OPTIMIZING VISUAL PERFORMANCE FOR SPORTS

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Disclosure Statement:
Consultant to Senaptec and ZeaVision
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Options to Enhance Visual Performance

• Refractive compensation for refractive errors
  – Methods for Refractive Compensation
  – Sports Protective Eyewear
• Filters to enhance visibility of important features
• Visual Performance Training
• Nutrient intake of carotenoids that enhance visual performance (e.g., Zeaxanthin, Lutein, Omega-3’s)

Visual Performance Training Overview

• Welford Model of Information Processing for Skilled Motor Performance
• Taxonomy Update:
  – Component Skill Training
  – Naturalistic Training

Welford Information Processing Model

NATURALISTIC APPROACHES

• Learning literature proposes that transfer of skill training occurs best if the training and transfer tasks engage highly overlapping cognitive processes (Dahlin, Neely, Larsson, Backman, & Nyberg, 2008)
• Naturalistic training situations that most closely resemble game situations might have the highest values in training practical athletic skills
• Technology innovations allow participants to practice actual or simulated sporting activities with altered or augmented visual information
AREAS OF SPORTS VT

- Remediation of vision inefficiencies that may negatively impact performance consistency
- Attentional load theories
- Enhancement of visually-dependent motor skills
- Enhancement of cognitive functions
  - Visual decision making
  - Modulation of attention

VT Procedures Related to Sports Performance

- Relate procedure to sport tasks
- Emphasize awareness of response & strategy
- Achieve quality of response initially
- Push speed of response when ready
- Build automaticity of response
- Discuss strategies to assist transfer of skills to the playing field
  - Integrate vision training with sport training (Naturalistic)

Sequencing and Hierarchy

- Static to Dynamic
- Visual skill isolation to sensory integration
- Low stress to high stress
- Low cognitive to high cognitive
- Elevate visual skills above critical level

VARIABLES FOR SUCCESS

- Athlete/Patient Selection
- Delivery Models
  - Traditional office-based programs
  - Integration w/other sports training programs
- Goals and Expectations

Designing a Training Program

- Use the Vision Pyramid as a reference when organizing and designing a training program
- Work on foundational visual skills first (if necessary), then progress up the Pyramid

COMPONENT SKILL TRAINING

- The field of perceptual learning has demonstrated many examples of dramatic improvements in visual abilities from appropriately structured tasks
- Practice leads to substantial gains in sensitivity that can last for months or years (Kolla, C., & Silver, 2016)
- Benefits can transfer to new, untrained contexts
  (Bowers, Cohen, & Wolf, 2012; Deveau, D’Arms, Zordan, & Seitz, 2014)
Welford Information Processing Model

**Perceptual Mechanism**
- Sensory Receptors
- Detection and Selection of Appropriate Inputs

**Decision Mechanism**
- Strategy Formation
- Response Selection

**Effector Mechanism**
- Response Organization and Control of Ongoing Movement

**Operational Memory**
- Expectation Based on Past Experience

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Static & Dynamic Visual Acuity

- Prism and lens sensitivity (H-D; Eis; Peri)
- Blur interpretation activities

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Bangerter Foil Training Steps

- Step 1: Practice the activity without the foil goggles for a short period of time (e.g., 2-5 minutes).
- Step 2: Repeat the activity with the foil goggles for 5-10 minutes; work to increasing foil density
  - Change after 3-5 successes at a level
- Step 3: Remove the foil goggles and repeat activity for at least 5 minutes to maximize retention of improved performance.

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Static & Dynamic Visual Acuity

- Wayne T-Scope Rotator
- Tachistoscopes (VA targets)
- Rotators with VA Discs, charts

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Static & Dynamic Visual Acuity

- Pitchback/ball machine with letters, numbers, colors, etc.

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ULTIMEYES

- ULTIMEYES interactive computer app uses an algorithm to provide customized vision training to “improve visual acuity, contrast sensitivity and attention”
  - Neuroplasticity technology synchronizes task reinforcement with the appropriate stimuli to improve brain plasticity and vision by:
    - alerting and orienting cues (sounds spatially located with visual targets)
    - training of executive attention (distractors progressively become more similar to tasks targets)
    - tasks designed to help with sustained attention (exercises become progressively longer with time)
Ultimeyes App

ULTIMEYES

- UC Riverside baseball (19 position vs 18 pitchers)
  - 24 30-minute training sessions
- Results demonstrated improvements in both visual acuity (7 improved to 20/7.5) and contrast sensitivity
- Analysis of batting performance before and after the training program demonstrated a significant reduction in strikeouts (4.4% improvement) and a combined increase of 41.2 runs created
- When calculated in relation to the prevailing conference statistics using Bill James’ Pythagorean Theorem of Baseball, this led to an estimated 4 – 5 extra games won over the 54-game season


RevitalVision™

- Revital Vision™ benefits advertised:
  - Ability to see better - in low light conditions
  - Enhanced vision - while driving and reading
  - Increase contrast sensitivity - 100% increase in Contrast Sensitivity
  - Increase visual acuity - Improve vision two lines on an Eye Chart on average
- Research support for improvements in VA & CS
  - No control/placebo comparison; effect retained after 12 mo

J Cataract Refract Surg 2008; 34:570-577

Accommodation & Vergence

- Distance Rock
- Lens Rock (Monoc)
- Prism Rock

Eye Movements

- Fixation steadiness
  - Haidinger Brush (MITT)
  - After-images
Eye Movements
- Hart Chart activities, 4+ charts/letters
- Marsden Ball (add motor & peripheral tasks)
- GOALS: Include loading

Speed & Accuracy of Depth Perception
- Eye Movement activities, 4+ charts/letters
- Marsden Ball (add motor & peripheral tasks)
- GOALS: Include loading

- EYEPORT® Vision Training System
  - Electronic Brock String-type applications
  - Saccadic eye movement applications
  - Peripheral vision training
  - Some research support for Little League baseball
  - No control group, or placebo training group for comparison

- Howard-Dolman Device

- Fixation Disparity
- Open Space Fusion

- Spatial localization techniques (z-axis); Imagery
Peripheral Vision
- Wayne Peripheral Awareness Trainer
- Spatial Localization techniques (laser pointer)
- Juggling (Strobe)
- Meter stick activities
- GOALS

Welford Information Processing Model

Speed of Recognition
- Tachistoscope activities
- Computer activities
- GOALS: targets

Game Vision™
- Formerly CP3 via GlassesOff app
  - “designed to challenge the brain’s image processing speed in order to achieve sharper vision focus faster”
  - Players identify flashing, near-threshold targets that vary in speed, size and contrast to progress through levels
    - Collinear facilitation
  - Prototype showed improvements in a wide range of visual tasks and overall enhancement in visual processing speeds
    (Lev & Polat, Federation of European Neuroscience Societies, 2015)
  - Coming soon...

Stroboscopic Training
- Strobelights/Strobe eyewear
  - Develops speed of visual processing
  - Slower flash rates require faster processing
  - Use w/pitchback, ball catching, practice drills, etc
  - Strobe eyewear can be worn during sport performance to train sport-specific visual processing speed

Other Strobe Products
Other Strobe Products

Strobe Training Steps

- Step 1: Practice the activity without the strobe for a short period of time (e.g., 2-5 minutes).
- Step 2: Repeat the activity with the Strobe for 5-10 minutes; work to decrease flash rate
  - Change after 3-5 successes at a level
- Step 3: Remove the strobe and repeat activity for at least 5 minutes to maximize retention of improved performance.

Football Turn & Catch Drill

Senaptec Strobe (formerly Nike)

- Integration training applications for various sports
  - Baseball/Softball, Football, Soccer, Basketball, Volleyball, Skiing/Surfing, Golf, etc.
- Duke University vision cognition research (N=504)
  "Those who trained with the Nike Strobes showed greater improvements than those in the control group, revealing training benefits due to the stroboscopic experiences." VSS '11
  http://today.duke.edu/2011/05/nikestrobe

Stroboscopic Training

- Stroboscopic training increased dynamic visual acuity (after one training session) and ball catching performance (over the course of the training) compared to training without a stroboscopic effect
- The strobe group averaged an 18% improvement in on-ice skill performance from pretraining to postraining, whereas the control group's performance did not improve
- Stroboscopic illumination reduced the severity of motion sickness symptoms, and shutter glasses with a flash frequency of 4 Hz are as effective as a strobe light

Brain Training Games

- BrainHQ partnered with TB12 to promote a sports-specific cognitive training module
- CogMed is promoting the use of their working memory training modules for athletes
- HeadTrainer app targets five areas of mental function specifically tailored to athletes
- Promising platforms, but no research at this time...
Visual Attention, Awareness & Responsiveness

- Metronome activities
- Yoked Prism Glasses
- Stress overloading activities
- Split Attention activities

NeuroTracker

- Immersive three-dimensional Multiple Object Tracking intervention with added dual-task functions to increase cognitive load
- Tracking objects (balls) as they move through space – targets and non-targets
  - Analagous to tracking teammates & opponents
- Speed and object number are adjusted in a staircase procedure, with other tasks added
- “Customize” and “Pro” versions
  (Note: This is not NeuroTrainer)

NeuroTracker

- Research shows it can discriminate high-level from lower-level athletes, and that a brief training regimen with the program can produce improvements in sports-related ability
  (Faubert et al., 2013; Korina, Gabriel, & Faubert, 2014)
- Performance has been correlated with actual game performance in professional basketball players (assists, steals & assist-to-turnover ratio), and that training with this program can selectively transfer to improved small-sided game passing performance in university-level soccer players
  (Mangine et al., 2014; Romeas, Guldner, & Faubert, 2016)

NeuroTrainer

- Virtual reality simulations that “integrate components across the perception-cognition-action continuum”
- Series of dual tasks that simultaneously challenge attention and peripheral vision, and purports to train eye-hand coordination, dynamic visual acuity, tracking, and visual reaction time
- Battery includes a number of visual tasks such as MOT, visual discrimination, visual search, visual crowding and go/no-go

The Quiet Eye™

- Mobile Eye Tracking

The Quiet Eye™
Visualization and Performance

- Pregame preparation (visualization)
- Analyze the situation
- Visualize desired performance
- Center on target (pre-action focus)
- Execution
- Playback emphasizing role of attention

SPORT SIMULATION APPROACHES

- Computerized simulations and virtual reality (VR) platforms have gained substantial use as alternate means by which to simulate game action, allowing athletes to gain ‘mental repetitions’ that mimic actual plays being run in the first-person with little-to-no risk of injury

SPORT SIMULATION APPROACHES

- Research with customized applications have evaluated the capacity to implement realistic sports-specific simulations of:
  - Baseball (Fink et al., 2009; Gray 2002; Zaal & RJ, 2011)
  - Tennis (Su et al., 2009)
  - Ping pong (Knorlein et al, 2007)
  - Billiards (Gourishankar et al., 2007)
  - Archery (Gobel et al., 2010)
  - Handball (Botte et al, 2010)
  - Rugby (Khos et al. 2012)

Virtual reality applications
• 17 football players ages from 7th grade to college
• Over a 3-day period, these athletes performed multiple repetitions on the SIDEKIQ™ football simulation, making pre-snap reads to identify the optimal receiver to throw the ball to on each play
• Over the course of the evaluation, individuals improved in their ability to make the correct passing decision by an average of 30%

Virtual reality applications

- **Steps 1 & 2: Compete & Assessment**
  - Strike Recognition will measure your Reaction Time with millisecond precision on every pitch you call a strike.
  - Pitch Recognition will do the same for pitches you sit on.
  - Both games will tell you how fast you are chasing pitches or how slow you are when you're late. Your Accuracy will measure how good your recognition is.
  - Ranks the athlete against the competition.

- **Step 3: Training**
  - Reaction Time Enhancement will use occlusion to train faster decisions.
  - Hitter’s Eye Zone Enhancement allows targeting of those parts of the strike zone most problematic.

- Available in VR & Mobile platforms
  - https://decervo.com/index.html

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Welford Information Processing Model

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**Perceptual Mechanism**
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**Decision Mechanism**
- Response Organization and Control of Ongoing Movement
- Expectation Based on Past Experience

**Effector Mechanism**
- Intrinsic Feedback
- Extrinsic Feedback

**Operational Memory**
- Interactive computer-based programs
- Large touchboard or touchscreen monitor
- Training algorithms for peripheral eye-hand response speed
- Training algorithms for decision-based peripheral eye-hand response speed
- Training algorithm for split attention

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Visual-Motor Reaction/Response
Time & Accuracy
(Eye-Hand, Body, Foot Coordination)

- Wayne Saccadic Fixator or Equivalent
- Pitchback/Table Tennis with strobe
- Juggling
- Split Attention
- Strobe training

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Lightboard-type Technologies

Most provide a platform of:
- Interactive computer-based programs
- Large touchboard or touchscreen monitor
- Training algorithms for peripheral eye-hand response speed
- Training algorithms for decision-based peripheral eye-hand response speed
- Training algorithm for split attention
• Options: SVT (Australia), Binovi Touch, Reflexion Edge

Lightboard-type Technologies

• Options: Vision Coach, BATAK Pro, Dynavision

Lightboard-type Technologies

• Good test-retest reliability for evaluation
• Dynavision with other SVT on collegiate baseball players found that batting averages, slugging percentage, and on-base percentage were all improved as compared to the previous season when no vision training was performed (Clark et al., 2012)
• 6 weeks of preseason training with 3x/week during the season
• With collegiate football, concussion incidences during the four years studied were reduced relative to the four years prior to the implementation of the training programs (Clark, Graman, et al., 2015)

Lightboard-type Technologies

• A 6-week training study used Dynavision with youth field hockey players
• Dynavision was used both as an assessment tool and as one of five training stations — along with Eyeport®, Hart charts, P-Rotator, and the Vision Performance Enhancement Program
• Performance on the Dynavision assessment task and a functional field of view assessment task both improved compared to a control group, but there was no difference in the MOT assessment (a transfer task)


The Quick Board
The Quick Board

- The Quick Board consists of a rubber mat positioned on the ground with sensor pads in five locations.
- The mat is connected to a control device that provides visual stimulus and feedback information about the movement responses.
- Four weeks of training with the Quick Board has been shown to produce significant improvements in foot speed, choice reaction, and change-of-direction in moderately active adults. (Galpin, K. Lehne, and Schilling 2008)

Vision & Balance

- Wayne Saccadic Fixator with Balance Board
- Balance Board Activities with reaction time
- Balance activities with other VT activities

Visual Anticipation Skills

- Wayne Speedtrack
- Bassin Anticipation Timer
- Stroboscopic activities

Integrated Sensorimotor Batteries

- Senaptec Sensory Station
- Vizual Edge Performance Trainer®
- Most of the research has correlated performance on specific measures of vision with sports performance metrics.
- Training studies with these instruments demonstrate improvements in visual performance measures, but there are only preliminary studies designed to determine effects on sports performance.

Senaptec Sensory Station: Training Programs

- Eye-Hand Coordination
- Go/No Go
- Depth Perception
- Near-Far Quickness
- Multiple Object Tracking
- Dynamic Perception

Senaptec Sensory Station
The Sensory Station was used as both a training tool and an evaluation benchmark in an applied program conducted by the University of Texas varsity softball. This intervention involved multiple weeks of SVT drills including practice with: Strobe Eyewear, Marsden Balls, Brock Strings, and Near Far Charts, as well as the Depth Perception, Eye-Hand Coordination, and Go/No-Go tasks on the Sensory Station. Results from 15 athletes who underwent SVT and 10 teammates who did not indicate significant relative improvements for the SVT group in three Sensory Station tasks (Near-Far Quickness, Target Capture & Go/No-Go). Appelbaum et al., 2016; Athletic Training & Sports Health Care. doi:10.3928/19425864-20160314-01

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  - Methods for Refractive Compensation
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Refractive Compensation
- Optimize Visual Acuity and Contrast Sensitivity through a careful balanced refraction
  - Consider the visual demands of the sport
- Determine the optimal method to deliver the Rx

Integrated Training Programs
Vizual Edge Performance Trainer®
- Training Paradigms
  - Visual Flexibility®
  - Visual Recognition®
  - Visual Tracking®
- RightEye
  - Training Paradigms
  - RightEye Cosmos Combat™
  - Space Storm™

Refractive Prescribing for Athletes
Prescribing Guidelines: “Raising the Bar”

<table>
<thead>
<tr>
<th>Refractive Status</th>
<th>Consider Prescribing at:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Myopia</td>
<td>-0.25 or more</td>
</tr>
<tr>
<td>Hyperopia</td>
<td>+1.00 or more</td>
</tr>
<tr>
<td>Astigmatism</td>
<td>-0.50 or more (WTR vs. ATR vs. Oblique)</td>
</tr>
<tr>
<td>Anisometropia</td>
<td>0.50 or more (consider meridians)</td>
</tr>
</tbody>
</table>

- **Bottom Line:** Maximize VA & Balance
Refraction Prescribing for Athletes
Other considerations for the Rx
• Timing of first prescription
• Value of over-minusing (CSF, Twilight)
• Re-evaluate visual performance with new Rx

Performance Contact Lenses

CONTACT LENS DESIGN FACTORS
• Selection of Material & Modality
• Nuances of fitting athletes
• Adjustments for environment
• Issues & performance of enhancement tints
• Orthokeratology (CRT)

Laser Refractive Surgery?
• Criteria: Who is a candidate
• Visual Effects
— SVA post-surgery = SVA pre-surgery with Rx?
— Where is the bar to be set for VA & Aniso?
— Dry Eye symptoms? Glare & Halo?
• Physical Effects: surgical options
— Surface procedures vs LASIK
• Clinicolegal Issues & Sports Eye Protection

EYE PROTECTION FOR SPORT
LENS DESIGN FACTORS

- “Street” glasses should never be used during sports activities
  - ANSI standards do not apply to sport
- Sports goggles & frames should meet ASTM safety standards
  - Traditional designs
  - Wrap-around style
  - Protective eyewear
- Prescribe protection for athletes following eye trauma or ocular surgeries when the ocular tissues have been weakened
  - e.g., keratoplasty, retinal detachments

Functionally Monocular Athletes

- Criteria: <20/40 (6/12) best corrected
- Risk of blindness increased by >15x
- Risk is averted with protective eyewear use
- Discourage participation in sports with a risk for serious eye injury in which an effective method of eye protection does not exist
  - Examples: boxing, wrestling, martial arts

American Society for Testing and Materials

- ASTM has established standards for sports where traditional eyewear designs are inadequate:
  - F803 basketball, baseball fielders, racquet sports, field hockey and women's lacrosse
  - F910 helmet shield, youth baseball batters/runners
  - F513 shields for ice hockey
  - F1776 protection for paintball
  - F659 skiing goggles/shields

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FILTER RECOMMENDATIONS

- Amber & Gray-Green tints (in CLs) have been shown to improve contrast sensitivity function and photostress recovery in natural sunlight
- Filters modify luminance contrast between the target and background to enhance visibility
- The improvements with filters can be limited in poor lighting
Filter Summary

- Athletes perform visual tasks that are driven by selected visual input
- Light filters have different activity applications depending on need
  - Task analysis: What should be enhanced?
  - There remains an aspect of filter preference that is subjective in nature – the athlete must engage in trials to determine the best filters for his/her needs

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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

Carotenoids

- ~50 in diet
- ~20 in blood
- Lutein and zeaxanthin concentrate in the eye (over 1000x the concentration of sera)

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)

MPOD & Glare Disability

Average improvement in Glare Disability was ~ 23%

MPOD and Photostress Recovery

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


Neural Efficiency: Reaction Speed

10% improvement in Visual Motor RT


Why Supplementation is Important

The Scarcity of Zeaxanthin in the Diet

Zeaxanthin Dietary Gap

MPOD Increases Due to Supplementation

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®

QUESTIONS?

References

• Appelbaum LG, Erickson G. Sports vision training: A review of the state-of-the-art in digital training techniques. Int Rev Sport & Exercise Psychology 2016; DOI: 10.1080/1750948X.2016.1266376