% were male. All of them were occasional users of CBD or cannabis, and held valid driving licenses.

Interventions: Three experimental sessions, conducted one week apart, in which a placebo, 15% CBD (16 mg) or 30% CBD (32 mg) was vaporized.

Measurements: The primary endpoint for driving performance was the overall driving performance score (ODPS). Secondary outcomes included visual function variables such as static and dynamic visual acuity, stereoacuity, contrast sensitivity, motion detection and other driving performance parameters such as mean speed, lateral vehicle control or reaction time.

Findings: Comparisons revealed no statistically significant changes in ODPS after vaporizing CBD at 15% or 30% compared with the placebo ($\chi^2 = 0.479$; $P = 0.787$). Visual function remained largely unchanged, with only a statistically significant decrease in motion detection ($\chi^2 = 7.980$; $P = 0.018$). Similarly, no statistically significant differences were found in driving performance secondary outcomes, such as the standard deviation of lateral lane position ($\chi^2 = 0.068$; $P = 0.966$), distance travelled outside the lane ($\chi^2 = 2.530$; $P = 0.282$), reaction time ($\chi^2 = 1.000$; $P = 0.607$), or collisions ($\chi^2 = 0.987$; $P = 0.610$). Additionally, correlations between ODPS and visual function did not yield statistically significant results.

Conclusions: Consumption of vaporized cannabidiol in 16 mg and 32 mg doses does not appear to affect simulated vehicle driving performance and visual function.

KEYWORDS
cannabidiol, cannabis, CBD, driving performance, driving safety, vision, visual function

INTRODUCTION

Cannabis is composed of a high variety of cannabinoids, with Δ9-tetrahydrocannabinol (THC) and cannabidiol (CBD) being the most prevalent [1]. The intoxicating effect is attributed to the first compound, whereas CBD is known for its relaxing and sedative effects.

Cannabidiol is currently being used in the treatment of conditions such as epilepsy and anxiety, with no evidence of abuse or dependence [2–4]. Cannabidiol-based products have gained considerable popularity in recent years [5]. In the United States (US), the number of Google searches for CBD increased by between 100% and 150% each year between 2016 and 2019 [6]. It has been reported that the global CBD market was valued at USD 6.4 billion in 2022 and is expected to grow at a yearly growth rate of 16.2% from 2023 to 2030 [7]. These figures demonstrate a considerable increase in interest in cannabidiol, and consequently, in its consumption.

Recent survey-based studies conducted in the United Kingdom (UK), France, the United States and Canada have revealed that between 10% and 26% of respondents use CBD, primarily for wellness purposes such as improving sleep and reducing stress [5, 8, 9]. In terms of the method of consumption, the data indicates that approximately 60% of users inhale products containing CBD products, whereas 20% take them sublingually [8]. The perception of CBD as a risk-free substance may be attributed to its non-intoxicating nature and the belief that its therapeutic effects are safe [5]. Such considerations give rise to concerns regarding the safety of CBD consumption, given the generation of adverse effects such as drowsiness. In light of this, it is imperative to exercise caution when consuming CBD, particularly in situations such as driving [4, 10].

The available evidence concerning the effect of CBD on driving performance is limited. The study by Arkell et al. [11] did not yield statistically significant results with regard to the impact of CBD-dominant cannabis on the SD of the lateral vehicle position, a measure of lane weaving. However, the authors noted that the dosage used was not typical. The operation of a vehicle requires the correct integration of the motor, cognitive and visual functions. The latter has been found to be negatively affected by the use of THC-containing cannabis in multiple ways [12], and this impairment has been significantly correlated with worse driving performance [13]. Despite its widespread use, there is currently no information available regarding the effect of CBD on visual function. Given that the endocannabinoid receptors are located within the visual system and that THC has been demonstrated to influence visual function, further investigation is required into the potential impact of other highly consumed cannabinoids, such as the CBD.

To gain further insight into the impact of CBD on driving performance, this study tested the effect of two common CBD doses (16 mg and 32 mg) on driving performance and visual function. A further objective was to ascertain whether the visual alterations induced by this substance could potentially impair driving performance.

METHODS

Design

This was a randomized, double-blind, placebo-controlled cross-over experimental study. Participants completed three experimental sessions (placebo, CBD 15% or 16 mg dose and CBD 30% or 32 mg dose) in a randomized order. A 1-week washout period was allowed between sessions.

Participants

The study recruited users of cannabis (containing THC) or CBD in Granada, Spain. For cannabis (containing THC) users, only occasional users were included, defined as self-reported use of cannabis at least once, but less than four times per week in the previous 3 months. This was checked by asking participants about the average number of days per week they had used cannabis in the previous 3 months [12, 14]. If they did not meet this requirement, they were not included in the study. Other inclusion criteria were: having a current driving licence with at least 1 year's driving experience; driving at least once a week; monocular visual acuity of at least 6/6 (Snellen) using any habitual correction for driving; and no binocular disorders. Exclusion criteria also included certain past or current medical conditions; current cannabis or alcohol use disorders as assessed by the Cannabis Use Disorders Identification Test-Revised (CUDIT-R) [15] and the Alcohol Use Disorders Identification Test (AUDIT) [16]; history of other drugs use (i.e. more than five times in their lifetime); pregnancy or lactation; and simulator sickness.

The study adhered to the tenets of the Declaration of Helsinki and was prospectively approved by the Human Research Ethics Committee of the University of Granada (3012/CEIH/2022). Before participation a signed informed consent was obtained from each participant.

Procedures

The first session was used to check the inclusion criteria and to explain all the conditions and procedures. After giving informed consent, participants completed a 20-minute training session on the driving simulator to familiarize themselves with the system. All participants were asked to abstain from drugs for 4 days and alcohol for 24 hours before each experimental session. All of them completed three experimental sessions (placebo, CBD 15% and CBD 30%) that were conducted in random order and separated by 1 week. The randomization of the sessions was controlled by one researcher external to the experimental sessions, and each one was coded, so that the researchers in charge of the experimental sessions did not know which condition was involved in each case.

In each session, participants vaporized a substance with different levels of isolated CBD [0%–placebo (0 mg CBD), 15% (16 mg CBD)

and 30% (32 mg CBD)], masked with mint essence. The inhalation protocol was as follows: participants had to inhale for 5 seconds, to maintain for 3 seconds and exhale. They rested for 30 seconds and the sequence started again until completing 15 repetitions [11]. Total time of consumption was 9.5 minutes.

Ten minutes after consumption, participants were also asked which session they thought they were participating in and what effect they perceived on a scale of 1 to 10, with 1 being no effect and 10 being a maximum effect. Finally, they were given the Memory Impairment Screen (MIS), a validated test to reflect memory impairment and dementia [17, 18]. It is a quick test from which scores from 0 to 8 are obtained. Scores between 5 and 8 points indicate no cognitive impairment. Twenty minutes after CBD use, the session started and visual function and driving performance were assessed, which took approximately 1 hour to complete.

On each experimental session, drug and alcohol use was checked. For this purpose, the Dräger DrugTest 5000 and the Dräger Alcotest 7110 MK–III (Dräger Safety AG & Co., KGaA) were used. The Dräger DrugTest 5000 is able to detect the use of amphetamines, benzodiazepines, cocaine, cannabis (THC), methamphetamines, opiates, methadone or ketamine. If tested positive for any substance, the session was cancelled.

Measures

Driving assessment

A fixed-base driving simulator with three high-definition 27″ screens was used, providing a view of 180°. The software used for the driving simulator was the SIMAX DRIVING SIMULATOR v.4.0.8 BETA (SimaxVirt S.L.) [19–21]. Participants completed a route of approximately 12.5 km that comprised three different sections based on the types of roads they usually drive on: dual carriageway, mountain road and city.

The overall driving performance score (ODPS) was computed. This general score was generated as in previous studies, as described in the Supporting Information [22–24].

Visual function assessment

Participants' vision was assessed using a battery of tests, which were undertaken binocularly. High-contrast static visual acuity (i.e. or the ability to resolve detail) was assessed binocularly at 5.5 m using the chart implemented in the POLA VistaVision Visual Chart System (DMD Med Tech srl.). Binocular contrast sensitivity was also measured with the same instrument and the spatial frequencies tested were 0.75, 1.5, 3, 6, 12 and 18 cycles per degree (cpd), at a distance of 3 m. Finally, we obtained the average value for all spatial frequencies.

Stereoacuity (i.e. the ability to distinguish the spatial or three-dimensional location of objects in the environment) was also investigated as a key visual function for driving. For distance testing, we used the differentiated stereo D8 polarized test implemented in the VistaVision monitor at 5.5 m. For near testing, we used the Randot Stereotest (Stereo Optical).

Motion detection and sensitivity were assessed by two different tests. Dynamic visual acuity was measured binocularly at 5.5 m, using the chart included in the OptoTab software (SmarThings4Vision, Zaragoza, Spain). We chose three different speeds [5 degrees per second (deg/s), 10 deg/s and 15 deg/s] and only one direction of movement (from left to right). The average of the different speeds was taken. Participants were also assessed for motion sensitivity using the coherent dot motion perception test (CDM) included in the same software. The test was performed in the dark at a distance of 5.5 m. It consisted of a circular pattern of white dots on a black background. Within the circle there was a set percentage of white dots that moved at the same speed and direction, whereas the rest moved randomly. The subject had to answer in which direction of global movement he/she had perceived (upward, downward, left or right). Dot motion detection was assessed binocularly for four different coherence values: 10%, 20%, 30% and 40% and presented as an average. The test configuration included 300 ms of stimulus presentation and a dot density of 10 dots/deg^2 and coherent dots moved at a speed of 7 deg/s.

Primary outcome

The primary outcome was the ODPS.

Secondary outcomes

Secondary outcomes included independent measures of driving performance: mean speed (km/h), distance driven invading the opposite lane (m), total distance driven outside the lane (m), SD of the lateral position (SDLP) (m), SD of the angular velocity of the steering wheel (rad/s), total time (s) and brake reaction time (s). As brake reaction times required specific conditions to occur [22], these events did not appear in all sessions. More information on this variable and its derivation can be found in the Supporting Information.

All parameters assessed for visual function (visual acuity, contrast sensitivity and motion detection) were considered secondary outcomes.

Statistical analysis

Statistical analysis was performed with the SPSS v.28 software (SPSS).

Sample size was determined by power calculation using the effect size obtained in a previous study on the effect of THC-containing cannabis on visual function (visual acuity, contrast sensitivity and stereoacuity) and driving performance (ODPS) [13]. The analysis showed that 14 participants were needed to detect an equivalent effect with 95% power in the ODPS.

In addition, the success of blinding in the study was assessed by the James Blinding. The scale of this instrument is from 0 to 1, with 0 being no blinding at all and 1 being total blinding [25].

Primary outcome

Normality of data distribution for the ODPS was checked with the Shapiro–Wilk test. As all the primary outcome did not follow a normal distribution, a Friedman test was used to determine whether the condition had an effect in the primary outcomes, providing the χ^2 statistic.

Secondary outcomes

Secondary outcomes were compared between sessions in the same way described for the primary outcome. As only the mean speed followed a normal distribution, a repeated measures analysis of variance was used for this variable, providing the *F* statistic. For variables in which the condition showed a significant main effect, pairwise comparisons with Bonferroni correction were used.

Finally, correlations between the ODPS and visual parameters were performed with Spearman test.

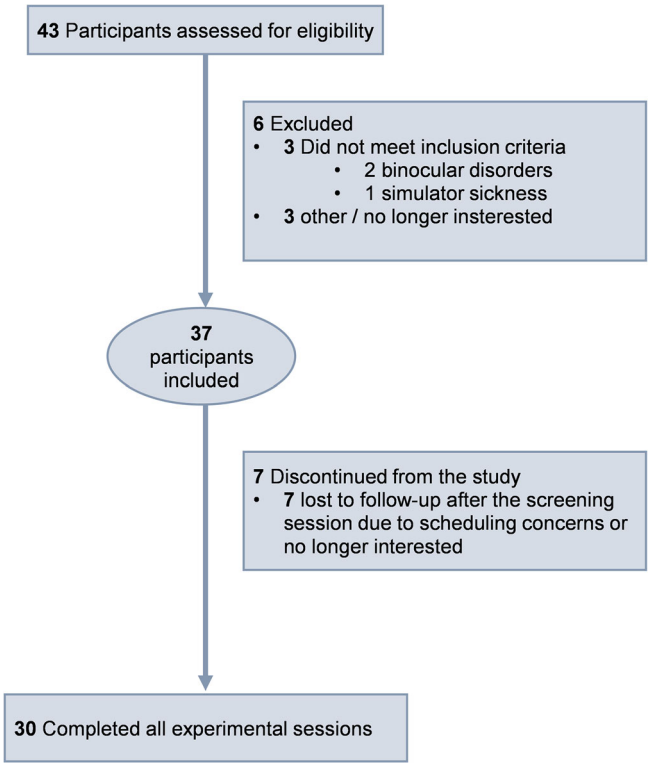

FIGURE 1 Flow diagram of participants through the study.

RESULTS

Characteristics of the sample, blinding procedure and self-perceived effect

Of the 37 participants initially included, seven dropped out of the study before attending the experimental sessions. The study was completed by 30 participants with a mean age of 26.2 ± 6.2 years (range, 19–43 years; 70% male) (Figure 1). With respect to substance use, 19 (63.3%) participants indicated to use both CBD and cannabis with THC content, seven (23.3%) only used cannabis and four (13.3%) used CBD isolated from THC. Participants were asked about their frequency of use, frequency of driving under the influence (DUI) and self-perceived effect on driving performance. Those who were both cannabis and CBD users were asked to give their responses regarding their CBD use. Table 1 shows the demographics, driving and clinical characteristics of the total sample and divided by groups of participants according to the first session of the study. Most participants used cannabis or CBD every week, and only 43% had never driven after using it. Most indicated driving gets worse (70%), but only 23% stated it gets much worse.

Table 2 shows the results of the blinding procedure, the self-perceived effect and the cognitive test scores. The experimental session that participants were able to identify more easily was the placebo. In the CBD 15% and CBD 30% conditions, more than half of participants incorrectly identified the session in which they were participating. The James Blinding index obtained was 0.47, which is close to 0.5, the level of blinding that would be expected by random guessing according to James et al. [25]. Self-perceived effect was rated similarly for both CBD sessions, but not much higher than in the placebo condition. Finally, cognitive assessment showed values very similar in all conditions, suggesting that CBD did not changed this aspect.

Driving performance

The driving performance results are presented in Table 3. All individual parameters remained stable despite CBD consumption. On the dual-carriageway, participants drove at similar mean speeds, below the speed limit (120 km/h). Similarly, vehicle control and lane position were similar, with no statistically significant differences found. In the same way, driving performance in the mountain road section did not show significant differences ($P > 0.05$). Mean speeds were very similar, with a slight reduction in CBD 30% condition. Participants drove comparable distances outside the lane in the three conditions, and SDLP and steering control (SD angular velocity of the steering wheel) did not worsen after CBD consumption, nor did reaction time.

In the city, the results for speed and vehicle steering control were also very similar, without significant differences between conditions. For the total circuit parameters, on average, crashes showed a slight decrease after CBD consumption and reaction time increased slightly in the 15% CBD condition. The driving performance index improved slightly in the CBD condition, although the differences were not statistically significant.

TABLE 1 Participant's baseline demographics, driving and clinical characteristics.

		1st session attended		
	Total sample	**Placebo (CBD 0%)**	**CBD 15%**	**CBD 30%**
n (%)	30 (100)	10 (33.3)	10 (33.3)	10 (33.3)
Age (mean ± SD)	26.2 ± 6.2	26.2 ± 7.0	25.3 ± 6.1	27.0 ± 6.1
% male; % female	70%; 30%	70%; 30%	70%; 30%)	70%; 30%
Driving experience (mean ± SD) (y)	6.9 ± 6.3	7.0 ± 7.1	6.3 ± 6.4	7.5 ± 5.9
Frequency of use, *n* (%)				
Daily	3 (10)	1 (10)	0 (0)	2 (20)
2–6 days/week	12 (40)	5 (50)	2 (20)	5 (50)
Once per week	8 (26.7)	2 (20)	3 (30)	3 (30)
Every 15 days	3 (10)	1 (10)	2 (20)	0 (0)
Monthly	3 (10)	0 (0)	3 (30)	0 (0)
Less frequent	1 (3.3)	1 (10)	0 (0)	0 (0)
Frequency of DUI, *n* (%)				
Weekly	4 (13.3)	2 (20)	1 (10)	1 (10)
Monthly	8 (26.7)	3 (30)	2 (20)	3 (30)
Less than monthly	5 (16.7)	1 (10)	3 (30)	1 (10)
Never	13 (43.3)	4 (40)	4 (40)	5 (50)
Perception of the effect in driving performance, *n* (%)				
Much worse	7 (23.3)	1 (10)	4 (40)	2 (20)
Slightly worse	14 (46.7)	6 (60)	5 (50)	3 (30)
Does not worsen	7 (23.3)	2 (20)	0 (0)	5 (50)
Improve	2 (6.7)	1 (10)	1 (10)	0 (0)

Note: Data are shown for the total sample and for participants grouped according to which was their first session of the study.
Abbreviations: CBD, cannabidiol; DUI, driving under the influence.

TABLE 2 Results of the blinding masking procedure, self-perceived effect and cognitive test score for each session.

	Placebo (CBD 0%)	**CBD 15%**	**CBD 30%**
Blinding *n* (%)			
Correct	19 (63)	11 (37)	13 (43)
Incorrect	11 (37)	19 (63)	17 (57)
Self-perceived effect mean (SD) (1-nothing; 10-maximum)	1.90 (1.47)	3.20 (2.14)	3.67 (2.25)
Cognitive test score mean (SD)	7.83 (0.39)	7.79 (0.51)	7.62 (0.75)

Abbreviation: CBD, cannabidiol.

Visual function assessment

The results of visual function assessment in the different conditions are shown in Table 4. Statistical comparisons have shown a significant difference only for dot motion detection, and pairwise comparisons showed significant differences between CBD 15% and 30% conditions ($P = 0.035$). The correlation analysis did not show significant associations between visual parameters and ODPS.

DISCUSSION

This double-blind, placebo-controlled randomized experimental study investigated the effect of vaporizing CBD in visual function and driving performance. Participants were evaluated in three different conditions: placebo (CBD 0%), CBD 15% and CBD 30%. Results indicated that CBD consumption did not significantly altered overall visual function, finding a statistically significant decrease in motion detection sensitivity after 30% CBD consumption. Driving performance was not altered at the concentrations used.

Although CBD use can have side effects, such as drowsiness, which could pose a risk when driving [10], our study suggests that vaporized CBD at the doses used did not affect simulated driving performance. The SDLP is considered the gold standard for studying drug-related driving impairment. This measure has been shown to be sensitive to the deterioration generated by THC [13, 14], but not by CBD consumption [11, 26]. Arkell et al. [11] found that after consuming THC-dominant cannabis, the SDLP was 20.59 cm, whereas after

TABLE 3 Driving performance comparisons between experimental sessions.

	Driving parameters	Placebo CBD 0% mean (SD)	CBD 15% mean (SD)	CBD 30% mean (SD)	Statistic (χ^2/F*) *P* value
Dual carriageway	Mean speed (km/h)	115.79 (11.62)	118.13 (12.86)	117.51 (12.15)	1.252* 0.293
	Distance driven onto the shoulder (m)	90.60 (105.01)	86.22 (94.17)	77.16 (67.28)	0.491 0.782
	SD angular velocity steering wheel (rad/s)	0.19 (0.05)	0.19 (0.05)	0.19 (0.06)	1.846 0.397
Mountain road	Mean speed (km/h)	56.03 (2.70)	56.10 (2.86)	53.30 (10.08)	0.479* 0.787
	Distance driven in the opposite lane (m)	240.02 (199.41)	212.61 (162.73)	206.30 (162.87)	0.205 0.903
	Distance driven onto the shoulder (m)	27.52 (43.75)	25.08 (37.02)	46.80 (112.33)	0.263 0.877
	Total distance driven outside the lane (m)	267.50 (197.62)	237.70 (172.56)	253.10 (169.02)	2.530 0.282
	SD angular velocity steering wheel (rad/s)	0.60 (0.19)	0.56 (0.13)	0.55 (0.12)	0.889 0.641
	SDLP (m)	0.50 (0.09)	0.50 (0.08)	0.45 (0.14)	0.068 0.966
City	Mean speed (km/h)	32.45 (5.55)	31.47 (5.68)	32.31 (5.73)	0.549* 0.580
	SD angular velocity steering wheel (rad/s)	1.17 (0.25)	1.13 (0.29)	1.14 (0.21)	0.889 0.641
Total circuit	Total time (s)	769.47 (68.14)	773.38 (66.52)	744.64 (126.99)	4.171 0.124
	Collisions	1.11 (1.29)	1.04 (1.45)	0.79 (0.96)	0.987 0.610
	Brake reaction time (s) (n = 13)	0.85 (0.10)	0.92 (0.22)	0.87 (0.18)	1.000 0.607
	ODPS	−0.09 (0.62)	0.01 (0.56)	0.10 (0.39)	0.479 0.787

Abbreviations: ANOVA, analysis of variance; CBD, cannabidiol; ODPS, overall driving performance score; SDLP, SD of the lateral position.
*A repeated measures ANOVA was applied and *F* statistic is reported.

TABLE 4 Visual function comparisons between experimental sessions.

Visual parameters	Placebo CBD 0% Mean (SD)	CBD 15% Mean (SD)	CBD 30% Mean (SD)	Statistic (χ^2) *P* value
Static VA (decimal)	1.25 (0.17)	1.23 (0.12)	1.28 (0.14)	2.094 0.351
Dynamic VA (decimal)	0.69 (0.11)	0.68 (0.09)	0.68 (0.08)	2.362 0.307
Stereoacuity (far; arcsec)	61.67 (61.14)	56.33 (56.84)	70.00 (58.66)	5.013 0.082
Stereoacuity (near; arcsec)	28.83 (14.67)	31.67 (15.88)	30.67 (15.08)	1.083 0.582
CS	145.48 (20.18)	145.25 (20.10)	138.09 (23.60)	0.661 0.719
Dot motion detection	0.85 (0.11)	0.88 (0.11)	0.84 (0.09)	7.980 0.018

Abbreviations: CBD, cannabidiol; CS, contrast sensitivity; VA, visual acuity.

CBD-dominant cannabis, it was 18.21 cm, similar to the placebo condition at 18.28 cm. In the simulator, SDLP values around 50 cm were observed, but they did not increase after CBD consumption, and were lower than those seen after THC use in a previous study [13].

Other parameters such as speed, steering control and distance travelled out of lane did not change significantly, in contrast to studies on the effect of THC-containing cannabis [13, 14, 27]. Although reaction time seemed to increase slightly in the 15% CBD session, for the 30% CBD session it showed a similar value to baseline, with no significant differences. Adverse effects of CBD include sedation and drowsiness, both of which could be related to poorer reaction time. However, our results cannot confirm this assumption, at least for the doses used and the reduced sample obtained for this parameter. Crashes did not increase significantly, in contrast to THC, for which there are data suggesting a 1.2-fold to twofold increase. Our findings are in agreement with that of Rudisill et al. [28], who studied the effect of taking 3 mg of CBD in 21 university students on variables such as SDLP, distance travelled out of the lane or reaction time, without finding a significant effect of the substance. As a general measure, the ODPS did not show an impairment, it was even slightly better in both CBD conditions with respect to the baseline. The ODPS has shown a significant impairment after THC use [13], as well as a similarly obtained overall score by Marcotte et al. [29]. This parameter has been sensitive to detect impairments in other studies with older drivers or drunk drivers, also showing significant associations with visual performance [22, 30, 31].

With regard to visual performance, the use of CBD did not significantly alter the majority of the visual parameters assessed, in contrast to THC [12, 32, 33]. One of the visual functions for which several studies have established an impairment for THC consumption is contrast sensitivity. Our results showed an average contrast sensitivity reduction of approximately 5% in the CBD 30% session, without being statistically significant. For cannabis with THC content, we found a reduction of 10% in a previous study, this change being statistically significant [12]. Other authors have also found permanent impairments in contrast sensitivity in cannabis users under low luminance conditions, indicating an impact in low level visual processing [33]. This visual parameter is of particular importance because it has been found to be the best predictor of cannabis users' subjective perception of visual changes [12], as well as for its proven influence on driving performance [34]. Similarly, other tests such as static and dynamic visual acuity or stereoacuity did not show significant differences. In this case, significant impairment was seen following cannabis use with THC content and, particularly, impaired stereopsis and static visual acuity were shown to be related to poorer vehicle lane control and poorer overall driving performance [12, 13]. Visual function results only showed a significant decrease for the dot motion detection test, which assesses motion sensitivity in central vision for random dot stimuli. For THC use, an increase in movement detection thresholds has been seen [33]. Motion detection is a crucial visual aspect of driving, because the environment is constantly in motion. Accurate detection is essential for timely responses to avoid accidents. Lacherez et al. [35] found a relationship between two similar tests of motion detection sensitivity and speed of obstacle detection in a video-based driving test. The evidence suggests that older drivers with reduced motion detection sensitivity struggle to detect hazards and road signs, leading to poorer performance in both controlled road courses and real-world driving tests [36, 37]. We have not obtained significant correlations with driving, and this may be explained by the fact that the impairment found in the CDM test is not sufficient to worsen this task or clinically significant.

Correlation analysis found no significant associations between visual parameters and driving performance. As these were young people with normal visual abilities, we did not have enough variability in the data to obtain this information. Our results are in agreement with those found in the work of Arkell et al. [11] using doses normally marketed for consumption. However, visual function has remained almost unchanged, when the same variables have been shown to be highly sensitive to changes brought about by THC consumption. Future work should, therefore, explore higher doses, larger sample sizes with similar gender distribution and different profiles of user to obtain more evidence to support safety and efficacy of CBD.

CONCLUSIONS

In this randomized, double-blind, placebo-controlled study, participants showed no significant changes in simulated driving performance after the vaporization of CBD with 15% and 30% concentrations with respect to the placebo (CBD 0%). The ODPS did not worsen, even with slight and non-significant improvements in CBD conditions. Visual function also demonstrated to be quite robust after CBD use, only showing a significant decrease for coherent dot motion detection at the CBD 30% dose. Given this lack of changes, visual data did not show significant correlations with driving performance.

The results of this study suggest that vaporized CBD seems to be a safe substance for visual function and vision-dependent tasks such as driving. Further studies are needed to ascertain if higher doses of CBD could pose a risk. Although higher doses of CBD via inhalation are not common, they may be common for oral consumption, therefore, these studies should focus on this route of administration. This would facilitate education and informed decision making based on research and evidence.

AUTHOR CONTRIBUTIONS

Sonia Ortiz-Peregrina: Concept and design; acquisition, analysis or interpretation of data; drafting of the manuscript; critical revision of the manuscript for important intellectual content; statistical analysis; obtained funding; administrative, technical or material support; supervision. **Francesco Martino**: Acquisition, analysis or interpretation of data; drafting of the manuscript; critical revision of the manuscript for important intellectual content; statistical analysis; administrative, technical or material support; supervision. **Miriam Casares-López**: Acquisition, analysis or interpretation of data; critical revision of the manuscript for important intellectual content; administrative, technical or material support; supervision. **Pilar Granados-Delgado**: Acquisition,

analysis or interpretation of data; critical revision of the manuscript for important intellectual content; administrative, technical or material support; supervision. **Rosario G. Anera**: Concept and design; critical revision of the manuscript for important intellectual content; obtained funding; administrative, technical or material support; supervision. **José J. Castro Torres**: Concept and design; critical revision of the manuscript for important intellectual content; obtained funding; administrative, technical or material support; supervision.

ACKNOWLEDGEMENTS

We thank Dräger Hispania S.A.U. (Madrid, Spain) and LABOGRAN (Granada, Spain) for lending us the drug analyzer. We also thank 'Los niños de la Puri' SL (Granada, Spain) for sharing information on common usage patterns in the population.

DECLARATION OF INTERESTS

None.

DATA AVAILABILITY STATEMENT

The datasets generated during the current study are available from the corresponding author on reasonable request.

CLINICAL TRAIL REGISTRATION

Trial registration: clinicaltrials.gov Identifier NCT06322303

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

How to cite this article: Ortiz-Peregrina S, Martino F, Casares-López M, Granados-Delgado P, Anera RG, Castro Torres JJ. Visual function and vehicle driving performance under the effects of cannabidiol: A randomized cross-over experiment. Addiction. 2025. https://doi.org/10.1111/add.16746