Instant Poll

- Do you manage sport related concussions as a part of your medical practice?
  - (1) Yes, frequently (5-10 patients per week)
  - (2) Yes, occasionally (5-10 patients per month)
  - (3) Yes, infrequently (5-10 patients per year)
  - (4) No
Instant Poll

- Do you have a standardized, objective way of measuring balance?
  - (1) YES
  - (2) NO

- Do you rely on it to help make return to play decisions?
  - (1) YES
  - (2) NO
Instant Poll

- Have you heard of the Balance Error Scoring System (BESS)?
  - (1) YES
  - (2) NO

- Do you use the BESS in your practice?
  - (1) YES
  - (2) NO
“Postural stability testing provides a useful tool for objectively assessing the motor domain of neurologic functioning and should be considered a reliable and valid addition to the assessment of athletes suffering from concussion, particularly where symptoms or signs indicate a balance component.”

Case to illustrate value of balance testing

- 13 year old male lacrosse player, average student, no concussion history or other relevant medical history
- Jumping in a bounce house, struck head against cement barrier
- 1 minute LOC, 60-90 minutes of PTA
- Initial eval 6 weeks later, symptoms improving but still present and clear triggers
- BESS score elevated at 21, unable to do SLS on foam surface
Next eval few weeks later
- Feels normal
- Denies symptoms
- Cognitive assessment: 3 of 4 composite scores between 30 and 50\textsuperscript{th} percentile, 1 of 4 < 20\textsuperscript{th} percentile
- BESS score remains elevated at 21

Not allowed to return to play, but encouraged to gradually increase conditioning
Case to illustrate value of balance testing

- Next eval few weeks later
  - Feels great, doing well in school
  - Tolerating increased levels of exercise, non-contact
  - Cognitive assessment: 4 of 4 composite scores between 30 and 50th percentile, largely unchanged
  - BESS score significantly improved to 11 (normal)

- Cleared to return to play
Objectives

- Appreciate the value of balance testing in sport concussion assessment and management
- Review the psychometric properties of the Balance Error Scoring System (BESS)
- Review how to administer and interpret the BESS
What is the BESS?

- Balance Error Scoring System
- Developed by Kevin Guskiewicz and colleagues at UNC
- Portable, cost-effective, objective method of assessing postural stability
  - Stopwatch
  - Firm Surface
  - Foam Pad
    - ~$50 on Amazon
2 surfaces:
- Firm surface
- Foam Pad

3 positions:
- Double Leg Stance
- Single Leg Stance
- Tandem Stance
Taking a step back…

- Concussions in sports are a tricky injury
  - High motivation to under report symptoms
  - Signs/Symptoms not always overtly obvious
  - Cursory neurologic exam almost universally normal, especially if the patient is showing up in your office days after the injury

- Multi-faceted approach to assessment is standard of care
  - Thorough history and symptom assessment
  - Neurocognitive assessment
  - Postural stability assessment
  - (Vestibular assessment)

Balance is a complex task

- 3 sources of afferent input
  - Vestibular Input
  - Visual Input
  - Proprioceptive Input

- Coordinated reflex arcs mediated at level of cerebellum, brainstem, and spinal cord to act on postural muscles

- BUT IT NEEDS TO BE CHALLENGED TO BRING OUT DEFICITS

The first study on balance in concussion...1996

- Series of postural stability tasks, challenging one system at a time
- "Computerized Dynamic Posturography"
- Significant changes post injury day 1 and 3 compared to controls

Sensory Organization Test

6 different conditions

Each condition performed 3 times

20 second trials

Neuro Com Smart Balance Master

Interesting…but not very practical
The BESS - History

- 1999, comparative study of 111 healthy male college athletes
  - Computerized Dynamic Posturography vs. BESS
  - Significant correlations between measures of postural sway on CDP vs clinical score of BESS on every position except double leg stance firm.

- 2000, 1st study in concussed athletes vs controls (16 subjects each)
  - BESS showed significant differences through day 3 post injury
  - CDP showed significant difference through day 1 post injury

So what do we know about the BESS 10 years later?
Is it helpful?

- Broglio et al., 2008 Meta-analysis to investigate effect sizes of typical post concussion assessment battery:
  - Symptom report
  - Neurocognitive Function
  - Postural Control
  - Large effect size at initial and 14 day assessment for all 3 components
    - 95% CI crossed zero for postural control
  - Conclusion: A multi-faceted approach to concussion assessment is important

Is it helpful?

- Broglio et al., 2008, measured the sensitivity of a ‘Concussion Assessment Battery’ to detect concussion 1 day removed from injury:
  - Computerized Neurocognitive test: 79%
  - Paper/Pencil Neurocognitive test: 43%
  - Symptom report: 68%
  - Postural Control: 62%
  - Battery as a whole: >90%

- A multi-faceted approach should be employed when assessing post-concussion patients

What’s normal?

- High school or collegiate athlete: ~12 errors

- Adults:
  - No correlation with height
  - Small correlation with weight
  - Did not vary by gender
  - Scores relatively stable by decade from 20s thru 50s, at which point started to decline. For ages 20 – 39:
    - Mean: ~11 – 13 errors
    - <2nd percentile: >22
    - <10th percentile: >17


What’s normal?

- Kids ages 9 thru 14
  - 50 kids, equal distribution male/female and 9-11/12-14 year age groups
  - Overall mean: 15.5
  - 9-11: 18.5
  - 12-14: 13 *significant difference
  - Boys: 17.3
  - Girls: 13.5 *NOT sig

- No data in kids < 9 years old

Is it reliable?

- Moderate test-retest reliability
- There is a modest learning effect with the test that needs to be kept in mind
  - 2-3 points from 2 separate cohorts of adolescent and high school athletes
- Reliability less robust with younger age groups

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What is a reliable change?

- **Reliable Change Index**
  - A way to help quantify how much change is needed to be significant and meaningful
  - Calculated in defined Confidence Intervals
  - In our sample of young athletes aged 9 thru 14:
    - 90%: -10/+6
    - 80%: -8/+4
    - 70%: -7/+3

What is a reliable change?

- Finnoff et al., 2009, tested 30 ‘athlete volunteers’ and had 3 independent reviewers score BESS, and again 2 weeks later
  - Inter and Intra rater reliability was good for some and not so good for other components of the BESS
  - “Minimum Detectable Change” around a 95% CI
    - 9.4 points if different testers
    - 7.3 points if the same tester

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Case Study – reliable change

16 yo male soccer player, concussion 6 days prior, no pre-injury data available for comparison. History of 4 prior sport related concussions

- PCSS: 41
- Impact:
  - Verbal memory: 41 %
  - Visual memory: 67 %
  - Visual motor speed: 81 %
  - Reaction time: 83 %
- BESS:
<table>
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<th>Firm</th>
<th>Foam</th>
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<tbody>
<tr>
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<td>0</td>
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<tr>
<td>Tandem</td>
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<td>2</td>
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<tr>
<td>SLS</td>
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<tr>
<td>Total Score</td>
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</table>
Recovery well over course of a couple weeks, did not repeat Impact or BESS.

Played soccer through spring and into summer without problems until 6 months later. Re-injured; felt better over course of few weeks, came to clinic:

- **PCSS**: 3
- **Impact**:
  - Verbal memory: 86% 41%
  - Visual memory: 91% 67%
  - Visual motor speed: 87% 81%
  - Reaction time: 35% 83%
- **BESS**:
  - DLS: 0 0
  - Tandem: 0 6
  - SLS: 0 4
  - Total Score: 10 (previously 5)
Case Study cont. – **reliable change**

- Worsened score by 5 points; one composite score on Impact exceeded RCI for impact; he feels great

- **What to do?**

<table>
<thead>
<tr>
<th>90%</th>
<th>80%</th>
<th>70%</th>
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<tbody>
<tr>
<td>-10/+6</td>
<td>-8/+4</td>
<td>-7/+3</td>
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</table>

- I can be 80% confident his worsening was a true worsening.
- Given the Impact data and his concussion history, I had him sit for a while longer
- Returned 3 weeks later, Impact improved, BESS back to 5; cleared to return to play
Miscellaneous nuggets

- Decent review of BESS published 2011
- Reliability generally good to moderate
  - Improves if average 3 tests
  - Modest learning effect does exist
- BESS correlates with instrumented measures of postural control
- BESS scores worsen with concussion, fatigue (generally resolves after 20 min), and ankle instability*
  - Taping and wearing a brace worsened BESS scores by 3 points

Test Administration
Materials Needed

- Timer or stopwatch
- Medium Density Foam Pad
- Firm Surface (recommend carpeted)
- Spotter (counter top or exam table)
‘The script’

- **Direction to the subject:** I am now going to test your balance.

- Please take your shoes off, roll up your pant legs above ankle (if applicable), and remove any ankle taping (if applicable).

- This test will consist of 6 - twenty second tests with three different stances on two different surfaces. I will describe the stances as we go along.

- **DOUBLE LEG STANCE:**

  - **Direction to the subject:** The first stance is standing with your feet together like this [administrator demonstrates two-legged stance]

  - **Direction to the subject:** You will be standing with your hands on your hips with your eyes closed. You should try to maintain stability in that position for entire 20 seconds. I will be counting the number of times you move out of this position. For example: if you take your hands off your hips, open your eyes, take a step, lift your toes or your heels. If you do move out of the testing stance, simply open your eyes, regain your balance, get back into the testing position as quickly as possible, and close your eyes again.

  - There will be a person positioned by you to help you get into the testing stance and to help if you lose your balance.

  - **Direction to the spotter:** You are to assist the subject if they fall during the test and to help them get back into the position.

  - **Direction to the subject:** Put your feet together, put your hands on your hips and when you close your eyes the testing time will begin [Start timer when subject closes their eyes]
‘The script’

**SINGLE LEG STANCE:**

**Direction to subject:** If you were to kick a ball, which foot would you use? [This will be the dominant foot]

Now stand on your non-dominant foot.

[Before continuing the test assess the position of the dominant leg as such: the dominant leg should be held in approximately 30 degrees of hip flexion and 45 degrees of knee flexion]

Again, you should try to maintain stability for 20 seconds with your eyes closed. I will be counting the number of times you move out of this position.

Place your hands on your hips. When you close your eyes the testing time will begin. [Start timer when subject closes their eyes]

**Direction to the spotter:** You are to assist the subject if they fall during the test and to help them get back into the position.

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**TANDEM STANCE:**

**Directions to the subject:** Now stand heel-to-toe with your non-dominant foot in back. Your weight should be evenly distributed across both feet.

Again, you should try to maintain stability for 20 seconds with your eyes closed. I will be counting the number of times you move out of this position.

Place your hands on your hips. When you close your eyes the testing time will begin. [Start timer when subject closes their eyes]

**Direction to the spotter:** You are to assist the subject if they fall during the test and to help them get back into the position.

*** Repeat each set of instructions for the foam pad***
2 surfaces:
- Firm surface
- Foam Pad

3 positions:
- Double Leg Stance
- Single Leg Stance
- Tandem Stance
Scoring

- Eyes open
- Hands off hips
- Feet go out of position
  - Raise heel or forefoot
- Move hip into >30 deg abduction
- Remain out of position >5 seconds

- Count the # of errors per condition
- Max of 10 per condition
- BESS score is total # of errors
- Multiple errors at the same time = 1 point
- If they cannot maintain position 5 seconds, fail that condition
<table>
<thead>
<tr>
<th></th>
<th>Firm Surface</th>
<th>Foam Surface</th>
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</thead>
<tbody>
<tr>
<td>Double Leg Stance</td>
<td>.009 +/- .12</td>
<td>.33 +/- .90</td>
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<tr>
<td>Single Leg Stance</td>
<td>2.45 +/- 2.33</td>
<td>5.06 +/- 2.80</td>
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<tr>
<td>Tandem Stance</td>
<td>.91 +/- 1.36</td>
<td>3.26 +/- 2.62</td>
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<tr>
<td>Surface Total</td>
<td>3.37 +/- 3.10</td>
<td>8.65 +/- 5.13</td>
</tr>
<tr>
<td>BESS TOTAL</td>
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