Concussion-Related Vision Problems: Vision Rehabilitation

Mitchell Scheiman, OD, PhD
Financial Disclosures

None
Presentation Overview

- Definitions
- Prevalence of vision problems after mTBI/concussion
- Vision Rehabilitation
- Underlying mechanisms for improved function
Three Component Model of Vision

- Visual Integrity
- Oculomotor Skills
- Visual Information Processing
Oculomotor Skills

- Saccades, Pursuits
- Binocular Vision
- Accommodation
Accommodation Disorders

Definition
- Age-related loss of accommodation
  - Structural
- Concussion-related loss of accommodation
  - Visual Pathway

Most common accommodative problem
- Accommodative Insufficiency
Binocular Vision Disorders

- Convergence Insufficiency
  - Condition in which eyes struggle to maintain convergence at near

- Symptoms
  - Eyestrain
  - Blurred vision
  - Double vision
  - Inability to sustain attention on task
  - Reduced comprehension
Convergence Insufficiency can make text look double when trying to read.

Some people with Convergence Insufficiency experience a “halo effect” instead of double vision.
Eye Movement Disorders

Eye movement problems
- Saccades
- Pursuits
Symptoms of Oculomotor Disorders

- Eyestrain
- Blurred vision
- Double vision
- Words moving on page
- Inability to sustain attention on task
- Reduced comprehension
- Loss of place
- Dizziness/nausea
Prevalence of Vision Deficits - Overview

Normal Population
- Binocular vision – 10%
- Accommodation – 3%
- Eye Movements – 2%

After Concussion/mTBI
- Binocular vision – 30%-45%
- Accommodation – 10%-50%
- Eye Movements – 20%-40%
## Prevalence Studies - Summary

<table>
<thead>
<tr>
<th>Problem</th>
<th>Goodrich N=46 Mean age=28</th>
<th>Brahman N=192 Mean age=28</th>
<th>Stelmack N=192 Mean age=31</th>
<th>Cuiffreda N=160 Mean age=42</th>
<th>Suchoff N= 62 Mean age=49</th>
<th>Master/Scheiman N= 100 Mean age=14</th>
</tr>
</thead>
<tbody>
<tr>
<td>Convergence Insufficiency (10%)</td>
<td>30%</td>
<td>42%</td>
<td>28%</td>
<td>36%</td>
<td>42%</td>
<td>49%</td>
</tr>
<tr>
<td>Accommodative Dysfunction (3%)</td>
<td>22%</td>
<td>42%</td>
<td>47%</td>
<td>41%</td>
<td>10%</td>
<td>50%</td>
</tr>
<tr>
<td>Saccadic Dysfunction (2%)</td>
<td>20%</td>
<td>33%</td>
<td>9%</td>
<td>57%</td>
<td>40%</td>
<td>29%</td>
</tr>
</tbody>
</table>
Concussion-Related Vision Problems in Adolescents

Salus University/Children’s Hospital of Philadelphia (CHOP)

- Objective: Determine prevalence of vision problems in children 11-17 years old with a medical diagnosis of concussion
- Method: Performed vision exam on 100 consecutive adolescents with diagnosis of concussion
Results

- N = 100
- Mean age = 14.3 years
- 69% had at least 1 vision problem
  - Accommodative problems: 50%
  - Convergence insufficiency: 49%
  - Saccadic dysfunction: 29%
Impact on Recovery

- Retrospective cohort of 432 pediatric patients with concussion
- The main outcome of interest was time to clinical recovery
- Results: 378 of 432 subjects (88%) presented with vision or vestibular problems
- Conclusions: Vision and vestibular problems predict prolonged concussion recovery in children
- Vision assessments in concussion must include smooth pursuits, saccades, near point of convergence, and accommodative amplitude

Treatment Options

- Lenses
- Prism
- Vision therapy/vision rehabilitation
Vision Therapy/Vision Rehabilitation

- Rehabilitation of ocular motor and other visual deficits using lenses, prisms, instrumentation, software
- Very basic techniques are sometimes integrated into physical therapy/vestibular Therapy
- Typically done by specialty trained optometrists
- In-office and home therapy components
Oculomotor Rehabilitation

VIDEO EXAMPLE

SALUS UNIVERSITY
Example of VT: Aperture Rule
Is Oculomotor Rehabilitation Effective?
Vision Rehabilitation: Effectiveness

- More research in non-traumatic brain injury (TBI) patients
- Expanding research in TBI/concussion
A Randomized Clinical Trial of Treatments for Convergence Insufficiency in Children

Mitchell Scheiman, OD; G. Lynn Mitchell, MAS; Susan Cotter, OD; Jeffrey Cooper, OD, MS; Marjean Kulp, OD, MS; Michael Rouse, OD, MS; Eric Borsting, OD, MS; Richard London, MS, OD; Janice Wensveen, OD, PhD; for the Convergence Insufficiency Treatment Trial (CITT) Study Group

Objective: To compare vision therapy/orthoptics, pencil push-ups, and placebo vision therapy/orthoptics as treatments for symptomatic convergence insufficiency in children 9 to 18 years of age.

Methods: In a randomized, multicenter clinical trial, 47 children 9 to 18 years of age with symptomatic convergence insufficiency were randomly assigned to receive 12 weeks of office-based vision therapy/orthoptics, office-based placebo vision therapy/orthoptics, or home-based pencil push-ups therapy.

Main Outcome Measures: The primary outcome measure was the symptom score on the Convergence Insufficiency Symptom Survey. Secondary outcome measures were the near point of convergence and positive fusional vergence at near.

Results: Symptoms, which were similar in all groups at baseline, were significantly reduced in the vision therapy/orthoptics group (mean symptom score decreased from 32.1 to 9.5) but not in the pencil push-ups (mean symptom score decreased from 29.3 to 25.9) or placebo vision therapy/orthoptics groups (mean symptom score decreased from 30.7 to 24.2). Only patients in the vision therapy/orthoptics group demonstrated both statistically and clinically significant changes in the clinical measures of near point of convergence (from 13.7 cm to 4.5 cm; P < .001) and positive fusional vergence at near (from 12.5 prism diopters to 31.8 prism diopters; P < .001).

Conclusions: In this pilot study, vision therapy/orthoptics was more effective than pencil push-ups or placebo vision therapy/orthoptics in reducing symptoms and improving signs of convergence insufficiency in children 9 to 18 years of age. Neither pencil push-ups nor placebo vision therapy/orthoptics was effective in improving either symptoms or signs associated with convergence insufficiency.

Randomized Clinical Trial of Treatments for Symptomatic Convergence Insufficiency in Children

**Objective:** To compare home-based pencil push-ups (HBPP), home-based computer vergence/accommodative therapy and pencil push-ups (HBCVAT+), office-based vergence/accommodative therapy with home reinforcement (OBVAT), and office-based placebo therapy with home reinforcement (OBPT) as treatments for symptomatic convergence insufficiency.

**Methods:** In a randomized clinical trial, 221 children aged 9 to 17 years with symptomatic convergence insufficiency were assigned to 1 of 4 treatments.

**Main Outcome Measures:** Convergence Insufficiency Symptom Survey score after 12 weeks of treatment. Secondary outcomes were near point of convergence and positive fusional vergence at near.

**Results:** After 12 weeks of treatment, the OBVAT group’s mean Convergence Insufficiency Symptom Survey score (15.1) was statistically significantly lower than those of 21.3, 24.7, and 21.9 in the HBCVAT+, HBPP, and OBPT groups, respectively ($P < .001$). The OBVAT group also demonstrated a significantly improved near point of convergence and positive fusional vergence at near compared with the other groups ($P \leq .005$ for all comparisons). A successful or improved outcome was found in 73%, 43%, 33%, and 35% of patients in the OBVAT, HBPP, HBCVAT+, and OBPT groups, respectively.

**Conclusions:** Twelve weeks of OBVAT results in a significantly greater improvement in symptoms and clinical measures of near point of convergence and positive fusional vergence and a greater percentage of patients reaching the predetermined criteria of success compared with HBPP, HBCVAT+, and OBPT.

**Application to Clinical Practice:** Office-based vergence accommodative therapy is an effective treatment for children with symptomatic convergence insufficiency.

**Trial Registration:** clinicaltrials.gov Identifier: NCT00338611

*Arch Ophthalmol.* 2008;126(10):1336-1349
Treatment of Accommodative Dysfunction in Children: Results from a Randomized Clinical Trial

Mitchell Scheiman*, Susan Cotter†, Marjean Taylor Kulp‡, G. Lynn Mitchell§, Jeffrey Cooper§,
Michael Gallaway‖, Kristine B. Hopkins‡, Mary Bartuccio**, Ida Chung‖,
and the Convergence Insufficiency Treatment Trial Study Group

ABSTRACT

Purpose. To report the effectiveness of various forms of vision therapy/orthoptics in improving accommodative amplitude and facility in children with symptomatic convergence insufficiency (CI) and co-existing accommodative dysfunction.

Methods. In a randomized clinical trial, 221 children aged 9 to 17 years with symptomatic CI were assigned to one of four treatments. Of the enrolled children, 164 (74%) had accommodative dysfunction; 63 (29%) had a decreased amplitude of accommodation with respect to age, 43 (19%) had decreased accommodative facility, and 58 (26%) had both. Analysis of variance models were used to compare mean accommodative amplitude and accommodative facility for each treatment group after 4, 8, and 12 weeks of treatment.

Results. After 12 weeks of treatment, the increases in amplitude of accommodation (office-based vergence/accommodative therapy with home reinforcement group (OBVAT) 9.9 D, home-based computer vergence/accommodative therapy group (HBCVAT+) 6.7 D, and home-based pencil push-up therapy group (HBPP) 5.8 D) were significantly greater than in the office-based placebo therapy (OBPT) group (2.2 D) (p-values ≤0.010). Significant increases in accommodative facility were found in all groups (OBVAT: 9 cpm, HBCVAT+: 7 cpm, HBPP: 5 cpm, OBPT: 5.5 cpm); only the improvement in the OBVAT group was significantly greater than that found in the OBPT group (p = 0.016). One year after completion of therapy, reoccurrence of decreased accommodative amplitude was present in only 12.5% and accommodative facility in only 11%.

Conclusions. Vision therapy/orthoptics is effective in improving accommodative amplitude and accommodative facility in school-aged children with symptomatic CI and accommodative dysfunction.

(Optom Vis Sci 2011;88:1–10)
Mean CISS Scores by Group

No significant differences were observed between the HBPP, HBCVAT+, and OBPT groups (pair-wise p-values all ≥ 0.38).
Non-surgical interventions for convergence insufficiency
(Review)

Scheiman M, Gwiazda J, Li T

This is a reprint of a Cochrane review, prepared and maintained by The Cochrane Collaboration and published in The Cochrane Library
2011, Issue 3

http://www.thecochranelibrary.com
Recent Treatment Studies
Vision Rehab after mTBI


Research - Adults after mTBI

- Funded by Department of Defense
  - Compared office-based VT to placebo VT in adult patients with mTBI
  - Not only used placebo control, but first study to use objective measures of vergence
    - Not susceptible to bias
Results

- Objectives measures of vergence improved markedly
- Near-vision symptoms reduced along with improved visual attention
- None of the measures were found to change significantly following the placebo training
- Demonstrates brain visual system plasticity after mTBI in adult subjects
Potential Underlying Mechanisms

Neural Synchronization
Out of sync...Analogous to a conductor in an orchestra who facilitates the synchronization of the musicians

Neural Recruitment
Fewer neurons participating in the task

Functional Connectivity
Poorer connectivity between neural sites involved in vergence or other visual functions

Slide courtesy of Dr. Tara Alvarez
Experimental Set-Up for fMRI Eye Movement Experiments

Saccade Stimulation

Vergence Stimulation

10 Deg Midline
Target

Target

Target

Near Target

Middle Target

Far Target

Slide courtesy of Dr. Tara Alvarez
Vergence Therapy Improves Synchronization

Interpretation: Vision Therapy stimulates improved neuronal synchronization

Jaswal, Gohel, Biswal Alvarez 2014
Vergence Therapy Stimulates Neural Recruitment

Binocular Normal Control (BNC)  CI Before Therapy  CI After Therapy

Frontal Eye Fields (FEF shows by green arrows) shows an increase in spatial extent

Interpretation: Vision Therapy stimulates increase in spatial extent

Alvarez et al. 2010
Vergence Therapy Improves Task Induced Functional Connectivity

The correlation between the time series of FEF (red) PPC (green) and CV (blue) improves. Broca’s region (purple) was not correlated to FEF, PPC or CV

Interpretation: Vision Therapy stimulates improved functional connectivity

Jaswal, Gohel, Biswal Alvarez 2014
Summary

Underlying mechanism of for improvement after vision therapy:
- Neural Synchronization
- Neural Recruitment
- Functional Connectivity
Conclusions

- Vision evaluation and rehabilitation should be part of the interprofessional care provided to patients after mTBI

- Non-eye care professionals should screen for oculomotor problems after concussion
  - Consider referrals for comprehensive oculomotor examination
  - Consider oculomotor rehabilitation
  - Randomized clinical trials required
Contact Information

Mitchell Scheiman

mscheiman@salus.edu

Thank You!