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Clinical Trials

Influence of Cannabidiol Use on Visual Function and Optical Quality: A Randomized Controlled Trial

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Purpose: To study the influence of different concentrations of vaporized cannabidiol (CBD; 0%, 15%, and 30%) on visual function and optical quality.

Methods: A randomized, crossover, double-blind, placebo-controlled, experimental study was conducted. A total of 30 participants with a mean age of 26.0 ± 6.3 years completed the study. Placebo (0 mg of CBD), 15% (16 mg of CBD), and 30% (32 mg of CBD) concentrations of CBD were employed. Visual function was evaluated through various tests, including pupil size, static and dynamic visual acuity, contrast sensitivity, dot motion detection, visual disturbance index (VDI), and stereoacuity. Optical quality was assessed by log(s), modulation transfer function (MTF) cutoff, objective scattering index (OSI), and Strehl ratio. Self-perceived visual effects were also recorded.

Results: There was no significant impairment of static and dynamic visual acuity. Contrast sensitivity was unaffected by CBD use. Mean dot motion detection showed no differences among the three concentrations. In optical quality, none of the parameters worsened under CBD use. No changes were observed for the VDI. In addition, no deterioration was observed for stereoacuity at distance or near. No changes in pupil size were found after CBD consumption.

Conclusions: This non-psychotropic CBD did not appear to adversely affect vision and seems to be a safe substance in the short term at the concentrations assessed.

Translational Relevance: The use of this cannabinoid would not be dangerous for tasks that rely heavily on vision. This study could be useful and helpful for evidence-based decision-making for public health policy on its use.

Introduction

Cannabidiol (CBD) is the main non-psychotropic constituent of cannabis. The use of CBD has increased significantly and has attracted interest worldwide.[1] In a cross-sectional study conducted in Canada and the United States in 2019 as part of the International Cannabis Policy Study, 16.2% and 26.1% of participants, respectively, reported using various CBD products.[2] In addition, a national survey in France reported that 10.1% of the sample used CBD products.[3]

Cannabidiol is marketed in various derivatives forms, such as oils, resins, or dried plant material.[1] The global cannabidiol market was valued at US$7.71 billion in 2023 and is projected to grow at a compound annual growth rate of 15.8% from 2024 to 2030.[1] According to the World Health Organization,[4] CBD is generally well tolerated and has a good safety profile and low toxicity. Several preclinical studies and acute dosing studies have reported varying levels of evidence regarding the therapeutic effects of CBD. These include limited evidence for its neuroprotective, neuropsychiatric, and anxiolytic properties and moderate evidence for its analgesic effects.[5–9] The most well-established therapeutic effect of CBD is its anti-epileptic property,[10] as demonstrated by the pharmaceutical formulation EPIDIOLEX (Jazz Pharmaceuticals, Dublin, Ireland), which was approved by the U.S. Food and Drug Administration in 2018 for the treatment of epilepsy in children,

specifically for Dravet syndrome and Lennox–Gastaut syndrome.[11] Regarding ocular health, whereas delta-9-tetrahydrocannabinol (THC) has shown some potential in reducing intraocular pressure (IOP), CBD has not demonstrated consistent evidence of significant efficacy and may even have the opposite effect by potentially increasing it.[12–14]

The endocannabinoid system is responsible for regulating, activating, and controlling many of our most important body functions, including vision.[15] Endocannabinoid receptors, mainly cannabinoid receptor 1 (CB1), play an important role in maintaining ocular homeostasis.[16,17] These receptors are located in important locations at the visual system such as the ciliary body or the retina.[15]

Previous research on the effects of cannabis containing THC on vision suggests a negative impact on visual function, including impaired visual acuity, contrast sensitivity, accommodative response, and stereopsis.[18,19] In these various studies, the concentration of THC (high or low) has not been controlled and isolated. Similarly, in a recent study,[20] we investigated the effects of different concentrations of CBD (0%, 15%, and 30%) on driving performance and visual parameters relevant to driving, including static and dynamic visual acuity, contrast sensitivity, and stereopsis. The results revealed no significant impairments in either driving performance or the visual parameters assessed. However, the current literature lacks sufficient research on the potential impact of CBD on visual function and optical quality, highlighting the need for further investigation in this area. So, it is important to determine whether the use of CBD could have negative effects on visual function and optical quality, as has been observed for THC-containing cannabis, given the increasing popularity of this compound. This would help to promote safe use and evidence-based decision-making for public health policy. Therefore, the aim of this study was to compare and provide a comprehensive understanding of the effects of different concentrations of CBD on vision, using objective and subjective tests to assess optical quality and visual performance.

Methods

Participants

Forty-three young occasional users of cannabis and/or CBD were initially recruited for the study. Occasional cannabis use was defined as using cannabis between one and three times a week in the last 3 months before the study. Inclusion criteria included monocular and binocular best-corrected visual acuity of at least to 1.0 (decimal notation), no binocular disorders, no pathologies or pharmacological treatments that could affect visual performance, a score of 8 or less on the Alcohol Use Disorders Identification Test (AUDIT),[21] and a score of less than 12 in the Cannabis Use Disorders Identification Test–Revised (CUDIT-R).[22] The exclusion criteria also included certain past or current medical conditions, use of other drugs, and pregnancy or lactation.

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). Prior to participation, subjects were verbally informed of the details and possible consequences of the study, and signed informed consent was obtained from each participant.

Visual Function

Pupil Size

Pupil size was measured in a darkened room using a VIP-300 pupillometer (NeurOptics, Irvine, CA), which is based on infrared technology. The device simulated and enabled measurement of pupil size under three illuminations levels corresponding to scotopic (background off), low mesopic (0.3 lux), and high mesopic (3 lux) viewing conditions.

Static Visual Acuity and Contrast Sensitivity

High-contrast static visual acuity (SVA) and contrast sensitivity (CS) were measured using a POLA VistaVision monitor (DMD MedTech, Villarbasse, Turin, Italy). Both tests were administered monocularly and binocularly. Visual acuity (decimal notation) was assessed at a distance of 5.5 meters and contrast sensitivity at a distance of 3 meters. For CS, six different spatial frequencies were evaluated: 0.75, 1.5, 3, 6, 12, and 18 cycles per degree (cpd).

Motion Detection and Sensitivity

Motion detection and sensitivity were assessed monocularly and binocularly with two different tests. On the one hand, detection of moving stimuli was evaluated horizontally at 5 meters by means of the dynamic visual acuity test (DVA, in decimal notation), using the chart included in the OptoTab software (SmarThings4Vision, Zaragoza, Spain). The test consisted of a series of five letters moving horizontally at a determined speed. Three different speeds (5°/s, 10°/s, and 15°/s) were tested. Motion sensitivity was also evaluated at 5 meters using the coherent dot motion (CDM) perception test. The test consisted of a circular pattern of white dots on a black background moving in a random direction (upward, downward,

left, or right). Within the circle, a set percentage of white dots moved at the same speed and direction while the rest moved randomly. Prior to the emergence of this pattern, a fixation cross briefly appeared in the location where the subject was required to direct their gaze. Subsequently, the dot pattern was presented, and after its disappearance the subject had to answer in which direction of global motion they had perceived it (upward, downward, left, or right). Dot motion detection was assessed for four different coherence values (10%, 20%, 30%, and 40%) and averaged. The test configuration included 300 ms of stimulus presentation and a dot density of 10 dots/deg, and the coherent dots moved at a speed of 7°/s.

Stereopsis

Stereopsis is the most advanced degree of binocular vision and allows depth perception. Stereopsis was evaluated by means of near and distance stereoacuity. Distance stereoacuity was assessed at a distance of 5.5 meters using the stereo D8 polarized test of the POLA VistaVision chart. A total of eight disparities (from 300 to 10 arcsec) were evaluated. In addition, near stereoacuity was measured at 40 cm with the Randot Stereotest (Stereo Optical, Chicago, IL). The task was to recognize stereoscopically perceived stimuli; the lower the stereoacuity obtained, the better the depth perception.

Visual Discrimination Capacity

Visual discrimination capacity in night-vision conditions was tested monocularly and binocularly using the Halo test with the freeware Halo V1.0 (University of Granada, Granada, Spain; http://hdl.handle.net/10481/5478). The test consists of detecting peripheral stimuli presented randomly around a central stimulus at a distance of 2.5 meters under low light conditions. Each peripheral stimulus was presented in one of the four possible positions per half-axis, out of a total of 15 half-axes. The visual disturbance index (VDI) was obtained to quantify the size of the halo and the participant's positive dysphotopsia. This index is calculated by taking into account the undetected stimuli relative to the total stimuli presented to the subject. The VDI ranges from 0 to 1, with higher values indicating a greater perception of halos. This parameter has been widely employed in clinical applications.[23,24]

Optical Quality

Retinal-Image Quality

The Optical Quality Analysis System II (OQAS II; Visometrics, Terrassa, Spain) double-pass device was used to objectively assess retinal image quality under low ambient illumination. This device has been extensively used and validated in clinical practice.[25–28] Three parameters were measured. The objective scatter index (OSI) quantifies the intraocular scattering in the outer part of the double-pass image for an artificial pupil size of 4 mm in such a way that the lower the value, the lower the amount of intraocular scattering. The Strehl ratio is defined as the ratio between the 2D-MTF (modulation transfer function curve in two dimensions) area of the eye and the diffraction-limited 2D-MTF area. A higher Strehl ratio value indicates fewer ocular aberrations and scattering. The MTF cut-off is the spatial frequency that corresponds to a theoretical MTF value of 0. The MTF and Strehl ratio data were referenced to a pupil size of 5 mm.

Straylight

Straylight is a phenomenon that causes a veil of scattered light over the retina.[29] The intraocular straylight was measured monocularly using the C-Quant device (OCULUS, Wetzlar, Germany).[29,30] The test consists of recognizing which of two central semicircular fields flickered the most by a compensation comparison method. At the end of the test, the logarithm of the straylight, log(s), is obtained. A higher value indicates greater intraocular straylight.

Experimental Procedure

The study was conducted at the University of Granada between February and September 2023. In the informed consent form, participants were explicitly informed and agreed not to drive under the influence of the substance after participating in the study. Visual and optical assessments in experimental sessions were conducted by the investigators (FM, SO-P, MC-L, and PG-D). All of them are optometrists each with over 10 years of experience in clinical research. To ensure consistency and standardization during data collection, all four jointly conducted a previous training and evaluated the first five participants, thereby ensuring total homogeneity in the study protocols. This was a randomized, crossover, double-blind, placebo-controlled study. The order of the three sessions involving different CBD concentrations was randomized using a computer-generated random sequence. The type of randomization used was simple randomization without restrictions such as blocking or stratification. Randomization and allocation concealment were performed by one of the authors (JJC-T) who was not involved in data collection. Because one of the CBD concentrations was not completely identi-

cal in color, the vials (all looking the same) were completely masked and prepared before each session by an author (JJC-T). Consequently, the investigators conducting the measurements remained blinded to the CBD concentration administered in each session. The allocation ratio used in our crossover trial was 1:1:1, meaning that each participant was equally assigned to the three intervention conditions in a randomized order. A crossover design was chosen to allow each participant to serve as their own control, thereby reducing inter-individual variability and increasing statistical power. This design also required fewer participants and allowed for more precise comparisons among the CBD conditions. Participants were equally allocated to the different intervention sequences with a 1:1:1 ratio, ensuring balanced exposure to each CBD concentration across the study. Participants underwent four experimental sessions. The screening visit and the subsequent experimental sessions were conducted with the following mean intervals: 13.1 ± 3.5 days between the screening visit and the first session, 8.8 ± 2.4 days between the first and second sessions, and 11.0 ± 5.1 days between the second and third sessions. Participants completed a screening visit to assess eligibility followed by three sessions conducted in random order (placebo, CBD 0%, CBD 15%, and CBD 30%). During the screening visit, all participants completed a questionnaire regarding their self-perceived visual effects under the influence of CBD. All participants were required to abstain from caffeine for 6 hours, drugs for 4 days, and alcohol for 24 hours prior to each session. The Dräger DrugTest 5000 and the Dräger Alcotest 7110 MK-III (Dräger Safety AG & Co. KGaA. Lübeck, Germany) were used for testing. If any substance tested positive, the session was canceled. Each experimental session was coded to ensure that the researchers were unaware of the CBD concentration. To mask the taste, a peppermint substance identical in taste and color was added to the CBD. For experimental sessions, participants vaporized cannabidiol containing 0 mg of CBD (placebo, CBD 0%), 16 mg of CBD (CBD 15%), or 32 mg of CBD (CBD 30%). The inhalation protocol was as follows[20,31]: Participants were instructed to inhale for 5 seconds, hold for 3 seconds, and exhale. They then rested for 30 seconds, and the sequence was repeated 15 times.[31] Ten minutes after consumption, participants were asked to report the concentration of CBD they thought they had consumed (CBD 0%, 15%, or 30%) and to rate the effect on a scale from 1 to 10 (with 1 being no effect and 10 being the maximum effect). A validated cognitive test, the Memory Impairment Screen (MIS)[32] was then used to screen for cognitive impairment. A score greater than 5 indicates no cognitive impairment.[32] When these tests had been completed (including the AUDIT and the CUDIT-R), visual function and optical quality were assessed using the tests described above.

Statistical Analysis

Sample size was determined by power calculation using GPower 3.1.9.2 software and data from a previous study on the effect of THC cannabis on visual function.[19] The analysis indicated that 21 participants were necessary to achieve equivalent effect sizes (Cohen's $d = 0.8–1.2$) with 95% power on some of the key measures in this study (SVA, mean CS, and stereopsis).

Statistical analysis was performed with the SPSS Statistics 28 (IBM, Chicago, IL). As this was a crossover trial, statistical analyses were restricted to participants who completed all three sessions. Normality of data distribution was checked with the Shapiro–Wilk test. For comparing visual performance in the three experimental conditions (CBD 0%, 15%, or 30%), a repeated-measures analysis of variance (ANOVA) test with Bonferroni correction was used for normal distributions. Otherwise, a Friedman test with Bonferroni correction was used. A significance level of 95% was considered. All P values were two sided. As there were six primary outcomes (mean dynamic visual acuity, contrast sensitivity, and coherent dot motion detection), only $P < 0.008$ after Bonferroni correction was considered statistically significant. All other visual measures (static visual acuity, specific speed for dynamic visual acuity, VDI, and stereoacuity) and optical measures (log[s], MTF cut-off, OSI, and SR) were categorized as secondary outcomes. These additions to the secondary outcomes initially defined extend the registered trial (NCT06322303) by providing a more comprehensive framework for investigating the effects of various CBD concentrations on visual function and optical quality.

Results

Participants and Self-Perceived Visual Effects

Data were collected from February 2023 to September 2023. As shown in Figure 1, in the crossover design all six possible treatment sequences (ABC, ACB, BAC, BCA, CAB, CBA) were used, where A = CBD 0%, B = CBD 15%, and C = CBD 30%. Participants were distributed as follows: ABC ($n = 6$), ACB ($n = 4$), BAC ($n = 5$), BCA ($n = 5$), CAB ($n = 4$), and CBA

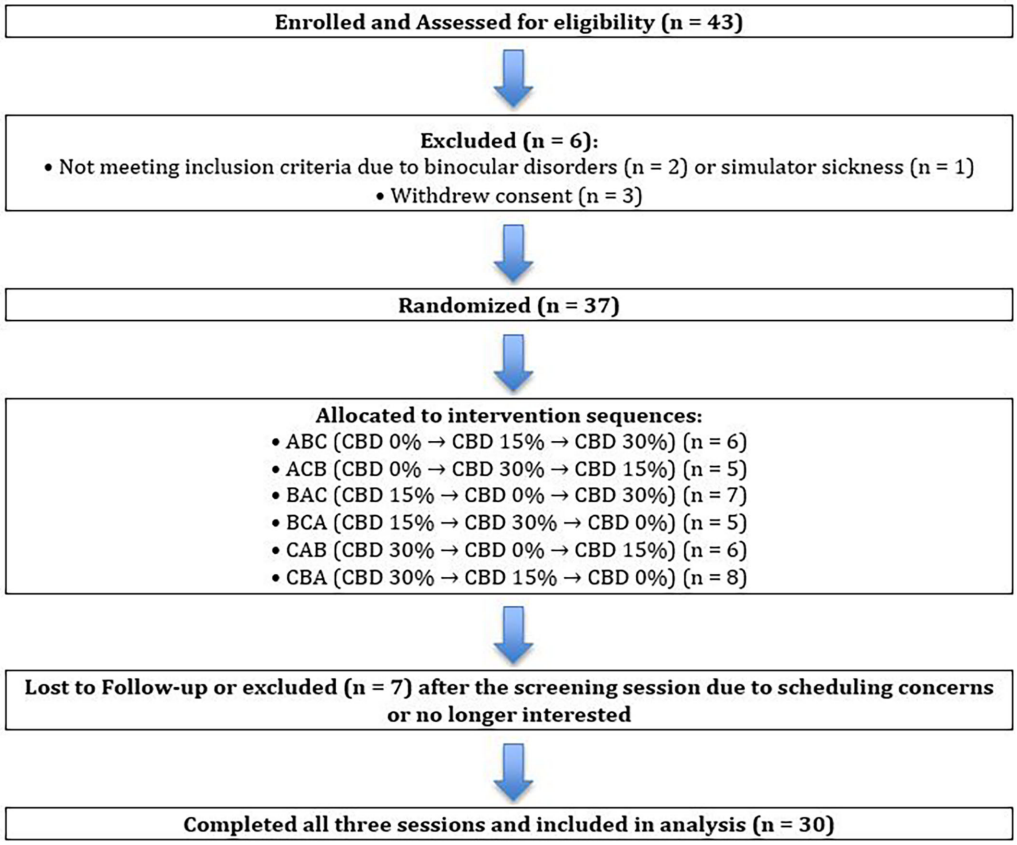

Figure 1. Flow diagram illustrating the progression of participants throughout the study.

($n = 6$). Of the 43 participants initially enrolled, 13 were excluded: three who did not meet the inclusion criteria due to binocular disorders, and 10 who withdrew consent. Finally, a total of 30 participants with a mean age of 26.0 ± 6.3 years completed the study and were included in the analysis (nine females and 21 males) (Fig. 1). The mean refractive error (spherical equivalent) was −1.00 ± 1.72 diopters (D). In self-perceived visual effects, most participants indicated that CBD consumption could slightly affect their vision (65.5%), but not in the long term (89.7%) (Table 1). According to their subjective responses, CBD use could slightly increase glare (48.3%) but not halo perception (44.8%). Results of the blinding procedure showed that over half of the participants correctly identified the CBD 0% (placebo), as opposed to CBD 15% and CBD 30%. No cognitive impairment was found at any CBD concentration, with mean scores close to 8 (the best result) (Table 1).

Visual Function

As shown in Figure 2, CS for all spatial frequencies and mean CS (Table 2) were not significantly affected by vaporized CBD after Bonferroni correction ($P < 0.05$). In addition, mean dot motion detection showed no significant differences after Bonferroni correction among the three concentrations: CBD 15% versus 0% difference was 0.03 (95% confidence interval [CI], −0.08 to 0.03); CBD 30% versus 0% difference was −0.03 (95% CI, −0.03 to 0.08; $P = 0.04$); CBD 15% versus 0% difference was 0.03 (95% CI, −0.08 to 0.03); CBD 30% versus 0% difference was −0.01 (95% CI, −0.03 to 0.08). $P = 0.02$ for monocular and binocular conditions, respectively (Table 2).

Moreover, Table 2 shows the results obtained for several visual function tests in the different CBD conditions (0%, 15%, and 30%). Under the three illumination conditions, after Bonferroni correction, no significant changes were found in pupil size: For the scotopic condition, the CBD 15% versus 0% difference was −0.17 (95% CI, −0.07 to 0.35); the CBD 30% versus 0% difference was −0.23 (95% CI, 0.00 to 0.44; $P = 0.31$). For the low mesopic condition, the CBD 15% versus 0% difference was 0.04 (95% CI, −0.39 to 0.26); the CBD 30% versus 0% difference was −0.26 (95% CI, −0.21 to 0.44; $P = 0.21$). For the high mesopic condi-

Table 1. Self-Perceived Visual Effects Under CBD Use and Results of the Blinding Procedure and Cognitive Test Scores

Self-Perceived Visual Effects Under CBD Use		
Question	Answer	Participants ($N = 30$), *n* (%)
Do you think CBD use could alter your long-term vision?		
	Yes	3 (10)
	No	27 (90)
Do you think CBD use affects your vision?		
	Much worse	1 (3)
	Slightly worse	20 (66)
	No change	6 (21)
	Improved	3 (10)
How does CBD use affect glare?		
	Much worse	1 (3)
	Slightly worse	14 (48)
	No change	12 (39)
	Improved	3 (10)
How does CBD use affect halo perception?		
	Much worse	4 (14)
	Slightly worse	10 (34)
	No change	14 (45)
	Improved	2 (7)

Blinding Procedure and Cognitive Test Scores			
	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, *n* (%)	1.90 (1.47)	3.20 (2.14)	3.67 (2.25)
Cognitive test score, *n* (%)	7.83 (0.39)	7.79 (0.5)	7.62 (0.75)

tion, the CBD 15% versus 0% difference was −0.08 (95% CI, −0.24 to 0.32); the CBD 30% versus 0% difference was −0.25 (95% CI, −0.14 to 0.51; $P = 0.27$).

Likewise, no significant impairment after Bonferroni correction of static visual acuity was observed after vaporizing CBD. With regard to the DVA test, this visual function was not affected by experimental conditions in any of the speeds evaluated. No significant differences after Bonferroni correction were observed for the VDI, indicating that halo perception remained similar. After Bonferroni correction, no significant deteriorations were found for either stereoacuity at distance, with a CBD 15% versus 0% difference of −5.34 (95% CI, −5.00 to 15.00) and CBD 30% versus 0% difference of 8.33 (95% CI, −25.00 to 0.00; $P = 0.08$), or near, with a CBD 15% versus 0% difference of 2.84 (95% CI, −5.00 to 0.00) and CBD 30% versus 0% difference of 1.84 (95% CI, −5.00 to 0.00; $P = 0.58$).

Optical Quality

Parameters relative to optical quality are presented in Table 3. The log(s) parameter was not impaired after vaporizing CBD. Similarly, MTF cutoff, OSI, and SR were not deteriorated by vaporized CBD.

Discussion

The present study showed that, at the concentrations used, CBD had no overall effect in the short term on any of the primary and secondary outcomes assessed. CBD can cause side effects such as headache and drowsiness.[33] Self-perceived visual effects of participants prior to starting the study indicated that CBD could slightly affect their vision but not in the long term. No cognitive impairment was observed at any CBD concentration. Unlike THC, several studies

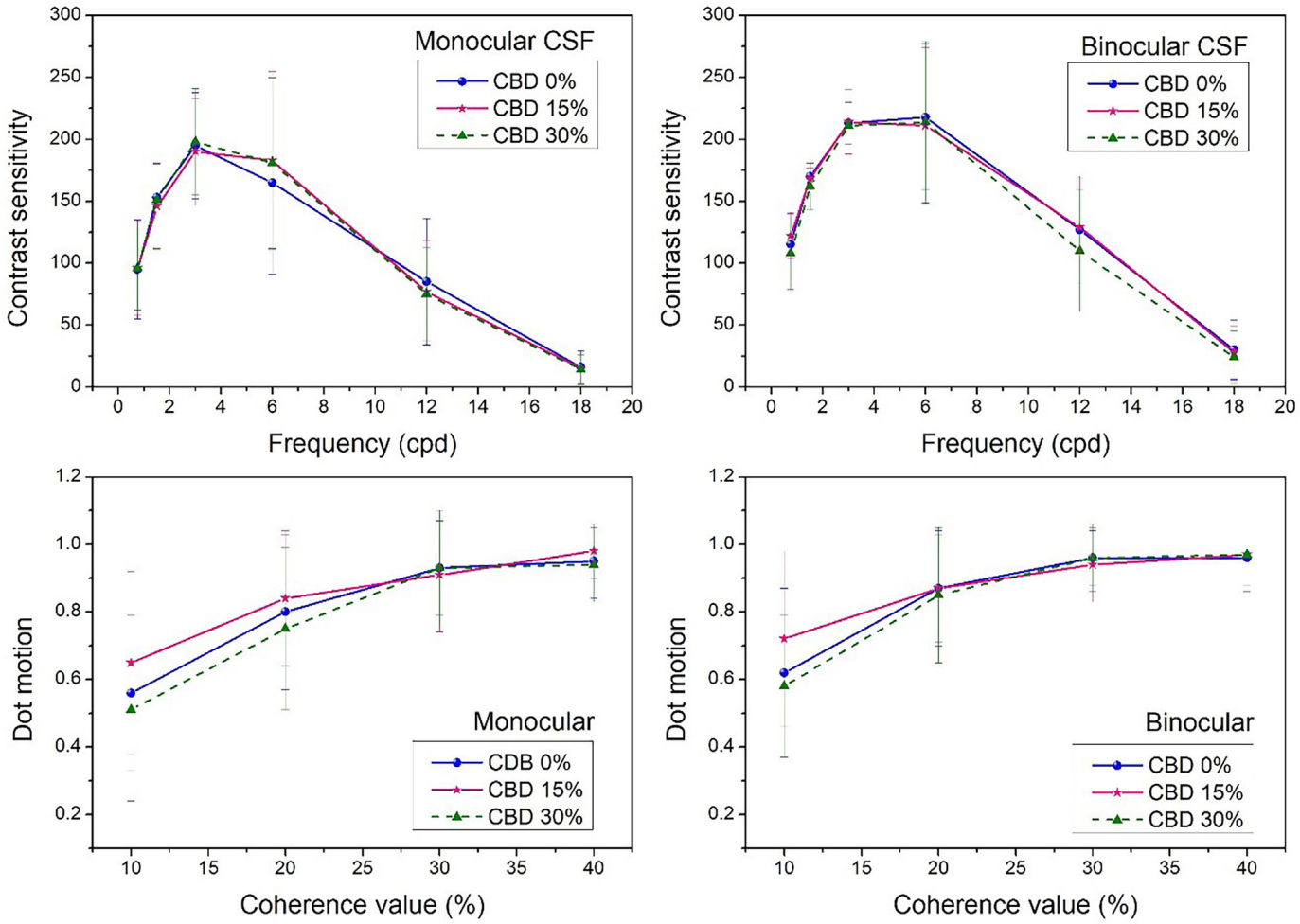

Figure 2. Contrast sensitivity and dot motion detection under different CBD conditions (0%, 15%, and 30%).

confirmed that CBD did not affect short-term memory and accuracy, even at high CBD concentrations.[34,35] Similarly, other studies have found that the administration of isolated CBD alone did not influence the emotional state, cognitive performance, and attention.[36,37]

CBD use did not affect CS. Several studies about the effect of cannabis with THC content in CS have shown a reduction in low spatial frequencies.[38,39] Ortiz-Peregrina et al.[19] also revealed a decrease in CS at low and high spatial frequencies after cannabis consumption. Cannabinoid receptors (CB1) are located in the thalamus and visual cortex, where high and low spatial frequencies are processed, so the consumption of cannabinoids may alter this visual function.[38] The use of cannabis containing THC has been shown to be associated with impaired dot motion detection and reduced neural activity underlying attention to motion stimuli.[39,40]

In the present study, vaporized CBD did not change pupil size under different illumination conditions (scotopic, low and high mesopic). Similarly, Ortiz-Peregrina et al.[19] did not find changes in pupil size after cannabis consumption under low-illumination conditions; the authors reported a reduction in pupil size for scotopic conditions. In contrast, other studies have observed an increase in pupil size after cannabis use.[41,42] For the remaining visual parameters measured (static and dynamic visual acuity, visual discrimination capacity, and stereopsis), no changes were observed with the different CBD concentrations, contrary to other studies on cannabis with THC content. Ortiz-Peregrina et al.[43] found a deterioration in visual acuity under the influence of cannabis. In addition, no deterioration in night vision (quantified by the VDI parameter) was observed with vaporized CBD, which is consistent with the self-perceived visual effect reported by the participants. In contrast, a previous study found an increase in VDI after smoking THC-

Table 2. Comparison of Visual Function Test Results Under the Three CBD Conditions ($N = 30$)

Condition	CBD 0%, Mean ± SD	CBD 15%, Mean ± SD	CBD 30%, Mean ± SD	CBD 15% vs. CBD 0%, Difference (95% CI)	CBD 30% vs. CBD 0%, Difference (95% CI)	*P*
Pupil size (mm)						
Scotopic	6.53 ± 0.80	6.36 ± 0.77	6.30 ± 0.79	−0.17 (−0.07 to 0.35)	−0.23 (0.00 to 0.44)	0.31
Low mesopic	5.21 ± 1.05	5.25 ± 0.95	4.95 ± 0.97	0.04 (−0.39 to 0.26)	−0.26 (−0.21 to 0.44)	0.21
High mesopic	4.70 ± 0.99	4.62 ± 0.92	4.45 ± 0.91	−0.08 (−0.24 to 0.32)	−0.25 (−0.14 to 0.51)	0.27
SVA						
Monocular	1.12 ± 0.20	1.07 ± 0.15	1.11 ± 0.17	−0.05 (0.00 to 0.10)	−0.01 (−0.05 to 0.05)	0.68
Binocular	1.25 ± 0.17	1.23 ± 0.12	1.28 ± 0.14	−0.02 (−0.05 to 0.05)	0.03 (−0.10 to 0.05)	0.35
DVA (5°/s)						
Monocular	0.76 ± 0.15	0.75 ± 0.13	0.75 ± 0.16	−0.01 (−0.05 to 0.05)	−0.01 (0.00 to 0.05)	0.60
Binocular	0.89 ± 0.12	0.87 ± 0.11	0.85 ± 0.12	−0.02 (−0.05 to 0.10)	−0.04 (0.00 to 0.10)	0.32
DVA (10°/s)						
Monocular	0.54 ± 0.12	0.54 ± 0.12	0.55 ± 0.12	0.00 (−0.05 to 0.05)	0.01 (−0.05 to 0.05)	0.91
Binocular	0.67 ± 0.13	0.66 ± 0.14	0.67 ± 0.08	−0.01 (−0.05 to 0.05)	0.00 (−0.05 to 0.05)	0.61
DVA (15°/s)						
Monocular	0.41 ± 0.09	0.44 ± 0.10	0.43 ± 0.12	0.03 (−0.05 to 0.00)	0.02 (−0.05 to 0.00)	0.50
Binocular	0.53 ± 0.11	0.52 ± 0.09	0.53 ± 0.09	−0.01 (−0.05 to 0.05)	0.00 (−0.05 to 0.05)	0.74
Mean DVA[a]						
Monocular	0.57 ± 0.11	0.57 ± 0.09	0.58 ± 0.12	0.00 (−0.03 to 0.03)	0.01 (−0.03 to 0.03)	0.93
Binocular	0.69 ± 0.11	0.68 ± 0.09	0.68 ± 0.08	−0.01 (−0.03 to 0.07)	−0.01 (−0.02 to 0.05)	0.31
Mean CS[a]						
Monocular	118.14 ± 26.83	117.64 ± 25.39	119.08 ± 27.05	−0.50 (−8.17 to 7.75)	0.94 (−9.83 to 7.42)	0.73
Binocular	145.48 ± 20.18	145.25 ± 20.10	138.09 ± 23.60	−0.23 (−7.92 to 6.92)	−7.39 (−1.17 to 13.33)	0.72
Mean CDM detection[a]						
Monocular	0.81 ± 0.13	0.84 ± 0.14	0.78 ± 0.14	0.03 (−0.08 to 0.03)	−0.03 (−0.03 to 0.08)	0.04
Binocular	0.85 ± 0.11	0.88 ± 0.11	0.84 ± 0.09	0.03 (−0.08 to 0.03)	−0.01 (−0.03 to 0.08)	0.02
VDI						
Monocular	0.22 ± 0.16	0.22 ± 0.18	0.25 ± 0.22	0.00 (−0.03 to 0.02)	0.03 (−0.02 to 0.00)	0.48
Binocular	0.15 ± 0.10	0.14 ± 0.07	0.19 ± 0.17	−0.01 (−0.01 to 0.01)	0.04 (−0.04 to 0.00)	0.06
Stereoacuity (arcsec)						
Distance	61.67 ± 61.14	56.33 ± 56.84	70.00 ± 58.66	−5.34 (−5.00 to 15.00)	8.33 (−25.00 to 0.00)	0.08
Near	28.83 ± 14.67	31.67 ± 15.88	30.67 ± 15.08	2.84 (−5.00 to 0.00)	1.84 (−5.00 to 0.00)	0.58

[a]As there were six primary outcomes, only $P < 0.008$ after Bonferroni correction was considered statistically significant.

Table 3. Comparison of the Optical Quality Parameters Under the Three CBD Conditions ($N = 30$)

	CBD 0%, Mean ± SD	CBD 15%, Mean ± SD	CBD 30%, Mean ± SD	CBD 15% vs. CBD 0%, Difference (95% CI)	CBD 30% vs. CBD 0%, Difference (95% CI)
log(s)	0.81 ± 0.11	0.83 ± 0.17	0.84 ± 0.11	0.02 (−0.04 to 0.04)	0.03 (−0.08 to 0.02)
MTF cutoff (cpd)	37.23 ± 9.31	36.46 ± 8.69	37.40 ± 9.21	−0.77 (−1.94 to 3.62)	0.17 (−3.91 to 4.03)
OSI	0.62 ± 0.50	0.61 ± 0.40	0.59 ± 0.43	−0.01 (−0.10 to 0.10)	−0.03 (−0.10 to 0.10)
Strehl ratio	0.26 ± 0.05	0.21 ± 0.05	0.21 ± 0.05	−0.05 (−0.02 to 0.02)	−0.05 (−0.03 to 0.02)

containing cannabis.[19] Similarly, CBD use did not affect near and distance stereoacuity, a parameter that has shown to be sensitive to smoked THC-containing cannabis.[19,44]

Similarly, optical quality was not adversely affected under the different CBD conditions, although participants' subjective responses indicated that CBD use could slightly increase glare. Optical quality is dependent on the pupil size, resulting in a loss of quality with the increase in its size.[45] No deterioration in optical quality was expected as the pupil size had not changed. Smoking cannabis with THC content have shown to increase straylight (log[s]), inducing a deterioration in the retinal image quality.[19] At the retinal and visual processing level, acute cannabis use appears to cause a transient reduction in photoreceptor activity with a decrease in cortical activity.[46]

It is important to note that this study is part of a larger project investigating the effects of CBD on both visual and driving performances. Some of the visual results reported here (namely, the binocular means of SVA, DVA, CS, CDM, and distance stereoacuity) have been previously published[20] in relation to their influence on driving performance. The present study provides a more comprehensive framework for understanding the effects of different CBD concentrations on visual performance and optical quality, thereby expanding the findings from our earlier work.

Strengths and Limitations

Although the primary visual outcomes were prespecified in the trial registration, the secondary outcomes (particularly optical quality measures) were not explicitly listed. These outcomes were, however, part of a broader objective outlined in our funded research project. Although no formal baseline correction or statistical tests for period or carryover effects were conducted, strict inclusion criteria and comprehensive visual assessments ensured good and stable baseline vision, minimizing variability. A minimum 1-week washout period further reduced the risk of carryover. The main limitation of this study is the sample size; however, this sample size was calculated to ensure sufficient statistical power based on previous results. It should be noted that a previous study on the effects of cannabis with THC showed significant differences in many of the visual parameters examined in this study using the same sample size. In addition, the relatively small and homogeneous sample could limit generalizability. Also, higher doses of CBD have not been studied because the doses used are representative of those commonly used by current CBD users, adding realism and clinical application to the results obtained. Future studies should investigate whether higher doses could lead to changes in visual function.

Conclusions

No short-term deterioration in visual function and optical quality was observed under the influence of vaporized CBD. Therefore, the use of this cannabinoid at the concentrations tested would not be dangerous for vision in the short term. Thus, the results of this study could be useful and helpful for evidence-based decision-making for public health policy on its use. As this is the first study, to our knowledge, to investigate the visual effects of CBD consumption, further research is necessary to substantiate the findings by increasing the number of participants (including different consumer groups) and expanding CBD concentrations.

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Data Availability: The datasets used and analyzed during the current study available from the corresponding author on reasonable request.

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