

Research

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# Effects of Milk vs Dark Chocolate Consumption on Visual Acuity and Contrast Sensitivity Within 2 Hours

## A Randomized Clinical Trial

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 Supplemental content

**IMPORTANCE** Consumption of dark chocolate can improve blood flow, mood, and cognition in the short term, but little is known about the possible effects of dark chocolate on visual performance.

**OBJECTIVE** To compare the short-term effects of consumption of dark chocolate with those of milk chocolate on visual acuity and large- and small-letter contrast sensitivity.

**DESIGN** A randomized, single-masked crossover design was used to assess short-term visual performance after consumption of a dark or a milk chocolate bar. Thirty participants without pathologic eye disease each consumed dark and milk chocolate in separate sessions, and within-participant paired comparisons were used to assess outcomes. Testing was conducted at the Rosenberg School of Optometry from June 25 to August 15, 2017.

**MAIN OUTCOMES AND MEASURES** Visual acuity (in logMAR units) and large- and small-letter contrast sensitivity (in the log of the inverse of the minimum detectable contrast [logCS units]) were measured 1.75 hours after consumption of dark and milk chocolate bars.

**RESULTS** Among the 30 participants (9 men and 21 women; mean [SD] age, 26 [5] years), small-letter contrast sensitivity was significantly higher after consumption of dark chocolate (mean [SE], 1.45 [0.04] logCS) vs milk chocolate (mean [SE], 1.30 [0.05] logCS; mean improvement, 0.15 logCS [95% CI, 0.08-0.22 logCS];  $P < .001$ ). Large-letter contrast sensitivity was slightly higher after consumption of dark chocolate (mean [SE], 2.05 [0.02] logCS) vs milk chocolate (mean [SE], 2.00 [0.02] logCS; mean improvement, 0.05 logCS [95% CI, 0.00-0.10 logCS];  $P = .07$ ). Visual acuity improved slightly after consumption of dark chocolate (mean [SE], -0.22 [0.01] logMAR; visual acuity, approximately 20/12) and milk chocolate (mean [SE], -0.18 [0.01] logMAR; visual acuity, approximately 20/15; mean improvement, 0.04 logMAR [95% CI, 0.02-0.06 logMAR];  $P = .05$ ). Composite scores combining results from all tests showed significant improvement after consumption of dark compared with milk chocolate (mean improvement, 0.20 log U [95% CI, 0.10-0.30 log U];  $P < .001$ ).

**CONCLUSIONS AND RELEVANCE** Contrast sensitivity and visual acuity were significantly higher 2 hours after consumption of a dark chocolate bar compared with a milk chocolate bar, but the duration of these effects and their influence in real-world performance await further testing.

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Several studies suggest that dark chocolate from flavanol-rich cacao beans may enhance blood flow to central and peripheral nervous systems,<sup>1</sup> improve cardiovascular function,<sup>2,3</sup> and retard memory loss and other signs and symptoms of degenerative diseases, including Alzheimer and Parkinson diseases.<sup>4,5</sup> The cacao flavanols in dark chocolate have antioxidant effects that retard and partially reverse degenerative changes in various diseases.<sup>1</sup> Dark chocolate consumption also has been associated with enhanced mood and cognition.<sup>6,7</sup> Short-term improvement in contrast sensitivity was observed after consumption of dark chocolate and attributed to increased blood flow, although direct evidence is lacking.<sup>7</sup> Moreover, the effect of dark chocolate on other visual functions remains unknown. We conducted a randomized, masked crossover clinical study to assess effects of dark chocolate vs milk chocolate within 2 hours of consumption on multiple aspects of vision, including contrast and color perception, distraction effects, marksmanship, and visual electrodiagnosis. We describe results for high-contrast visual acuity and large- and small-letter contrast sensitivity after consumption of dark vs milk chocolate.

## Methods

Thirty healthy adults with no history of ocular, systemic, or neurologic disease were recruited from students and staff of the University of the Incarnate Word Rosenberg School of Optometry, San Antonio, Texas. The institutional review board of the University of the Incarnate Word approved the study protocol (found in the Supplement) in accordance with the Declaration of Helsinki and its revisions.<sup>8</sup> After a briefing of all testing and time requirements, each participant provided written informed consent.

Participants were informed that the intent of the study was to evaluate possible effects of chocolate on visual performance, but the type of chocolate was not specified. Each participant was awarded a \$25 gift card for participation in the study. No participant withdrew from the study, no adverse events occurred, and data reported herein derive from all 30 participants. However, the first participant was enrolled June 25, 2017; all subjects were enrolled before clinical trial registration. The request for clinical trial registration was sent to [clinicaltrials.gov](http://clinicaltrials.gov) on October 19, 2017, and the trial was first posted on October 31, 2017, after we realized that the study design met the definition of a clinical trial. The study flow diagram is shown in Figure 1.

Each participant was tested approximately 1.75 hours after ingestion of a 72% Cacao Dark Chocolate bar (47 g; cacao, 34 g; total flavanols, 316.3 mg; Trader Joe's; <https://www.consumerlab.com>) or a Crispy Rice Milk Chocolate bar (40 g; milk chocolate cocoa, 12.4 g; total flavanols, 40 mg [8 times less than dark chocolate bar]; Trader Joe's). The investigator was not masked to the assignment. Participants were randomly assigned to the group that began testing after dark chocolate consumption or the group that began testing after milk chocolate consumption. Although the bars were of comparable size, shape, and content of sugar, protein, fat,

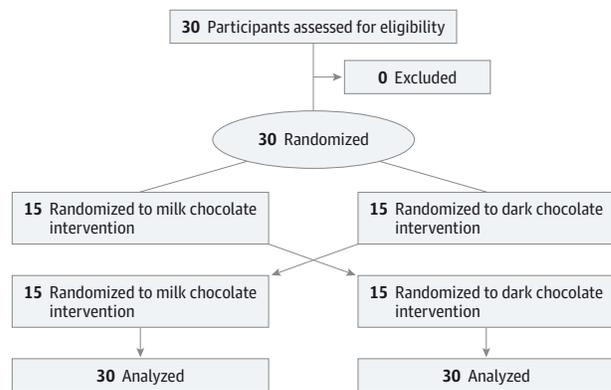
## Key Points

**Question** How does consumption of milk vs dark chocolate affect visual acuity or contrast sensitivity within 2 hours of consumption?

**Findings** In this randomized crossover clinical trial of 30 adults, small enhancements in visual acuity and large-letter contrast sensitivity and a slightly larger improvement in small-letter contrast sensitivity were noted after consumption of dark compared with milk chocolate.

**Meaning** Consumption of a commercially available dark chocolate bar improves the ability to see low- and high-contrast targets, possibly owing to increased blood flow, but the functional relevance of these slight improvements remains to be determined.

Figure 1. CONSORT Diagram



At least 72 hours elapsed before the crossover was implemented.

and nutrients, the outer wrapping was removed to ensure that each participant was unaware of the name or type of chocolate bar. The aluminum foil inner wrapper remained intact to optimize hygiene. All participants refrained from consumption of caffeine and/or caffeinated beverages and milk products on the day of testing because these agents can affect the efficacy of flavanol-rich food products. Each participant underwent testing with the other chocolate bar at least 72 hours after the first session (mean [SD] intersession interval, 8 [5] days; range, 3-21 days). Testing was conducted at the Rosenberg School of Optometry from June 25 to August 15, 2017.

All participants underwent binocular testing with their habitual correction based on a comprehensive eye examination within 1 year of testing. High-contrast visual acuity and small-letter contrast sensitivity (20/25 letter size) were measured binocularly with a retroilluminated Rabin Super Vision Test (Precision Vision)<sup>9</sup>; large-letter contrast sensitivity (20/700 letter size) was measured with the wall-mounted Pelli-Robson chart.<sup>10</sup> Visual acuity was expressed as log of the minimum angle of resolution (logMAR) and contrast sensitivity as the log of the inverse of the minimum detectable contrast (logCS). We scored logMAR and logCS as the number of letters read correctly (0.02 logMAR per visual acuity letter and 0.05 logCS per letter).<sup>10</sup> Because all 3 measures of spatial

Table. Visual Acuity and Contrast Sensitivity After Chocolate Consumption

| Spatial Vision Test                           | Chocolate Consumed, Mean (SE) Score |                           | Difference (95% CI) | P Value <sup>a</sup> |
|---|-------------------------------------|---------------------------|---------------------|----------------------|
|   | Milk                                | Dark                      |                     |                      |
| Visual acuity, logMAR unit                    | -0.18 (0.01) <sup>b</sup>           | -0.22 (0.01) <sup>c</sup> | 0.04 (0.02-0.06)    | .05                  |
| Large-letter contrast sensitivity, logCS unit | 2.00 (0.02)                         | 2.05 (0.02)               | 0.05 (0.00-0.10)    | .07                  |
| Small-letter contrast sensitivity, logCS unit | 1.30 (0.05)                         | 1.45 (0.04)               | 0.15 (0.08-0.22)    | <.001                |

<sup>a</sup> Calculated using 2-tailed paired t test.

<sup>b</sup> Visual acuity was approximately 20/15.

<sup>c</sup> Visual acuity was approximately 20/12.

vision showed improvement after consumption of dark chocolate, we sought to combine these data in a unique and meaningful way that encompassed different contrasts and letter sizes (spatial frequencies). To quantify overall improvement in spatial vision, we computed the sum of logMAR (corrected for sign) and logCS values from each participant to achieve a composite score that spans letter size and contrast. Composite score results were analyzed using Bland-Altman analysis, with  $P < .05$  indicating significance.

## Results

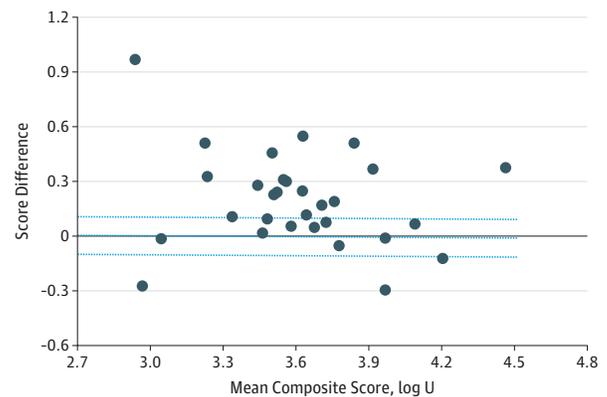
A total of 30 adults (9 men and 21 women; mean [SD] age, 26 [5] years) participated. The Table shows mean results for each vision test and differences between dark and milk chocolate consumption. Two-way, repeated-measures analysis of variance across chocolate type (dark vs milk) and vision test (visual acuity vs large- vs small-letter contrast sensitivity) showed an overall improvement after consumption of dark vs milk chocolate (mean improvement, 0.07 log U;  $P = .04$ ). Post hoc 2-tailed, paired t tests revealed significantly higher small-letter contrast sensitivity after consumption of dark chocolate (mean [SE], 1.45 [0.04] logCS) vs milk chocolate (mean [SE], 1.30 [0.05] logCS; mean improvement, 0.15 logCS [95% CI, 0.08-0.22 logCS];  $P < .001$ ). Large-letter contrast sensitivity was higher after consumption of dark chocolate (mean [SE], 2.05 [0.02] logCS) vs milk chocolate (mean [SE], 2.00 [0.02] logCS; mean improvement, 0.05 logCS [95% CI, 0.00-0.10 logCS];  $P = .07$ ). High-contrast visual acuity was slightly improved after consumption of dark chocolate (mean [SE], -0.22 [0.01] logMAR; visual acuity, approximately 20/12) vs milk chocolate (mean [SE], -0.18 [0.01] logMAR; visual acuity, approximately 20/15; mean improvement, 0.04 logMAR [95% CI, 0.02-0.06 logMAR];  $P = .05$ ).

Figure 2 shows a Bland-Altman plot of the difference in spatial vision composite score (dark chocolate minus milk chocolate) plotted against the mean for each participant. Values above the upper horizontal line indicate improvements in spatial vision after dark chocolate consumption (mean improvement, 0.20 log U [95% CI, 0.10-0.30 log U];  $P < .001$ ). Twenty-four participants (80%) showed some improvement with dark chocolate vs milk chocolate (Wilcoxon signed-rank test,  $P < .001$ ).

## Discussion

These results show that high- and low-contrast vision can be improved within 2 hours after consumption of a com-

Figure 2. Bland-Altman Plot Showing the Difference in Composite Visual Score



The score difference is calculated for dark chocolate minus milk chocolate consumption plotted against the mean value for 30 participants with normal vision. The mean composite score is calculated using scores for dark and milk chocolate consumption for each participant. The 95% CI based on paired t test analysis is shown as dotted horizontal lines above and below the 0 line representing no difference in performance. Higher scores represent greater overall improvement in spatial vision after ingestion of dark vs milk chocolate.

mercially available dark chocolate bar. Although the specific mechanism for visual improvement awaits further study, an increase in retinal, visual pathway, and/or cerebral blood flow could be contributory, enhancing bioavailability of oxygen and nutrients to metabolically active sites.<sup>1-3,11,12</sup> Dietary bioavailability of flavonoids is influenced by coingestion of other food products, susceptibility to oxidation, and a short half-life, with plasma clearance occurring in as little as 4 hours.<sup>11</sup> However, the exact duration of any improvement in vision performance was not determined in this study.

## Limitations

Limitations of this study include the lack of masking of the investigators, which may have influenced results, although this seems to be unlikely because the same by-letter scoring method was used in each study arm. Participants also may have been aware of the type of chocolate consumed based on taste, although none were informed that the intent of the study was to compare dark and milk chocolate. Finally, the duration of the effect of dark chocolate on vision beyond 2 hours is unknown and needs further evaluation.

## Conclusions

Enhancements in visual acuity and large-letter contrast sensitivity after dark chocolate ingestion were small, and the functional relevance is unclear. Additional testing may reveal utility in these effects. However, a more substantial improvement occurred in small-letter contrast sensitivity, a visually challenging task that can reveal decrements and increments in visual

performance despite normal high-contrast visual acuity.<sup>9,12,13</sup> The highly vascularized retina, particularly the macula with its substantial projection to the visual cortex, may be most susceptible to enhanced blood flow and increased metabolic supply afforded by polyphenol flavanols in dark chocolate.<sup>14,15</sup> The findings reported suggest that a single dose of dark chocolate improves visibility of small, low-contrast targets within 2 hours compared with milk chocolate, but the duration of this difference and clinical relevance remains uncertain.

### ARTICLE INFORMATION

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**Statistical analysis:** All authors.

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