The Role of Speech-Language Pathology in Managing Sports-Related Concussion

A.P. Salvatore, Ph.D.
B.S. Fjordbak, Ph.D.
D. Dominguez, Ph.D.
J.S. Sipla, Ph.D.

University of Texas at El Paso, College of Health Sciences
Learner Outcomes

After this session, participants will be able to:

1. Describe the mechanisms of structural and metabolic changes in concussion.
2. Discuss the tools used for assessment of subtle cognitive-communicative deficits in concussion.
3. Explain the role of the SLP in concussion management.

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Motivation for Establishing the Concussion Management Clinic

• Interest in the diagnosis, treatment, prevention of blast injuries of soldiers in Iraq and Afghanistan.

• Interest in investigating sports-related concussion as a model for pursuing the interest in blast injuries.

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Motivation for Establishing the Concussion Management Clinic

• Established UTEP’s Concussion Management Clinic in 2006 and instituted a model to study concussion/mTBI: "Sports as a Laboratory Assessment Model (SLAM)."

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Sports as a Laboratory Assessment Model (SLAM).
Barth, et al. (1989, 1996, 2001)

1. Use a pre and post-trauma assessment approach.

2. Use a young, healthy, and motivated population with a high probability of sustaining mild acceleration-deceleration head injury.

3. College football, soccer, basketball and volleyball players meet the above criteria.

4. Requires cooperation of head athletic trainer and team physician, as well as the head coach.

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Concussion Management Clinic

• Well received by the university athletic trainers; involves pre-participation testing of all athletes at UTEP.
• Now includes several high schools and the local professional hockey team.
• Working relationship with the sports medicine clinic physician at the Texas Tech medical school in El Paso.
• CMC Research Team continues to grow in interest across several disciplines.
What is mTBI/concussion?

- Disturbance in Brain Function:
  - Physical damage such as shearing, tearing, breaking of neurons
  - Neuro-metabolic changes

- Prevalence: 1.6 to 3.8 million sports and recreation-related head injuries occur in US each year.

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What is mTBI/concussion?

- Risks:
  - Repeated concussion before recovery can cause \textbf{Second Impact Syndrome} involving brain swelling, permanent brain damage, even death.

- Behavioral Changes:
  - Cognitive, Emotional, Neurovegetative

- \textbf{Post-Concussion Syndrome}

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Common Signs & Symptoms

• Appears to be dazed or stunned
• Is confused about assignment
• Forgets plays
• Is unsure of game, score, or opponent
• Moves clumsily
• Answers questions slowly
• Shows behavior or personality change
• Forgets events prior to or after being injured
• Loses consciousness, even temporarily

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Assessment of Concussion/mTBI

Dr. Bess Sirmon Fjordbak

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• Traditional neurological and radiologic procedures are not useful in identifying the effects of concussion. Such tests are typically unremarkable, even in athletes sustaining a severe concussive injury.

• Concussion is a **metabolic** as well as **structural** injury; traditional neuroimaging techniques are insensitive to the effects of concussion.

• Emerging technologies are showing promise for identifying deficits at the neuronal level.

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Assessment of Concussion/mTBI

• **Two pronged approach:**
  - Baseline assessment
    • Preseason testing
  - Follow-up testing
    • Post-concussion
    • Serial re-evaluations

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Protocols

- ImPACT
- Word Fluency
- Story Retell Protocol
- Computerized Revised Token Test
- SPICA
- BDAE Aphasia Severity Rating Scale
- Balance Error Scoring System

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Immediate Post-concussion Assessment and Cognitive Testing (ImPACT)

• Computer-based program, objective administration
• Strong psychometric basis
• Three components:
  – Demographics
  – Symptoms
  – Neurocognitive assessment
• Available in 13 languages
• NFL, NHL, Major League Soccer, US Lacrosse

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www.impacttest.com
• Assesses
  - Attention span
  - Working memory
  - Sustained and selective attention
  - Response variability
  - Non-verbal problem solving
  - Reaction time

• Measures
  - Current status
  - Change over time

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www.impacttest.com
• Can be administered in about 40 minutes
• Provides tabular and graphic data on a time line
Word Fluency

- Word fluency tasks are used to measure cognitive-linguistic changes involving access, association, and retrieval of stored information in a timed milieu.
- Administered in about five minutes (F-A-S).
Word Fluency

• Tombaugh and colleagues (1999) established normative data on a large sample in North America using F-A-S, which has served as the basis for the current study.

• Baseline measures of a local sample suggest results consistent with those norms.
Word Fluency

• As a point of comparison, the Verbal Memory Composite from the ImPACT Test (2007) is an average of performance on *Word Memory, Symbol Match*, and *Three Letters* subtests. Both of these assessment tools address cognitive-linguistic skill sets involving:

☆ efficient word storage, access, and retrieval;
☆ working memory;
☆ cognitive speed;
☆ consolidation of linguistic concepts in timed tasks.

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• Cognitive-linguistic testing can be a sensitive measure of impairment and recovery, and changes in skills such as word fluency can provide useful data for clinical management of concussion.

• Word fluency appears to be a sensitive measurement of impairment, as changes in the cognitive-linguistic processes involved in access and retrieval are evident in the days post-injury.
• Three discourse-length stories are presented, and participants are asked to re-tell each one immediately after presentation.

• Scored according to the number of information units retained and retrieved.

• Measures retention of contextually-based sequential information in immediate recall.
Story Re-Tell Protocol


• Can be administered in about ten minutes.
• Use with mTBI and concussion
• Further analysis will address patterns of recall (e.g., phonological, semantic, primacy vs. recency)

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Computerized Revised Token Test

Eberwein, Pratt, McNeil, Fossett, Szuminsky, & Doyle, 2007

• Computer-based administration allows for:
  
  – Standardized administration
  
  – Multidimensional scoring of speed and accuracy
  
  – Analysis of error patterns (e.g., right/left differentiation)

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Computerized Revised Token Test

• Administration time is about five minutes.

• Uses one subtest (VIII) which presents three part stimuli with two modifiers

  For example:

  Put the little red circle
  to the left of the big white square

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SPICA
DiSimoni, Keith & Darley, 1980

• The shortened version of the Porch Index of Communicative Ability

• Four subtests are used:

  **Subtest I** – describing function
  **Subtest VI** – pointing to object by function
  **Subtest VII** – reading name and position
  **Subtest D** – writing name, spelling dictated

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SPICA

- Can be administered in about ten minutes
- Allows for implementation of multidimensional scoring system, which accommodates for subtle changes in cognitive-linguistic function
- Reliability and validity compared to PICA
- Use with TBI population

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BDAE Aphasia Severity Rating Scale

Goodglass & Kaplan, 1983

- Allows for qualitative description of overall communicative function, rated on a scale of 0-5

0. No usable speech or auditory comprehension

1. Fragmentary communication

2. Can converse about familiar subjects

3. Can discuss almost all everyday problems

4. Some obvious loss of fluency, no significant limitation

5. Minimal discernible speech handicaps

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After injury to the brain, there can be temporary or permanent changes to dynamic standing balance, reflective of neurological involvement.

Changes in balance can be measured across time, as symptom presentation changes.

Administration time is 10-15 minutes.
Neurophysiological Correlates of Concussion/mTBI

Dr. Justin S. Sipla

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Purpose of the Vestibular System

- Motion sensors embedded in the otolithic macula and semicircular canal ampullae respond to changes in head position and—combined with visual and proprioceptive inputs—drive reflexive movements of the eyes, neck, and spine.
Organization of the Vestibular System

Sensory Input
- Vestibular
- Visual
- Proprioceptive

Central Processing
- Primary Processor (Vestibular Nuclear Complex)
- Adaptive Processor (Cerebellum)

Motor Output
- Motor Neurons

Eye Movements
- Positional Movements

Sensu Herdman, 2007
Vestibular Reflexes

- **VOR** (Vestibuloocular reflexes)
  - Acts to maintain stable vision during head motion

- **VSR** (Vestibulospinal reflexes)
  - Acts to stabilize the body when perturbed

- **VCR** (Vestibulocollic reflexes)
  - Acts on the neck musculature to stabilize the head

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Head trauma-induced vestibular symptoms can result from injury to...

- Inner ear
- Vestibular nerve
- Brainstem or vestibulocerebellum
Benign Paroxysmal Positional Vertigo (BPPV)

- Most common vestibular sequela to TBI (Ernst et al., 2005)
- Intense acceleration of the utricular otolithic membrane dislodges otoliths
  - Cupulolithiasis or canalithiasis
- Produces a transient positional nystagmus (involuntary eye movements) and vertigo ("dizziness")
- Primary treatment consists of repositioning maneuvers or surgical occlusion of affected canal

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Labyrinthine Concussion

- Damage to peripheral vestibular organs due to blunt trauma or barotrauma
- Often associated with variable hearing loss
- Persistent symptoms attributed to secondary endolympathic hydrops
- Labyrinthine hemorrhage may trigger inflammation
  - Leads to fibrosis and ossification
  - Audiovestibular dysfunction

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Post Traumatic Endolymphatic Hydrops

• Endolymphatic channels are ruptured, causing fluid to flow into restricted spaces, or to accumulate due to blocked drainage

• Tetrad of symptoms:
  – Fluctuating hearing loss
  – Episodic vertigo
  – Tinnitus or ringing in the ears (usually low-tone roaring)
  – Aural fullness (pressure and discomfort in the ears)

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Perilymphatic Fistula

• Caused by changes in intracranial pressure, which can rupture the round or oval window
• Perilymph leaks into the air-filled middle ear cavity
• Symptoms:
  – Fluctuating hearing loss
  – Episodic vertigo
  – Gait and balance disturbances
Temporal Bone Fractures

• Can disrupt the bony labyrinth, membranous labyrinth, or VIIIth cranial nerve

• Resulting in unilateral or bilateral vestibular hypofunction

• Anatomic damage to middle ear ossicles can result in conductive hearing loss
Central Vestibular Lesions

- Contusion or hemorrhage of brainstem or vestibulocerebellum
  - Reported in both mildly and moderately head-injured patients (Herdman, 2007)
  - Symptoms can include:
    - Spontaneous nystagmus and oculomotor problems
    - Spontaneous and/or provoked vertigo
All of These Syndromes Can Contribute to Postural Instability

• Numerous controlled studies have demonstrated postural stability deficits secondary to TBI on post-injury day 1 (e.g., Guskiewicz et al., 2003; Valovich et al., 2003) using the BESS protocol.

• Initial 2 days post are most problematic, due to sensory interaction problems between visual, vestibular, and somatosensory systems (ibid.).
Balance Deficits Post Concussion

• Balance = process of maintaining the body’s center of gravity (COG) within the body’s base of support (Guskiewicz, 2001).

• Two tests to measure functional skills related to postural control and stability:
  – Berg Balance Scale
  – Balance Error Scoring System (BESS)
Berg Balance Scale

- Rates performance from 0 (cannot perform) to 4 (normal performance) on 14 different tasks, including ability to safely and independently:
  - Sit
  - Stand
  - Reach
  - Lean over
  - Turn and look over each shoulder
  - Turn in complete circle

Score of 56 = excellent balance
Excellent inter-rater reliability and good concurrent validity
Effective predictor of fall risk

(Berg, 1993)

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Balance Error Scoring System (BESS)

- Objective measure of postural stability.
- Portable and more cost-effective than the Sensory Organization Test (SOT).
- Injured athlete maintains three stances—double, single, and tandem—while standing on a firm surface or foam substrate.

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Balance Error Scoring System (BESS)

- Subject instructed to maintain stance for 20 seconds with eyes closed, hands to hips
- Subject instructed to make any necessary adjustments to maintain balance, returning to original position as soon as possible
- Examiners are trained to recognize 6 types of errors
- Scoring based on total number of errors observed over the 6 trials

Image from Collegiate Sports Medicine Foundation (http://www.csmfoundation.org)

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Balance Error Scoring System (BESS)

- **ERRORS:**
  - Hands lifted off iliac crest
  - Eyes opened
  - Stepping, stumbling, or falling
  - Hip moved >30° in flexion or extension
  - Forefoot or heel lifted
  - Out of testing position >5 sec

- Total BESS score calculated by adding 1 error point for each error committed.

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Guskiewicz et al. (2001)
Balance Error Scoring System (BESS)

- Validity: Interrater reliability coefficients range from .78 to .96.
- Injured athletes show signs of impairment immediately after injury and for 3-5 days post.
- Recovery curves parallel those obtained with SOT.
- Studies comparing BESS to various neuropsychological tests have found no relationships. Each measure contributes unique information.

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Guskiewicz et al. (2001)
mTBI Laboratory analysis

Dr. Delfina Cisneros-Dominguez

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In TBI, primary injury occurs rapidly after trauma.

Blood vessels are damaged, there is contusion and neurons may be torn.
Background Information

- Secondary injury occurs gradually and may involve several subcellular processes.
- While primary injury can be detected by imaging and histochemistry, the degree of secondary injury is difficult to assess.

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Secondary Injury

- A hallmark of secondary TBI is the imbalance of calcium ions within neurons.
- Calcium (Ca) ions regulate many cellular processes.
- Intracellular concentration of Ca ions is normally tightly regulated.

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Cellular Damage after Brain Injury

1. Narrowing of blood vessels
2. Breakdown of blood barrier
3. Destruction of neurons
4. Excess influx of Calcium ions leading to axonal disconnection
5. Protein destruction
6. Inflammatory substances released leading to cell death

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Park et al. (2008)
Major Pathways Associated with Progression of 2° injury after TBI

1. Microvascular stenosis
2. Astrocyte foot-process swelling
3. Astroglisis
4. Glutamate transport reversal
5. NMDA receptor activation
6. Cellular depolarization
7. Oxidative stress
8. Excitotoxicity
9. Mitochondrial dysfunction
10. Caspase cascade
11. Intra-axonal Ca²⁺ accumulation
12. Proinflammatory cytokine release
13. Cytoskeletal breakdown
14. Protease activation
15. Excess glutamate
16. Presynaptic glutamate release

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Park et al. (2008)
Proteins Associated with TBI

- **S-100**
  - Ca-binding protein involved in various intracellular and extracellular processes. Present in various non-neuronal cells including glial cells, chondrocytes, and Schwann cells.

- **Neuron Specific Enolase (NSE)**
  - Found in the cytoplasm of neurons, involved in glycolytic pathways.

- **Cleaved-Tau Protein (CTP)**
  - Microtubule associated protein abundant in neurons.
mTBI Project Pilot Project

• **GOALS**
  
  – To investigate the relationship of brain-related proteins, symptoms, and neurocognitive function in concussed and non-concussed athletes.
  
  – To assist in the evaluation, treatment and prevention of post-concussion syndrome.
  
  – To promote education and awareness of concussion management

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mTBI Research Project

- **HYPOTHESIS**
  - We hypothesize that the serum measurements of potential neurological biomarkers such as S-100 protein isoform B, cleaved Tau protein (CTP), and Neuron-Specific Enolase (NSE) would help in the clinical evaluation of mild head injury and may help in the prediction of post-concussion syndrome (PCS).

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METHODS

- Athletes with and without history of concussion will be identified from the files of the concussion management clinic. A third sample of athletes will be those referred to the clinic with an acute onset of concussion.

- These three groups will be matched as closely as possible for age, gender, education, time post onset of concussion and severity of concussion.

- Serum draws will be made from the two non-acute samples. The acute sample will have blood drawn on each post-concussion assessment appointment, usually 3-4 days and 21 days post onset.
• METHODS

– Various proteins and enzymes will be analyzed by immunoassay techniques.

1. Serum proteins
2. Primary Specific antibody binds to protein
• **METHODS**
  
  – Various proteins and enzymes will be analyzed by immunoassay techniques.

  3. Second tagged-antibody binds to the first antibody
  4. Substrate added to develop reaction

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Positive reaction indicated by purple color

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Management of Concussion/mTBI

Dr. Anthony P. Salvatore

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Preseason Screening

Concussion occurs

Remove from play

Medical Evaluation

Return to CMC for f/u

Results and rec.

Gradual increase in activity

MD: RTP readiness

Safely return to play

Continuity of Care

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Goal of Management:

*Permit the brain injury to heal.*

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Goals of the Concussion Management Clinic:

- Promote baseline testing to improve outcomes
- Provide follow-up serial assessments to contribute to return-to-play decisions in case of injury.
- Present public education and training regarding the mechanism of concussion/mTBI in athletes.
- Conduct research to contribute to the understanding the sequelae of concussion/mTBI.

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The Future

• To date we have collected pre-participation data on over 600 athletes at the collegiate, high school, middle school and professional hockey.

• We have managed over 40 post-concussion athletes. The feedback from athletes, trainers and physicians has been encouraging.
The Future

- We have established research relationship with the Office of Clinical Investigations at WBAMC and have collected pilot data, which was followed by a large multi group study of control, PTSD only, PTSD + TBI, TBI only soldiers in collaboration with the Human Performance Lab at Ft. Rucker.

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We have presented a preliminary comparison between soldiers with a history of TBI and athletes with a history of concussion.

– Do symptoms of cognitive–linguistic disturbance present similarly in both populations?

– Do the diagnostic criteria in place adequately describe the changes in these two groups?
• Additional avenues of research are in the areas of metabolic and radiologic assessment in correlation with behavioral data, and investigation of the recovery pattern of athletes following concussion.

• The recent findings using diffuse tensor imaging suggest a bright future in diagnosing and treating concussion/mTBI whether acquired in combat or on the athletic field.

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References


• [www.impacttest.com](http://www.impacttest.com)
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* Graduates of the SPLP program

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Thank You for Your Attention

Questions?

- asalvatore@utep.edu
- bsfjordbak@utep.edu
- jssipla@utep.edu
- delfina@utep.edu