The Use of Tandem Gait & BESS Test for Concussion Management

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Disclosure Statement

I have nothing to disclose.

Course Objectives

- 1. To identify the effects of how sustaining a concussion can have on motor and balance function of a patient.
- 2. To understand the evaluation process of motor and balance function using the tandem gait and BESS tests both pre- and post-concussion to properly manage and make return to play decisions.
- 3. To implement return-to-play guidelines following a concussion utilizing the BESS test and tandem gait test with modifications (single-task, dual-task) as functional rehabilitation techniques that address all deficits a patient may have post-concussion.

Concussions

What is a Concussion?

NATA Position Statement: Management of Sport Concussion- A concussion, which is a form of mild traumatic brain injury (mTBI), has been defined as a trauma-induced alteration of mental status that may or may not involve the loss of consciousness.¹

McCrory et al. defines a concussion diagnosis as an injury caused by a direct blow to the head, face, neck or elsewhere on the body with impulsive force transmitted to the head, resulting in impaired neurological function and acute clinical symptoms.²

Concussion Frequency

The World Health Organization's (WHO) Collaborating Centre Task Force estimate that the annual incidence of concussion is 100 to 300/100,000 emergency department visits³

• Many go unreported – closer to 600/100,000³

It is estimated that 1.6-3.8 million concussions occur annually as a result of sport participation⁴

- Many by high school aged students^{5,6}
- Account for approximately 5% of all collegiate sport-related injuries⁷

Mechanisms of Concussion

Direct blow to the head or body

• Head snap forward, backward, or rotate to the side⁸

Common in collision or contact sports⁹

• Football, soccer, lacrosse, boxing, ice hockey wrestling¹⁰

Not limited to only contact sports

• Baseball, softball, gymnastics, field hockey, volleyball, cheerleading, track

Non-sport related

Motor vehicle accidents & direct contact with an inanimate object¹¹

Signs & Symptoms¹²

Dizziness

Headaches

Blurred vision

Abnormal eye tracking

Diplopia

Photophobia

Tinnitus

Delayed verbal & motor responses

Slurred speech

Concentration problems

Memory deficit

Disrupted coordination

Behavioral changes

Loss of consciousness^{9,13}

Evaluation

Determining level of consciousness

Assessing ABC's and cervical spine

HOPS

- Neurological Exam
 - Cranial Nerves
 - Dermatome, myotome, and reflexes
- Coordination (Cerebellar) Tests
- Cognitive (Cerebral) Tests

Cerebellar (Balance) Tests

Romberg Test

- Non-dominant single-leg stance
- Tandem stance
 - Eyes open and closed
 - Firm and foam surfaces¹⁴

Romberg Test



Single Leg Non-Dominant Stance (eyes open/closed)

Tandem Stance Non-Dominant in Back (eyes open/closed)





Single Leg Non-Dominant Stance (eyes open/closed) on Foam

Tandem Stance Non-Dominant in Back (eyes open/closed) on Foam



Cerebellar (Balance) Tests

Balance Error Scoring System (BESS)⁹

Types of Errors

- 1. Hands lifted off iliac crest
- 2. Opening eyes
- 3. Step, stumble, or fall
- 4. Moving hip into > 30° ABD
- 5. Lifting forefoot or heel
- Remaining out of testing position for > 5 sec

The BESS is calculated by adding one error point for each error during the six 20second tests.

Score Card (# errors)	FIRM Surface	FOAM Surface
Double-Leg Stance (narrow stance- feet together)		
Single-Leg Stance (nondominant foot)		
Tandem Stance (nondominant foot in back)		
Total Scores		

BESS Test



Coordination (Cerebellar) Tests

Upper-limb Coordination

• Finger-to-nose test



Coordination (Cerebellar) Tests



Cognitive (Cerebral) Tests

Baseline measurements vs. post-concussion^{10,18}

- Memory recall
 - Retrograde amnesia who won last week, where they live, food ate for breakfast
 - Anterograde amnesia game score, last play, 3 word recall
- Serial 7
- Backward spelling
- Months in reverse order

Sport Concussion Assessment Tool (SCAT)

Development & Implementation^{19,20}

- Symptom scale
- Maddocks' questions/score
- On-field markers of concussion
 - Amnesia, loss of consciousness
- Return to play

Revisions

- SCAT2: 2004 Glasgow Coma Scale (GCS), alternate word lists, BESS (hard surface only)
- SCAT3: 2013 additional physical/objective signs, option for foam stances or timed tandem gait
- SCAT5: 2017 more alternative digits, neurological screen, modified tandem gait (no timing)

Children's SCAT (< 13yo)²¹⁻²³

• Versions 3 and 5

Balance & Stability

Balance & Stability

Control of joint posture & motion²⁴

- Results from physiological constraints in the body
 - Muscular & non-muscular tissue
 - Nervous system's control of muscle activity
 - Resulting muscle force

Develops in stages during childhood²⁴

 Learns to integrate inputs from visual and other sensory sources

Maintaining Balance & Stability

Joint posture

- Relies on nervous system
 - Spinal cord
 - Brain
- Voluntary control
 - Muscle selection during movement
 - Conscious
 - Unconscious



Sensory Influence

Sensory signals

 Initiated by brain, peripheral nervous system (PNS), or both

Visual (Eyes)

- Vision
- Spatial orientation & positions relative to environment

Vestibular (Ear)

 Head movement & orientation relative to gravity

Somatosensory (Receptors)

- Location of one body part to another
- Awareness in space (proprioception)
- Loads
- Joint position receptors
 - Ruffini endings, Golgi receptors, Pacinian corpuscles
- Muscle length & tension receptors
 - Muscle spindles & Golgi tendon organ



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Age Considerations²⁵

Ages 4 to 6

- Integration of all systems can overload brain
 - Balance & coordination may suffer

Ages 7 to 10+

- More reliant on somatosensory & vestibular systems
- Fewer postural adjustments
- Concentrate on other tasks (ball movement, monitoring opponents)
- Process information related to developing strategies and tactics





Evaluating Gait Post-Concussion

Balance & Motor Symptoms Associated with Concussion²⁶⁻³⁰

Short-term

- Balance & static postural control
- Gait unsteadiness & dynamic postural control

Long-term

- Altered postural control
- Gait impairment
- Increased risk of lower extremity injury

Clinical symptoms vs. Balance & Gait alterations

Evaluation of Gait Post-Concussion

Number of objective tools to evaluate concussions³¹⁻³⁵

• Concussion in Sport Group (CISG) recommends most recent version of SCAT

SCAT ³⁶

- > 13 y/o
- <12 y/o use the Child SCAT</p>
- Adapted as new knowledge develops

Tandem gait modifications³⁷

- No timing from previous version (SCAT3)
 - "One size does not fit all"
- Quality testing

Balance Testing

BESS

- Clinically feasible
- Low reliability^{38,39}
 - Interrater 0.57
 - Intrarater 0.74
- Low sensitivity 0.34
- Negatively influenced by:⁴⁰⁻⁴²
 - Affected by ankle instability
 - Acute fatigue after exertional activities
 - Testing environment



Gait Testing

Tandem Gait 15-17

- Clinically feasible
- Highly reliable 0.97
- Evaluates cerebellar activities⁴³
 - Dynamic balance
 - Gait speed
 - Coordination



Single-Task vs. Dual-Task Testing

Single-Task Balance & Gait Deficits

Increased sway during balance and gait

- Inability to balance
- Inability to stay on the line

Slower tandem gait velocities

All compared to baseline testing



Dual-Task

Require dividing attention to multiple stimulus^{29,44,45}

- Motor task
- Cognitive task
- Sport-specific
- Return-to-play
- Decrease risk of further injury

Example

• Tandem gait with reciting the months backwards

Dual-Task Balance & Gait Deficits

Altered motor control

- Focus more on cognitive task
- Disrupted gait patterns (speed, transition from SS to DS, frontal plane sway)^{28,46}
- $^{\circ}$ Less suited for high-demand situations $\rightarrow \uparrow$ rate of musculoskeletal injury⁴⁷⁻⁵¹

Altered cognitive response

Slower response times

Hard to divide focus between the two systems

Dual-Task Gait Testing

Simultaneous completion of gait & cognitive task

- Detect persistent post-concussion deficits beyond self-reported symptoms resolution⁵²
 - fMRI demonstrated diminished neural networking efficiency in adolescents⁵³
- May yield more accurate index of readiness to RTP than ST^{54,55}
- Baseline norms for ST assessment, deficits still present with DT^{56,57}

Dual-Task Gait Testing (cont.)

Performing a DT gait test (motor & cognitive)

- Tandem gait test³⁴ or walking on a "runway"⁵⁴
- Performing with cognitive test
 - Question & answer, spelling 5-letter words backward, Serial 7, months backward

Population Considerations

Age Differences: Adolescents vs. Young Adults

Concussed vs. Controls^{27,58-60}

- No differences in gait speed for adolescents; YA were slower (48-72 hours)^{31,54,61,62}
- Both adolescents & YA had increased medial-lateral sway during a dual-task assessment^{30,51,63-68}

Baseline differences

- Normative values age-based^{2,69}
- Longer RTP for adolescents based on symptoms & testing
 - \circ ≤2.5 days to return to baseline for verbal memory, visual memory, & reaction time⁸²

Gender Differences

Females

- Females may report more concussion symptoms⁷⁰
- Greater memory impairments⁷¹
- Require longer duration of time for symptoms resolution⁷²
- Cadence & stride length differences during dual-task assessment⁵⁴

Males

 Report more symptoms with amnesia or confusion^{74,75}



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Recommendations for Return to Play Post-Concussion

Timing of Return to Physical Activity

Testing

• DT vs. ST⁵²

Early return⁵⁹

• Less gait stability, slower velocity

Symptoms may be resolved, but motor control disruptions still exist^{27,59,76,77}

- Symptom resolution = RTP criteria^{31.78}
- Decreased motor cortex function > recovery time^{77,79}

Clinical Decisions

Gait parameter assessment

- Pre- & post-concussion
- Dual-task
 - Tandem gait
 - Cognitive task
- Always compare to baseline measurements

Gait Rehabilitation

Assessment tests now become rehabilitation exercises

Progression

- Static balance (eyes closed, foam surface) → ST Gait → DT Gait → RTP
- Asymptomatic
- No frontal plane sway
- Return to baseline speed with tandem gait



Summary

Clinical Symptoms

Cognitive & Motor Deficits

Subjective Criteria for:

- Assessment
- Population Considerations
- Return to Play Decisions

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Thank You!

