

# The Use of Tandem Gait & BESS Test for Concussion Management

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## Disclosure Statement

I have nothing to disclose.

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## Course Objectives

1. To identify the effects of how sustaining a concussion can have on motor and balance function of a patient.
2. Describe 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. Determine 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.

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## Concussions

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## 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.<sup>1</sup>

McCrory et al., with updates from Patricios et al., defines a sport-related concussion as a **traumatic** brain injury caused by a direct blow to the head, neck or body **resulting in an impulsive force being transmitted to the brain that occurs in sports and exercise-related activities**. This initiates a **neurotransmitter and metabolic cascade, with possible axonal injury, blood flow change and inflammation affecting the brain**. Symptoms and signs may present **immediately, or evolve over minutes or hours, and commonly resolve within days, but may be prolonged**.<sup>2</sup>

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## Concussion Frequency

The World Health Organization's (WHO) Collaborating Centre Task Force estimate that the annual incidence of concussion is 200 to 300/100,000 emergency department visits<sup>3</sup>

- Many go unreported – closer to 700/100,000<sup>3</sup>

It is estimated that 1.6-3.8 million concussions occur annually as a result of sport participation<sup>4</sup>

- Many by high school, then college aged students<sup>5,6</sup>
- Account for approximately 5% of all collegiate sport-related injuries<sup>7</sup>

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## Mechanisms of Concussion

Direct blow to the head or body

- Head snap forward, backward, or rotate to the side<sup>8</sup>

Common in collision or contact sports<sup>9</sup>

- Football, soccer, lacrosse, boxing, ice hockey wrestling<sup>10</sup>

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 object<sup>11</sup>

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## Signs & Symptoms<sup>12</sup>

Dizziness	Delayed verbal & motor responses
Headaches	Slurred speech
Blurred vision	<b>Concentration problems</b>
Abnormal eye tracking	Memory deficit
Diplopia	<b>Disrupted coordination</b>
Photophobia	Behavioral changes
Tinnitus	Loss of consciousness <sup>9,13</sup>

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## 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

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## Cerebellar (Balance) Tests

### Romberg Test

- Non-dominant single-leg stance
- Tandem stance
  - Eyes open and closed
  - Firm and foam surfaces<sup>14</sup>

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## Romberg Test

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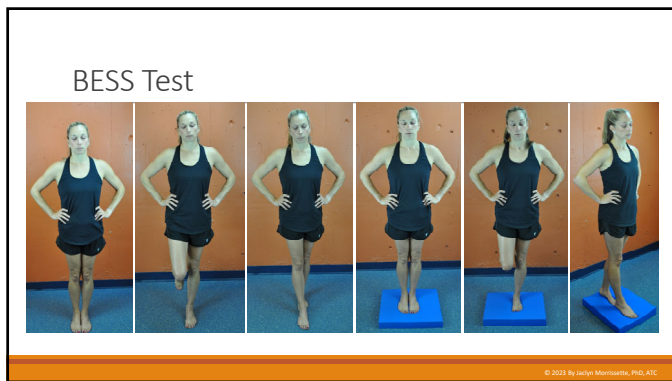
## Cerebellar (Balance) Tests

### Balance Error Scoring System (BESS)<sup>9</sup>

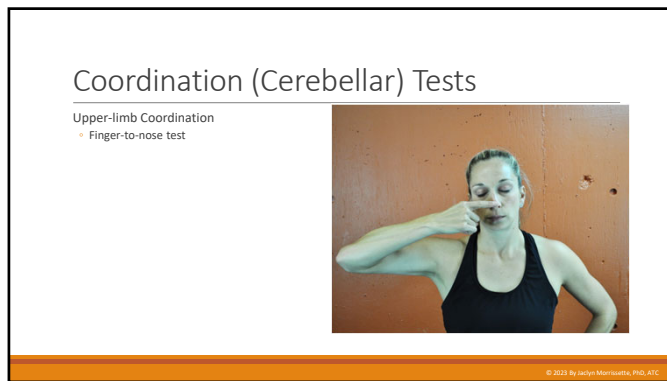
<b>Types of Errors</b> 1. Hands lifted off iliac crest 2. Opening eyes 3. Step, stumble, or fall 4. Moving hip into > 30° ABD 5. Lifting forefoot or heel 6. Remaining out of testing position for > 5 sec  The BESS is calculated by adding one error point for each error during the six 20-second tests.	Score 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		

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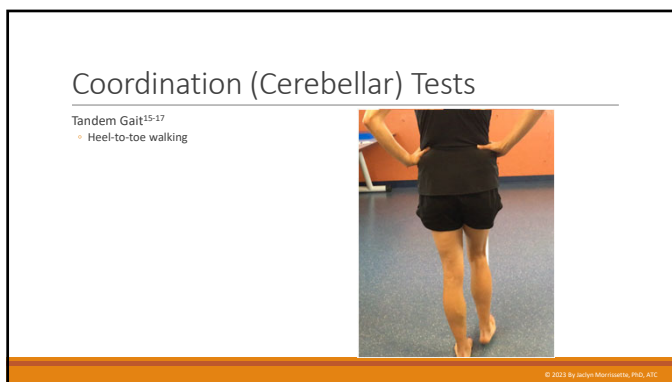
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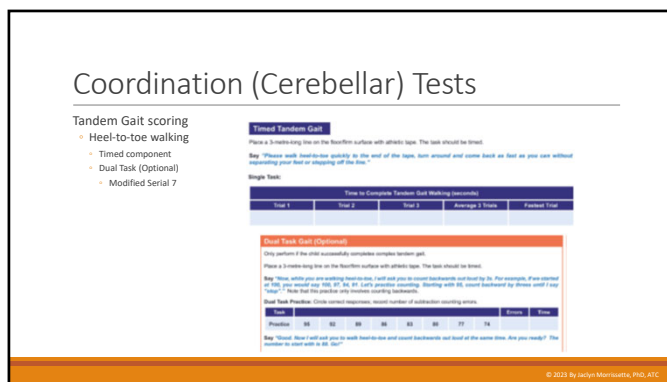
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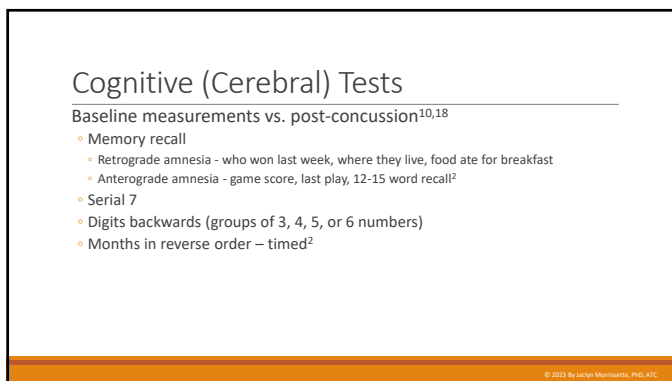
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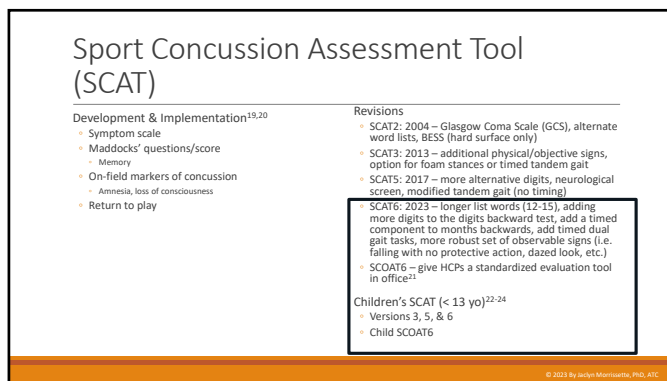
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## Do you know the differences between SCAT6 and Child SCAT6?

BESS TESTING

# NONE

**TANDEM GAIT**

**Complex Tandem Gait**

**Forward**  
 Say "These walk heel-to-toe again, backwards. Be sure to maintain heel-to-toe contact for the whole 10 feet. Turn off the toe, 1 point for correct step."  
 Forward Eyes Open Points:   
 Forward Eyes Closed Points:   
 Forward Total Points:

**Backward**  
 Say "These walk heel-to-toe again, backwards. Be sure to maintain heel-to-toe contact for the whole 10 feet. Turn off the toe, 1 point for correct step."  
 Backward Eyes Open Points:   
 Backward Eyes Closed Points:   
 Backward Total Points:

**Total Points (Forward + Backward):**

**Distal Task Gait (Optional)**  
 Say "Stand heel to heel and toe to toe with feet close and closed backwards out heel of the same line. Are you ready? Be ready to start with 'Go'!"

**Distal Task Cognitive Performance:** Circle correct responses, record number of substitution/omission errors.

Task	88	89	90	91	92	93	94	95	96	97	98	99	100	Errors	Points
Task 1															
Task 2															
Task 3															

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# Balance & Stability

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## Balance & Stability

### Control of joint posture & motion<sup>25</sup>

- 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 childhood<sup>25</sup>

- Learns to integrate inputs from visual and other sensory sources


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## Maintaining Balance & Stability

### Joint posture

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



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## 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

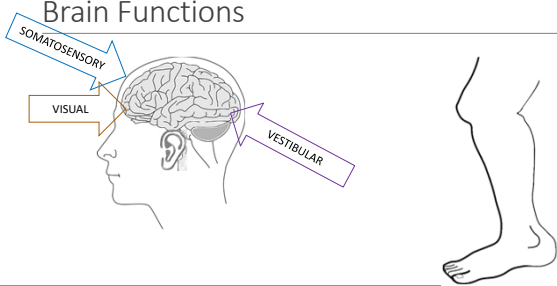
### Somatosensory (Receptors)

- 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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## Brain Functions



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## Age Considerations<sup>26</sup>

### 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



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## Evaluating Gait Post-Concussion

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## Balance & Motor Symptoms Associated with Concussion<sup>27-31</sup>

### 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

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## Evaluation of Gait Post-Concussion

### Number of objective tools to evaluate concussions<sup>32-36</sup>

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

### SCAT<sup>37</sup>

- ≥ 13 y/o
- 8-12 y/o – use the Child SCAT
- Adapted as new knowledge develops

### Tandem gait modifications<sup>38</sup>

- No timing in previous versions (SCAT2, SCAT3)
- "One size does not fit all"
- Timing added back
- Compare to baseline
- Dual-task (modified Serial 7 or counting backwards by 3 for Child version)

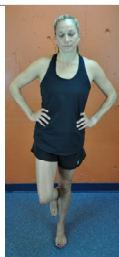
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## Balance Testing

### BESS

- Clinically feasible
- Low reliability<sup>39,40</sup>
  - Interrater – 0.57
  - Intrarater – 0.74
- Low sensitivity – 0.34
- Negatively influenced by:<sup>41-43</sup>
  - Affected by ankle instability
  - Acute fatigue after exertional activities
  - Testing environment



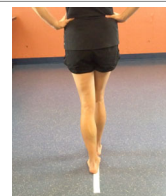
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## Gait Testing

### Tandem Gait<sup>15-17</sup>

- Clinically feasible
- Highly reliable – ICC 0.97
- Evaluates cerebellar activities<sup>44</sup>
  - Dynamic balance
  - Gait speed
  - Coordination



**Note:** If the mBESS yields negative or questionable findings then proceed to the Tandem Gait/Complex/Dual-Task Tandem Gait. If the mBESS reveals clinically significant difficulties, Tandem Gait is not necessary at this time. The Tandem Gait, Complex Tandem Gait and optional Dual-Task component may be administered later in the office setting as needed.

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## Single-Task vs. Dual-Task Testing

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## 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



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## Dual-Task

Require dividing attention to multiple stimulus<sup>30,45,46</sup>

- Motor task
- Cognitive task

Sport-specific

Return-to-play

- Decrease risk of further injury

Example

- Tandem gait with reciting the months backwards or Serial 7 (SCAT 6)

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## 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)<sup>29,47</sup>
- Less suited for high-demand situations → ↑ rate of musculoskeletal injury<sup>48-52</sup>

Altered cognitive response

- Slower response times

Hard to divide focus between the two systems

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## Dual-Task Gait Testing

Simultaneous completion of gait & cognitive task

- Detect persistent post-concussion deficits beyond self-reported symptoms resolution<sup>53</sup>
  - fMRI demonstrated diminished neural networking efficiency in adolescents<sup>54</sup>
- May yield more accurate index of readiness to RTP than ST<sup>55,56</sup>
- Baseline norms for ST assessment, deficits still present with DT<sup>57,58</sup>

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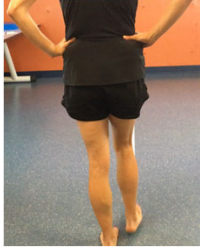
## Dual-Task Gait Testing (cont.)

Performing a DT gait test (motor & cognitive)

- Tandem gait test<sup>35</sup> or walking on a "runway"<sup>55</sup>
- Performing with cognitive test
  - Question & answer, spelling 5-letter words backward, Serial 7, months backward

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## Example of Dual-Task Gait Testing



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## Population Considerations

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## Age Differences: Adolescents vs. Young Adults

### Concussed vs. Controls<sup>28,59-61</sup>

- No differences in gait speed for adolescents; YA were slower (48-72 hours)<sup>32,55,62,63</sup>
- Both adolescents & YA had increased medial-lateral sway during a dual-task assessment<sup>31,52,64-69</sup>

### Baseline differences

- Normative values age-based<sup>70,71</sup>
- Longer RTP for adolescents based on symptoms & testing
  - $\leq 2.5$  days to return to baseline for verbal memory, visual memory, & reaction time<sup>71</sup>

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## Gender Differences

### Females

- Females may report more concussion symptoms<sup>72</sup>
- Greater memory impairments<sup>73</sup>
- Require longer duration of time for symptoms resolution<sup>74</sup>
- Cadence & stride length differences during dual-task assessment<sup>75</sup>



### Males

- Report more symptoms with amnesia or confusion<sup>76,77</sup>



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## Recommendations for Return to Play Post-Concussion

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## Timing of Return to Physical Activity

### Testing

- DT vs. ST<sup>53</sup>

### Early return<sup>60</sup>

- Less gait stability, slower velocity

Symptoms may be resolved, but motor control disruptions still exist<sup>28,60,78,79</sup>

- Symptom resolution = RTP criteria<sup>32,80</sup>
- Decreased motor cortex function > recovery time<sup>79,81</sup>

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## Clinical Decisions

### Gait parameter assessment

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

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## 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



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## Summary

### Clinical Symptoms

### Cognitive & Motor Deficits

### Subjective Criteria for:

- Assessment
- Population Considerations
- Return to Play Decisions

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# Thank You!

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