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NUTRACEUTICALS FOR VISUAL (SPORTS) PERFORMANCE
COPE 69590-GOI

THE VISION PYRAMID

WELFORD INFORMATION PROCESSING MODEL

SELF SELECTION?

VISIBILITY, CONTRAST SENSITIVITY & GLARE
(TYPICALLY NOT EVALUATED IN THE EYE EXAM)
OPTIONS TO ENHANCE VISUAL ACUITY & CONTRAST SENSITIVITY

• Refractive compensation
• Methods for refractive compensation
• Filters / tints to enhance visibility of important features
• Visual feedback training to enhance CS function
• Nutrient intake of carotenoids

WHICH NUTRIENTS ARE BENEFICIAL FOR EYE HEALTH & FUNCTION?

• Endogenous – 60% of antioxidant capacity
• Exogenous Nutrients – 40% of antioxidant capacity of eye
  • Lutein & Zeaxanthin
  • Vitamin D3 (really a hormone)
  • Omega-3 fatty acids
  • Non-enzymatic antioxidants
    • Vitamins A, C, E, COQ10 and glutathione
  • Minerals
    • Magnesium, Zinc, Selenium
  • OTHER NEWCOMERS:
    • quercetin, resveratrol, pterostilbene, pycnogenol and astaxanthin

WHAT DO THESE NUTRIENTS DO?

• Protective effects for age-related changes to the crystalline lens & retina (eg. cataracts & AMD)
  • AREDS B carotene, C and E, Zinc, lutein & zeaxanthin
• Epigenetic modulators (longevity)
  • Omega-3’s - dry eye / MGD / AMD
  • Vitamin C, D3 & magnesium-arcus, retina CVdz
  • Vitamin A & selenium, night vision, dry eye
• Protect both retina and brain
  • Lutein, Zeaxanthin, DHA

WHERE ARE THESE NUTRIENTS FOUND?

• Green, leafy vegetables such as spinach, kale, collards and orange peppers / paprika / goji berries
• Salmon, tuna, and other oily (cold-water) fish
• Eggs, nuts, beans, and other protein sources
• Oranges and other citrus fruits - C / bioflavonoids
• Colorful fruits and vegetables (bell peppers, berries)- polyphenols
• Whole grains such as quinoa, brown rice, whole oats
• Flaxseed oil (females), EPR, black currant seed oil

LUTEIN AND ZEAXANTHIN INTAKE (MCG/D) BY AGE
(NHANES 2003-2004 DATA)

ZEAXANTHIN: WHY SUPPLEMENTATION IS IMPORTANT

The Scarcity of Zeaxanthin in the Diet
THINK - ZEAXANTHIN INTAKE

- Zeaxanthin and Lutein accumulate at a 2:1 ratio (Z to L) in the fovea
- Zeaxanthin isomers (Z & M) are the foveal carotenoids
- The fovea has 3x the metabolic activity of any other tissue
- Potently increase foveal (1 degree) MPOD
- Z publication data supports fewer anti-VEGF injections required
- AVG American diet consists of 5:1 ratio of L to Z and the avg American gets << 1 mg of Z per day
- Why Supplementation is Important

NUTRITION FOR BETTER PERFORMANCE: ZEAXANTHIN

- Nutrient found in bright colored fruits and vegetables
- 20+ years of research, 150+ published studies to support zeaxanthin’s role in healthy vision
  - Masked, placebo-controlled studies
- Higher daily intake of zeaxanthin relates to improved vision, faster response time

Richer et al. The Zeaxanthin and Visual Function Study (ZVF), 2011, ClinicalTrials.gov Identifier: NCT00584902

LUTEIN AND ZEAXANTHIN MISSING FROM THE DIET CAN INFLUENCE VISUAL FUNCTION THROUGH OPTICAL AS WELL AS BIOLOGICAL MECHANISMS

- Optical mechanisms
  - GD, GR, CSF, CC, VISUAL RANGE
- Biological mechanisms – eyes + brain

REGIONS OF THE BRAIN ANALYZED FOR CAROTENOIDS


thinking, planning, central executive function, attention and motor execution
visual perception and processing
Language function, auditory perception, long term memory and emotion
motor control, language and attention
BRAIN CAROTENOIDS


Regions of the infant brain

- Auditory Cortex (n=11)
- Occipital Cortex (n=28)
- Hippocampus (n=24)
- Frontal Cortex (n=29)

Amount of carotenoid found (mol/g)

- Lutein
- Zeaxanthin, trans-Cryptoxanthin
- B-carotene, trans-19

INDIVIDUAL DIFFERENCES IN VISUAL FUNCTION
HAMMOND & BUCH, EXP EYE RESEARCH 2020

- There are dramatic individual differences in visual function even in college students
  - Vernier acuity
  - Resolution Acuity
  - Lens density
  - Intra-ocular light scatter
  - MPD by retinal eccentricity
  - Photoreceptor loss
- Performance declines before midlife aging and obvious disease, and may indicate poor aging and susceptibility to disease
- Concierge optometry?

Macular Pigment & Visual Performance

Zeaxanthin and Lutein

Static Visual Performance
  - "See Better"
  - Glare Disability
  - Photostress Recovery
  - Contrast Enhancement
  - Optical Effects (LZ in Retina)

Dynamic Visual Performance
  - "React Faster"
  - Temporal Vision
  - Coincidence Anticipation
  - Reaction Time
  - Neural Effects (LZ in Brain)

EFFECTS OF SUPPLEMENTATION

Table 3. Changes in Macular Pigment and Visual Function Compared to Placebo

<table>
<thead>
<tr>
<th>Variable</th>
<th>Slope, Change per Day*</th>
<th>SE of Slope</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>MPD 10'</td>
<td>0.00025</td>
<td>0.00006</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>MPD 30'</td>
<td>0.00025</td>
<td>0.00005</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>MPD 60'</td>
<td>0.00015</td>
<td>0.00005</td>
<td>0.0001</td>
</tr>
<tr>
<td>MPD 10'</td>
<td>0.00010</td>
<td>0.00004</td>
<td>0.0004</td>
</tr>
<tr>
<td>Photostress recovery</td>
<td>-0.019</td>
<td>0.008</td>
<td>0.013</td>
</tr>
<tr>
<td>glare disability</td>
<td>0.00018</td>
<td>0.00014</td>
<td>0.21</td>
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<tr>
<td>chromatic contrast</td>
<td>0.00037</td>
<td>0.00017</td>
<td>0.0301</td>
</tr>
</tbody>
</table>

* Daily change in treatment group versus daily change in placebo group.

CONTRAST SENSITIVITY IN SPORT

- Judgment of subtle differences in contrast:
  - Between the “target” and its background
  - Rotation of the “target”
- Helps to better judge speed & trajectory
  - Research: Athletes > Non-athletes
- Reduced sensitivity may contribute to performance inconsistency due to variable lighting conditions, figure-ground characteristics

YELLOW RANGE FILTERS

- Selectively filters shorter wavelength light
- Ocular media scatters short wavelength light more - improves contrast by eliminating some of this “internal glare”
- May enhance contrast differences (contours) by reducing chromatic aberration
Reduced Chromatic Aberration of the Eye with Light Filtration

Zeaxanthin/lutein absorbs blue light which is a major factor in limiting our vision outdoors. Peak Optical Density of Zeaxanthin and Lutein (Bone, et al. 1991)

2012 MINOR LEAGUE BASEBALL SUPPLEMENTATION TRIAL

Contrast Acuity

N = 12 (45 did not participate)

2012 MINOR LEAGUE BASEBALL SUPPLEMENTATION TRIAL

Contrast Acuity

N = 12 (45 did not participate)

GLARE EFFECTS IN SPORT

- Judgment of “target” speed and trajectory can be affected by
  - Sun angle and intensity
  - Stadium lighting
  - Color contrast between “target” and background
- Glare sensitivity and slow glare recovery may contribute to errors in certain game conditions

Challenges facing athletes:
Optical considerations

Characteristics of the target:
- Color
- Contrast
- Form
- Brightness
- Optical characteristics of the illuminant (sun angle, cloud cover, etc.)

Characteristics of the observer:
- Temporal visual processing speed
- Refractive error
- Object detection thresholds

Courtesy of Dr. Billy Hammond
MACULAR PIGMENT & GLARE DISABILITY


PHOTOSTRESS: VISUAL RECOVERY AFTER A BLINDING LIGHT EXPOSURE

- Improvement in photostress recovery has been found to be proportional to the level of macular pigment

PHOTOSTRESS RECOVERY EFFECTS IN SPORT

- Some sport situations require the athlete to move quickly between areas of bright sunlight and shadow
- Slow visual recovery following photoreceptor supersaturation can lead to performance errors
  - These errors may put the athlete at risk for injury, such as in cycling sports or downhill skiing

MPOD & GLARE DISABILITY

Average improvement in Glare Disability was ~ 23%

AVERAGE GLARE DISABILITY IMPROVEMENT FROM LOW TO HIGH MACULAR PIGMENT IS ABOUT 40% (AVERAGE IS ~23%)

MPOD AND PHOTOSTRESS RECOVERY

Average improvement in Photostress Recovery over the 1 year trial was 9 seconds

Images: TJTP Van Den Berg

Increased straylight 40%
NUTRITION EFFECTS ON NEURAL PERFORMANCE

- MPOD is linked to L and Z levels in the brain
- Neuroimaging of brain structure in vivo confirms L&Z influences white matter integrity, particularly in regions vulnerable to age-related decline
- L and Z are incorporated in cell membranes and axonal projections, which serve to enhance inter-neuronal and neural-glial communication
- 66-76% of total carotenoid concentration in occipital cortex, but highly variable

CNS EFFECTS OF L AND Z

![Graph showing macular pigment density](image)

VISUAL MOTOR EFFECTS OF A CAROTENOID INTERVENTION (1 YEAR STUDY)

- Study design: Randomized, double-blinded, placebo-controlled, intervention trial
- Subjects: Healthy young healthy adults (18-32 yrs) N = 92 in 1 year study 4 month data
- 3 Interventions:
  1) Placebo (n=10)
  2) Zeaxanthin, 20 mg/d (n=29)
  3) Multi-condition, 26 mg Z, 8 mg L 1480 mg Omega-3 fatty acids (n =25) (Eye Promise Vizual Edge Pro)

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Cross-sectional arm (n = 92): LZ measured in the retina strongly related (p<0.01) to fixed and variable reaction time, temporal contrast sensitivity, Critical flicker fusion thresholds, Coincidence anticipation timing (15 mph).

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**Zeaxanthin group - 20 mg/d (n=29)**

<table>
<thead>
<tr>
<th>MP area tested</th>
<th>Baseline</th>
<th>4 months</th>
</tr>
</thead>
</table>
| Macular Pigment Optical density | 0.06 | 0.14 | 0.05 increase in 1 degree MPOD (p<0.05)

**Multiple supplement group 26 mg Z, 8 mg L, 190 mg Omega-3 fatty acids (n=25)**

<table>
<thead>
<tr>
<th>MP area tested</th>
<th>Baseline</th>
<th>4 months</th>
</tr>
</thead>
</table>
| Macular Pigment Optical density | 0.075 | 0.15 | 0.075 increase in 15 of arc (for 1 degree P<0.05 based on 1 tailed T test)
**MACULAR PIGMENT AND TEMPORAL CONTRAST SENSITIVITY**

Present a grating in time rather than space

Average improvement in t CSF was 20%


**WAYS OF MAKING THE BRAIN FASTER AND MORE EFFICIENT**

LZ connects cells makes them interact more efficiently; also makes the brain faster through structural change

Caffeine blocks adenosine receptors; makes the brain faster

**INCREASED VISUAL PROCESSING SPEED**

* SF Chronicle
SUPPLEMENTATION OF MACULAR PIGMENT

MACULAR PIGMENT OPTICAL DENSITY INCREASE FROM SUPPLEMENTATION

Stypham and Hammond, 2007

2xL = 12 mg

Studies find a non-responder rate range from 5-10% rate, depending on the supplement used.

EFFICACY OF SUPPLEMENTATION IN LIFTING PLASMA CAROTENOIDs


SUPPLEMENTATION EFFECTS ON MPOD


Simple & Efficient
5 minute clinical test of foveal macular pigment for 1 or 2 eyes

- Validated
- Identify low macular pigment
- Assess change with supplementation
100% of the players did not need their sunglasses as often outside.

89% of players were less sensitive to light.

63% of players had less issue with losing the ball in the sky.

63% of players were able to find the ball easier in the night sky and/or stadium lights.

71% of players were able to pick up on the ball’s rotation and/or see the threads on the ball better.

N = 43

**EXTRA PROTECTION BY INCREASED MP**

- Reduced “blue-light” damage
- Antioxidant and anti-inflammatory effects
- Possible protection from screen time (esp. in e-sports)

Barker et al., 2011, IOVS

**SUPPLEMENTS AND COMPETITIVE ATHLETES**

- Advise athletes to verify any supplements to assure that the ingredients are certified as acceptable for sports competition regulations.
- I reference the NSF International website:
  - Products will say: NSF Certified for Sport®

**TIMING OF SUPPLEMENTATION BENEFITS**

- Protects Vision: Immediately
- Vision Quality Benefits: 1-2 months
- Visual Processing Speed Benefits: 3-4 months

**CHALLENGES OF NUTRIENT SUPPLEMENT STUDIES**

- Nutrient trials are not pharmaceutical trials because all subjects have been exposed to the nutrients
  - No real “placebo” group since everyone ingests nutrients
    - A true RCT would require subjects that are nutritionally deficient
    - Cannot adequately control for daily nutrient intake
  - Nutrients are pan-systemic vs. system targeted
  - As a disease/condition prevention, the sample size to show effect would have to be extremely large