Clinical Use of Concussion Balance Test

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What is COBALT?

COBALT (Concussion Balance Test) is a balance test for athletes. The test protocol includes up to eight conditions designed to challenge vestibular, visual and somatosensory systems. For each condition, the subject stands on a force plate that measures postural sway, and that information is processed and stored by a computer. The test reports postural sway velocity for each condition as an indication of balance control.

COBALT can be used as part of a concussion screening and management program. Balance is one indicator that is sensitive to change resulting from concussion. COBALT results provide an objective measure of balance control that can be helpful in identifying individuals with suspected concussion, and can be used to monitor recovery to determine safe return to play.

COBALT is designed to be a brief test that can be used for high volume screening programs used in concussion management. Ideally, the first assessment is performed prior to the athlete participating in his or her sport. This test then becomes the baseline test (how he or she performs at a normal state). Later, if a concussion is suspected, subsequent tests will be compared to the baseline so that an individual is compared to his or her own results. The objective data provided by COBALT allow the clinician to monitor the test results over time. Detecting changes in performance by referencing individual baseline tests increases the sensitivity of the monitoring program.

A growing database of age-corrected norms for COBALT is available to assist in the interpretation of test results. Any COBALT test can be compared to normative data to evaluate how a subject is performing relative to age-peers, and that can help interpret results whether or not an individual baseline test is available. As routine monitoring continues, test results are compared to age-norms and to individual baseline tests.

COBALT is a standardized test, designed to provide consistent test conditions even when used in a portable format. Foot position is specified on the force plate used with the test. Head turns are required for certain test conditions, and a wall chart marked with required excursions is used. The subject wears a headlamp, and the light moving between the wall chart markings is used to monitor for appropriate head movement excursions. Directions are given for specific placement of the force plate in relation to the wall and wall chart so that the correct amount of head movement is standardized based on markers on the wall chart. The software uses a metronome to maintain the specified head velocity during conditions requiring head turns.

Why is COBALT different from other balance tests?

There are several clinical and computerized balance tests available. For example, the Clinical Test for Sensory Integration and Balance (CTSIB) is frequently used in balance screening applications. The CTSIB was developed for a general population. When used with athletes, the conditions used on this test may not provide enough challenge and the test may not identify subtle balance deficiencies. Another screening test developed for athletes is the Balance Error Scoring System (BESS) that uses more challenging conditions, some of which are too difficult for athletes, even at baseline.

The dilemma in choosing an appropriate test protocol for an athletic population is to avoid a test that is too easy or too difficult. If the CTSIB is too easy for athletes, the results will not identify subtle deficiencies (high false negatives). If the BESS test is too difficult, a high number of failures may result in a high false positive rate for the test. The COBALT protocols use conditions that increase the challenge, but the subject can still perform the task.

Both the CTSIB and BESS use test conditions where the subject maintains a static position. COBALT incorporates head turns into several test conditions to increase the challenge to the vestibular system. In addition, the BESS test requires the athlete to stand in single leg stance and tandem stance. In these conditions, the athlete could have difficulty with balance if there is an underlying orthopedic issue versus a true postural control problem. In contrast, the entire COBALT protocol is performed with both feet on the force plate at all times to help limit the influence of possible orthopedic deficits on the results.

What are the 8 Conditions in COBALT?

Condition 1	Firm Surface eyes open
Condition 2	Firm surface eyes closed
Condition 3	Firm surface, head shake, eyes closed
Condition 4	Firm surface VMS
Condition 5	Foam surface eyes open
Condition 6	Foam surface eyes closed
Condition 7	Foam surface, head shake, eyes closed
Condition 8	Foam surface VMS

Why perform a balance test with Head Shake and Visual Motion Sensitivity (VMS)?

Head shake: Balance control depends on the brain monitoring and integrating sensory information from somatosensory, visual and vestibular systems. Performing head turns while assessing balance increases the challenge for that test condition. Head turns will stimulate more activity from the vestibular system, and the task of using constantly changing vestibular input becomes more complex. The vestibular system (peripheral and central components) and the sensory integration process are sensitive to changes from concussion. Adding test conditions that place more demand on effective use of vestibular information and more challenge to the sensory integration task makes COBALT more sensitive to changes that may occur as a result of concussion. In conditions where the subject is standing on a foam pad, somatosensory information is distorted and the subject will have to rely more heavily on vestibular information. Adding head turns to foam pad conditions places more demand on effective use of vestibular information, and even more-so when the subject's eyes are closed in foam pad conditions.

Assessing an athlete's performance regarding functional demands is enhanced by adding head turns to test conditions. When an athlete is in play (on a field, running, catching, throwing or jumping) it is imperative that he or she be able to maintain balance while moving their head in a busy and distracting environment. Due to the high demands that are placed on athletes, objective assessment of balance should replicate the demands needed on the field. Adding head turns while measuring postural control allows for objective assessment of how the athlete can maintain balance while actively stimulating the vestibular system (as is needed when performing all sports).

Visual Motion Sensitivity (VMS): Assessing how an athlete maintains balance while performing a visual motion sensitivity (VMS) task provides objective measurement of balance performance during this condition. In the VMS conditions, the subject stands on the force plate with outstretched arms and rotates en bloc left and right while maintaining visual focus on the thumbs. Focusing on a target (thumbs) while rotating en bloc against a static background produces a moving visual field which is similar to what athletes experience during play (everything around them is moving). Along with measuring postural control, the clinician can also assess how well the athlete can tolerate visual motion before returning to play. Symptom provocation through a VMS task has been found to be good predictor in discriminating between concussed and non-concussed athletes as in shown in the Vestibular/Ocular-Motor Screen (VOMS) for Concussion (Mucha et al, 2014). The VOMS is a screening procedure that assesses symptom provocation while doing various visual/vestibular tasks. In the VOMS, the athlete performs a VMS task while measuring symptom provocation. In COBALT, the athlete performs a VMS task while objectively measuring postural sway with the force plate. The addition of this condition adds a unique assessment to balance testing while doing a task that is similar to what is demanded of them on the field.

The addition of both head turns and the VMS while assessing balance allows for the clinician to add challenge to the test conditions appropriate for an athletic population without overwhelming a healthy system, and make routine monitoring (re-screening) more sensitive to subtle changes. If a concussion does occur, the clinician also has a more objective measure to determine if recovery is complete and the athlete is really prepared to return to play. These two tasks are challenging at a normal state, but are not so challenging that the athlete cannot perform them. At a post injury level, these two tasks become very difficult if any of the three balance systems are affected. Adding these objective assessments will give a more complete picture of how well the athlete can maintain balance before returning to play.

COBALT testing offers objective data on postural control when performing tasks that are demanding to the visual and vestibular systems. When assessing an athlete at post injury, symptom provocation becomes very important as athletes with a concussion can often be too symptomatic to complete the entire test. When this occurs, it is important for the clinician to record symptom provocation with both the head turn and VMS conditions. This can allow another measure of progress through recovery as the tests are performed over time. Measuring symptom provocation with each condition is not a mandatory field in COBALT but is highly recommended when performing post injury testing.

Sway Scores

The computerized system calculates the subject's Center of Gravity (COG) and tracks the movement of COG over the force plate during each test condition. The test report displays the movement of COG for each trial and condition (in the box display). The velocity of the COG movement during the trial (change in position over time) is calculated and reported as Sway Score. Sway velocity is considered the more sensitive measure of postural stability.

Marking Errors

During each 20 second trial on COBALT, the clinician will mark errors observed in the athlete's performance defined as follows:

- Lifting hand(s) off hips
- Opening eyes during an eyes closed trial
- Stepping off force plate or moving feet from starting position
- Unable to maintain action with beat of the metronome for two or more consecutive beats

When performing COBALT, the clinician has the option of 4 or 8 conditions

Baseline assessment of COBALT only uses the head turn and VMS conditions (3, 4 and 7,8) and does not include the four easiest conditions (1,2 and 5,6). The head turn and VMS conditions are more difficult for the athlete to perform and will yield greater variance in sway. At a baseline testing level, the easier conditions on COBALT are not challenging enough and yield very similar sway scores across all age groups. The baseline COBALT test uses just the 4 more challenging conditions that allow for a much shorter testing time and can help accommodate high volume testing for groups.

Baseline Testing with 4 Conditions: Head turns and VMS on firm and foam

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Post-Injury Testing with 8 Conditions

When performing post injury assessment, it is recommended to perform all 8 conditions of the COBALT protocol. When testing an athlete post injury, the clinician can often find that just standing with eyes closed on a firm surface (condition 2) can be challenging to the athlete and may yield high sway scores. This information in invaluable to a clinician as it will help to determine if the athlete will be able to tolerate the later conditions that are much more challenging. It has been shown through research that on the initial testing day post injury, approximately 30% of the athletes studied cannot complete the COBALT test in its entirety due to symptom provocation, difficulty with balance, etc. If the athlete can tolerate the test, it is important for the clinician to complete all eight conditions when testing post injury to determine at which level the athlete begins to be challenged. This information can help the clinician develop an appropriate treatment plan to improve balance and tolerance to higher level visual and vestibular stimulation.

At baseline, test results are stored for later reference and are used if the athlete suffers a concussion. If this is the case, the post injury results can be compared to baseline to determine if there has been a change in balance performance. This information can help the clinician determine if the athlete is ready to return to play based on postural control. The goal is for the athlete perform at the same or at a very similar level post injury as he or she did at baseline.

If an athlete is evaluated post injury and does not have a baseline COBALT test, the normative data collected for sway scores and errors can be used to compare the athlete to peers of the same age group. This information can help the clinician determine if there is a postural control problem post injury that needs to be addressed based on comparison to the normative data.

Please see the Appendix for normative data and sway scores based on age.

Results Analysis

When reviewing the results of COBALT, the clinician has two options:

No baseline test available

- The first objective measure at post injury is to determine if the athlete can complete all eight conditions of the COBALT test. Research completed in the development of COBALT indicated that at baseline, 100% of athletes tested were able to complete all conditions of the test. If at post injury the athlete cannot complete the test, it is an indicator that they are not ready to return to play and further evaluation and treatment is warranted. If the athlete cannot complete the test, the clinician should also determine the cause (most commonly due to dizziness) and note this in the record.
- If the athlete can complete the test, the next step is to determine number of errors in conditions 7 and 8. When errors are noted, compare the individual's error results to the normative information. This provides the clinician with a quick comparison to the performance of age peers in the same test conditions.(See error table above based on age.)
- Finally, the clinician should analyze the sway scores for conditions 7 and 8. The baseline normative sway score data is established with all athletes that had one error or less on C7 and C8. The sway score, compared to norms, should help place the individual in the distribution for that age group.

OR

Baseline test available

- Compare the post injury results to the baseline test to identify any deterioration of performance in any test condition. Note any increase in marked errors or increase in sway score.
- If either marked errors or sway scores in the post injury results falls in the 25th percentile or less, check to see if similar results were present at baseline.

Training

As a practical example, assume that the athlete is 20 years old and completing a post-injury test. During condition 7 (head turns on foam, eyes closed), 3 total errors are recorded and the average sway score is 2.2 deg/sec. When focusing on errors, the norms for this age group indicate that 99% of subjects complete this trial with no more than one error (see appendix for normative data). This individual's performance is well outside expected performance, and is an indicator that they are not ready to safely return to place based on postural control.
In this example, the sway score for condition 7 was 2.2 deg/sec. In this case, the sway score would indicate the individual's performance is poorer than the 5th percentile. That means that more than 95% of the age-peers had better performance on this condition. The test results suggest that there is a significant balance issue present, and that should be further evaluated prior to participation in sports because at best it would affect performance, and at worst it may predispose the athlete to injury on the field.

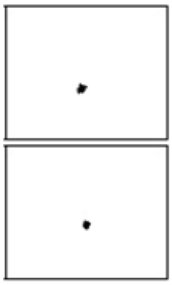
In either option, the clinician must make a professional determination regarding training or treatment to address deficiencies suggested by COBALT results. If no baseline test is available, training goals could be to demonstrate the patient's ability to perform all conditions at 50th percentile or better with no more than one error on conditions 7 and 8. The sway score percentile target would be up to the clinician who is treating the athlete. Research suggests that average scores are most commonly represented between the 25-75 percentiles.

If the clinician has a baseline COBALT, the goal would be for the athlete return to the same number of errors and similar sway scores as what was achieved at baseline. It is also important to make sure the athlete can perform at the same level as baseline and without any symptoms. Symptom provocation during COBALT is another indicator for further evaluation and treatment. If the athlete can complete the test without any errors and with sway scores in the 50th percentile, but has a dizziness score of 5/10, the provocation of symptoms would still warrant further evaluation and suggest that the athlete would benefit from additional treatment.

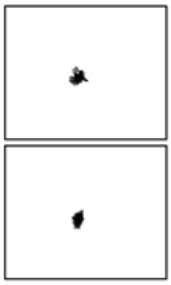
The test results can now be used as a benchmark and the basis of objective goals for training or therapy. A therapy goal might be, "Patient will demonstrate improvement in balance while performing head turns with eyes closed on an unstable surface by completing condition 7 without any errors and sway scores in the 50th percentile or higher for age to assist with safe return to sport." Periodic retesting during training or therapy can provide the objective data to document achievement of established goals. The final goal for each athlete is dependent on the clinician's professional opinion. Most importantly, based on the baseline data, the athlete should be able to complete COBALT with one error or less on conditions 7 and 8 without any symptoms, and the sway scores should be in a desired range that is in alignment with their particular sport. Sports that place a higher demand on the vestibular system should require the athlete to fall in the higher percentile ranges for balance.

Case Example 1

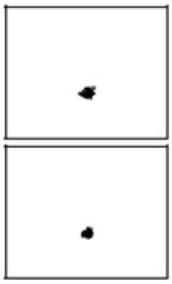
This 15-year-old football player was baseline tested in the summer prior to football season using the Baseline COBALT assessment. Sway scores for conditions 3, 4 and 7, 8 are below:



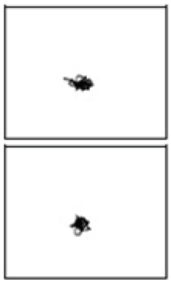
Firm Normal - EC HS	Sway score	No. of Errors	Time to 1st fall (secs)
Trial 1	0.36	0	0.00
Trial 2	0.38	0	0.00
Average	0.37	0.00	0.00



Foam Normal - EC HS	Sway score	No. of Errors	Time to 1st fall (secs)
Trial 1	0.91	0	0.00
Trial 2	0.91	0	0.00
Average	0.91	0.00	0.00



Firm Normal - VMS	Sway score	No. of Errors	Time to 1st fall (secs)
Trial 1	0.77	0	0.00
Trial 2	0.59	0	0.00
Average	0.68	0.00	0.00



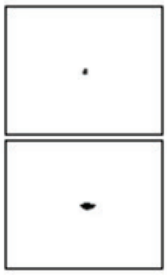
Foam Normal - VMS	Sway score	No. of Errors	Time to 1st fall (secs)
Trial 1	1.23	0	0.00
Trial 2	1.08	0	0.00
Average	1.16	0.00	0.00

Normative Data for sway scores for Conditions 7 (eyes closed head turn on foam) are as follows: At baseline, this athlete's sway score on Condition 7 is .91 degrees/second which is between the 75th-90th percentile for balance in his age group (see sway score table in the appendix).

Normative Data for sway scores for Condition 8 (Visual Motion Sensitivity on foam) are as follows: At baseline, this athlete's sway score on Condition 8 is 1.16 which is between the 50th and 75th percentile for balance in his age group (Condition 8 Visual Motion Sensitivity)

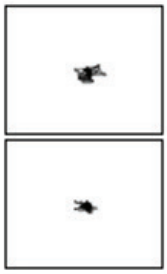
Case Example 1

This athlete returned to the clinic in the early fall after suffering a concussion in his high school football game with a helmet to helmet injury that left him feeling dizzy, nauseous, with a headache and difficulty focusing. He was evaluated using the COBALT 8 condition protocol at one-week post injury. The following are results from his initial post injury test:



Firm Normal - EO	Sway score	No. of Errors	Time to 1st fall (secs)
Trial 1	0.28	0	0.00
Trial 2	0.52	0	0.00
Average	0.40	0.00	0.00

Foam Normal - EO	Sway score	No. of Errors	Time to 1st fall (secs)
Trial 1			
Trial 2			
Average			



Firm Normal - EC	Sway score	No. of Errors	Time to 1st fall (secs)
Trial 1	0.99	0	0.00
Trial 2	0.85	0	0.00
Average	0.92	0.00	0.00

Foam Normal - EC	Sway score	No. of Errors	Time to 1st fall (secs)
Trial 1			
Trial 2			
Average			

Firm Normal - EC HS	Sway score	No. of Errors	Time to 1st fall (secs)
Trial 1			
Trial 2			
Average			

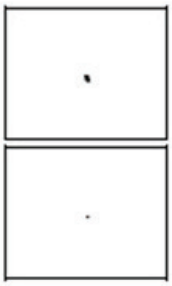
Foam Normal - EC HS	Sway score	No. of Errors	Time to 1st fall (secs)
Trial 1			
Trial 2			
Average			

Firm Normal - VMS	Sway score	No. of Errors	Time to 1st fall (secs)
Trial 1			
Trial 2			
Average			

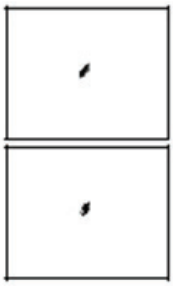
Foam Normal - VMS	Sway score	No. of Errors	Time to 1st fall (secs)
Trial 1			
Trial 2			
Average			

He was able to complete Conditions 1 and 2, but he was not able to complete Condition 3 due to being too dizzy with head turns when trying to keep up with the metronome. At baseline, this athlete could complete Conditions 3, 4, 7, and 8 without any errors and without difficulty. The change in performance provided objective information to support the clinician's impression that he was not yet ready to return to play. Vestibular therapy exercises were provided. After doing his home program, he returned one week later for a follow-up COBALT assessment:

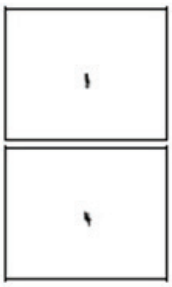
Case Example 1



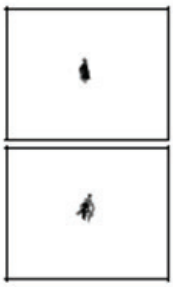
Firm Normal - EO	Sway score	No. of Errors	Time to 1st fall (secs)
Trial 1	0.41	0	0.00
Trial 2	0.15	0	0.00
Average	0.28	0.00	0.00



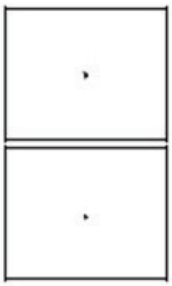
Foam Normal - EO	Sway score	No. of Errors	Time to 1st fall (secs)
Trial 1	0.74	0	0.00
Trial 2	0.69	0	0.00
Average	0.72	0.00	0.00



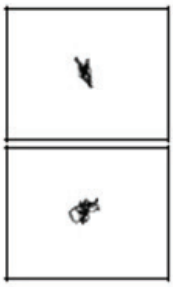
Firm Normal - EC	Sway score	No. of Errors	Time to 1st fall (secs)
Trial 1	0.49	0	0.00
Trial 2	0.59	0	0.00
Average	0.54	0.00	0.00



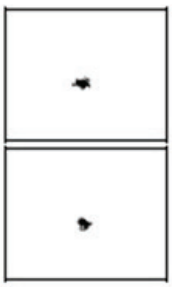
Foam Normal - EC	Sway score	No. of Errors	Time to 1st fall (secs)
Trial 1	1.02	0	0.00
Trial 2	1.12	0	0.00
Average	1.07	0.00	0.00



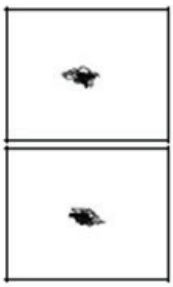
Firm Normal - EC HS	Sway score	No. of Errors	Time to 1st fall (secs)
Trial 1	0.24	0	0.00
Trial 2	0.24	0	0.00
Average	0.24	0.00	0.00



Foam Normal - EC HS	Sway score	No. of Errors	Time to 1st fall (secs)
Trial 1	1.20	3	6.08
Trial 2	1.39	3	6.71
Average	1.30	3.00	6.39



Firm Normal - VMS	Sway score	No. of Errors	Time to 1st fall (secs)
Trial 1	0.67	0	0.00
Trial 2	0.67	0	0.00
Average	0.67	0.00	0.00

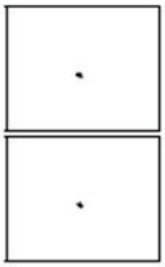


Foam Normal - VMS	Sway score	No. of Errors	Time to 1st fall (secs)
Trial 1	1.41	0	0.00
Trial 2	1.34	0	0.00
Average	1.38	0.00	0.00

At this point in his recovery, the athlete has demonstrated significant improvement in his ability to maintain balance on the COBALT test. On his first visit, he was unable to complete the COBALT protocol due to increase in dizziness and difficulty maintaining balance. On the second testing date (one week later) he could complete the test, but he had 5 total errors on Condition 7 and his sway scores are for Conditions 7 and 8 that were much higher (indicating less stability) than at baseline. Because this athlete had a baseline test, the clinician was able to compare his sway scores and errors from his baseline and determine that he was not yet ready to return to contact sports. He returned one week later after continuing with his home program with no further complaints of dizziness and the following results on COBALT:

Case Example 1

Firm Normal - EO	Sway score	No. of Errors	Time to 1st fall (secs)
Trial 1	0.16	0	0.00
Trial 2	0.21	0	0.00
Average	0.19	0.00	0.00



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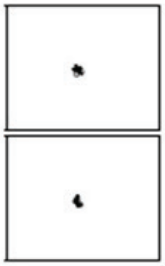
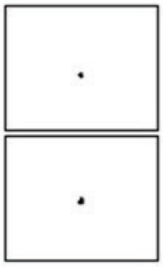


Foam Normal - EC	Sway score	No. of Errors	Time to 1st fall (secs)
Trial 1	0.66	0	0.00
Trial 2	0.79	0	0.00
Average	0.72	0.00	0.00



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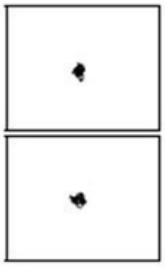
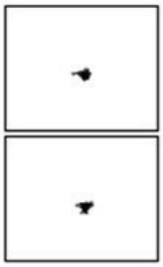
Trial 2	0.40	0	0.00
Average	0.34	0.00	0.00



Foam Normal - EC HS	Sway score	No. of Errors	Time to 1st fall (secs)
Trial 1	0.84	0	0.00
Trial 2	0.96	0	0.00
Average	0.90	0.00	0.00



Firm Normal - VMS	Sway score	No. of Errors	Time to 1st fall (secs)
Trial 1	0.72	0	0.00
Trial 2	0.79	0	0.00
Average	0.75	0.00	0.00

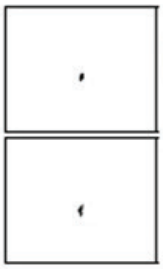
Foam Normal - VMS	Sway score	No. of Errors	Time to 1st fall (secs)
Trial 1	0.91	0	0.00
Trial 2	1.24	0	0.00
Average	1.07	0.00	0.00

Test	C7 Sway	C7 Errors	C8 Sway	C8 Errors
Baseline	.91	0	1.16	0
Post Injury 1	Unable	Unable	Unable	Unable
Post Injury 2	1.30	6	1.38	0
Post Injury 3	.90	0	1.07	0

In summary, this athlete has returned to his baseline performance. His results are even a little better than baseline for both Conditions 7 and 8, which are the two conditions that are the most challenging and yield the greatest variation in sway scores. He was able to complete the test without any errors as he did on his baseline. This allows the clinician to use objective balance data to support the return to play decision.

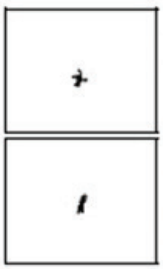
Case Example 2

This 19-year-old ice hockey player sustained a concussion in a hockey game with a helmet to ice injury. He did not have a baseline assessment prior to his injury. He arrived at the clinic 10 days post injury and was tested using COBALT 14 days post injury. The following are his COBALT results of testing on his initial evaluation:



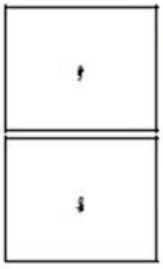
Firm Normal - EO	Sway score	No. of Errors	Time to 1st fall (secs)
Trial 1	0.49	0	0.00
Trial 2	0.58	0	0.00
Average	0.53	0.00	0.00

Foam Normal - EO	Sway score	No. of Errors	Time to 1st fall (secs)
Trial 1			
Trial 2			
Average			

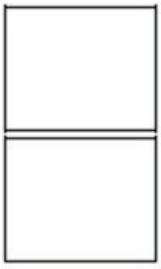


Firm Normal - EC	Sway score	No. of Errors	Time to 1st fall (secs)
Trial 1	0.96	0	0.00
Trial 2	1.11	0	0.00
Average	1.04	0.00	0.00

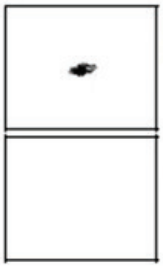
Foam Normal - EC	Sway score	No. of Errors	Time to 1st fall (secs)
Trial 1			
Trial 2			
Average			



Firm Normal - EC HS	Sway score	No. of Errors	Time to 1st fall (secs)
Trial 1	0.48	1	12.24
Trial 2	0.64	0	0.00
Average	0.56	0.50	6.12



Foam Normal - EC HS	Sway score	No. of Errors	Time to 1st fall (secs)
Trial 1			
Trial 2			
Average			

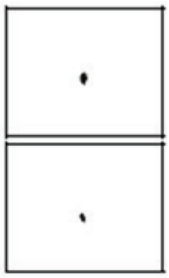


Firm Normal - VMS	Sway score	No. of Errors	Time to 1st fall (secs)
Trial 1	1.05	0	0.00
Trial 2	--	--	--
Average	1.05	0.00	0.00

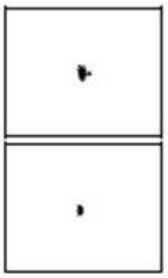
Foam Normal - VMS	Sway score	No. of Errors	Time to 1st fall (secs)
Trial 1			
Trial 2			
Average			

During testing, this athlete was unable complete the test due to increased dizziness on Condition 3 and 4. The clinician used these results to determine that this patient would benefit from vestibular exercises for visual motion sensitivity and dynamic vestibular exercises to help with tolerance to head movement. He completed a home program of visual/vestibular exercises for one week and returned for the second visit with the following results:

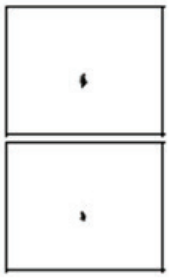
Case Example 2



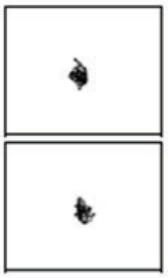
Firm Normal - EO	Sway score	No. of Errors	Time to 1st fall (secs)
Trial 1	0.66	0	0.00
Trial 2	0.37	0	0.00
Average	0.51	0.00	0.00



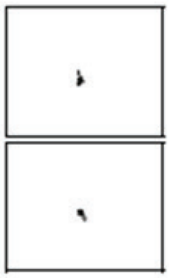
Foam Normal - EO	Sway score	No. of Errors	Time to 1st fall (secs)
Trial 1	0.86	0	0.00
Trial 2	0.51	0	0.00
Average	0.69	0.00	0.00



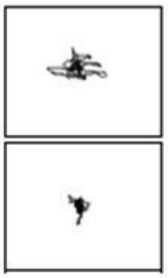
Firm Normal - EC	Sway score	No. of Errors	Time to 1st fall (secs)
Trial 1	0.59	0	0.00
Trial 2	0.47	0	0.00
Average	0.53	0.00	0.00



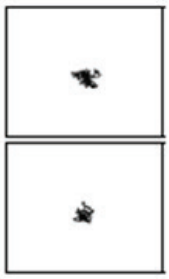
Foam Normal - EC	Sway score	No. of Errors	Time to 1st fall (secs)
Trial 1	1.50	0	0.00
Trial 2	1.39	0	0.00
Average	1.45	0.00	0.00



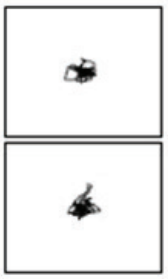
Firm Normal - EC HS	Sway score	No. of Errors	Time to 1st fall (secs)
Trial 1	0.62	0	0.00
Trial 2	0.52	0	0.00
Average	0.57	0.00	0.00



Foam Normal - EC HS	Sway score	No. of Errors	Time to 1st fall (secs)
Trial 1	2.04	0	0.00
Trial 2	1.31	0	0.00
Average	1.68	0.00	0.00



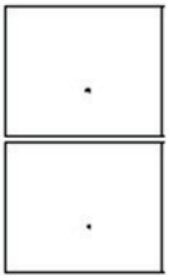
Firm Normal - VMS	Sway score	No. of Errors	Time to 1st fall (secs)
Trial 1	1.48	0	0.00
Trial 2	1.22	0	0.00
Average	1.35	0.00	0.00



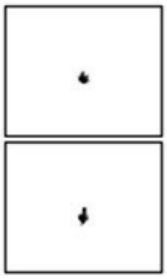
Foam Normal - VMS	Sway score	No. of Errors	Time to 1st fall (secs)
Trial 1	1.46	0	0.00
Trial 2	1.69	0	0.00
Average	1.57	0.00	0.00

When evaluating these results, the clinician had objective evidence that the patient is demonstrating improvement. This time he could complete the test, whereas he was unable to complete it upon initial evaluation due to dizziness. The clinician then checked if the patient had any errors in any conditions and also compared the sway scores on Conditions 7 and 8 to the normative values of his age-related peers. This athlete did not have any errors, but in evaluating his sway scores, he was around the 10th percentile for both Condition 7 and Condition 8 based on the normative data for a 19-year-old. At this point, the clinician had to determine if this is appropriate for this athlete's particular sport. Ice hockey requires a very high level of balance it would not be of the best interest to put this athlete back on the ice while his postural control system was still not functioning at a level required for that sport. The athlete continued with his home program and was tested again one week later with the following results:

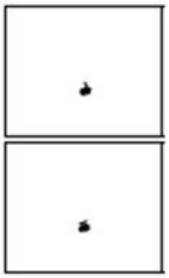
Case Example 2



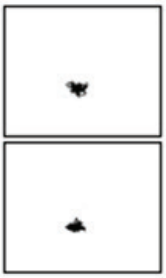
Firm Normal - EC HS	Sway score	No. of Errors	Time to 1st fall (secs)
Trial 1	0.18	0	0.00
Trial 2	0.17	0	0.00
Average	0.18	0.00	0.00



Foam Normal - EC HS	Sway score	No. of Errors	Time to 1st fall (secs)
Trial 1	0.57	0	0.00
Trial 2	0.74	0	0.00
Average	0.65	0.00	0.00



Firm Normal - VMS	Sway score	No. of Errors	Time to 1st fall (secs)
Trial 1	0.66	0	0.00
Trial 2	0.61	0	0.00
Average	0.63	0.00	0.00



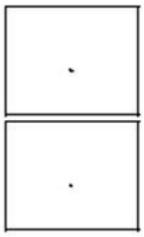
Foam Normal - VMS	Sway score	No. of Errors	Time to 1st fall (secs)
Trial 1	0.93	0	0.00
Trial 2	0.82	0	0.00
Average	0.88	0.00	0.00

This is a report of Conditions 3, 4, 7, and 8. At this point in the recovery process, Conditions 1, 2, 5, and 6 were consistently normal, so only the more difficult conditions were tested. The sway scores for Conditions 7 and 8 on this test placed the athlete in the 95th percentile for his age on condition 7 and in the 90th percentile for Condition 8. In summary, the results show that at this point in his recovery, this athlete completed the test, did not have any errors or complaints of dizziness and had sway scores that were in the range that the clinician determined was an appropriate level for return to play. Objective measures were used to validate this decision for the clinician. A summary of results is as follows:

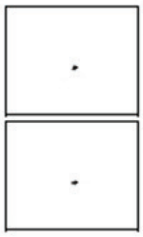
Test	C7 Sway	C7 Percentile	C7 Errors	C8 Sway	C8 Percentile	C8 Errors
Post Injury 1	Unable	Unable	Unable	Unable	Unable	Unable
Post Injury 2	1.68	10th - 25th	0	1.57	10th - 25th	0
Post Injury 3	.68	95th	0	.88	90th	0

Case Example 3

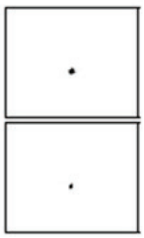
This 13-year-old female soccer player was evaluated three days after a collision with a teammate during a weekend game. She was held out of play due to complaints of dizziness, headache and light sensitivity. She rested over the rest of the weekend and was seen by a physician who referred her for COBALT testing to evaluate any possible vestibular dysfunction related to postural control. At the time of COBALT testing,she did not have any further complaints of dizziness at rest. Testing was performed to determine if there were any postural control deficits or observed symptoms during testing. The following are the results from her evaluation:



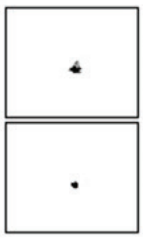
Firm Normal - EO	Sway score	No. of Errors	Time to 1st fall (secs)
Trial 1	0.17	0	0.00
Trial 2	0.13	0	0.00
Average	0.15	0.00	0.00



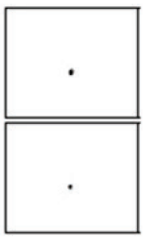
Foam Normal - EO	Sway score	No. of Errors	Time to 1st fall (secs)
Trial 1	0.25	0	0.00
Trial 2	0.21	0	0.00
Average	0.23	0.00	0.00



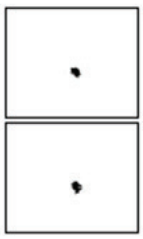
Firm Normal - EC	Sway score	No. of Errors	Time to 1st fall (secs)
Trial 1	0.28	0	0.00
Trial 2	0.21	0	0.00
Average	0.25	0.00	0.00



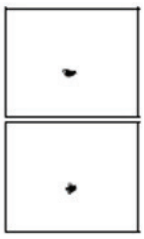
Foam Normal - EC	Sway score	No. of Errors	Time to 1st fall (secs)
Trial 1	0.55	1	5.67
Trial 2	0.45	0	0.00
Average	0.50	0.50	2.83



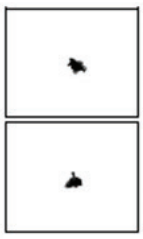
Firm Normal - EC HS	Sway score	No. of Errors	Time to 1st fall (secs)
Trial 1	0.35	0	0.00
Trial 2	0.27	0	0.00
Average	0.31	0.00	0.00



Foam Normal - EC HS	Sway score	No. of Errors	Time to 1st fall (secs)
Trial 1	0.63	0	0.00
Trial 2	0.70	0	0.00
Average	0.66	0.00	0.00



Firm Normal - VMS	Sway score	No. of Errors	Time to 1st fall (secs)
Trial 1	0.72	0	0.00
Trial 2	0.67	0	0.00
Average	0.70	0.00	0.00



Foam Normal - VMS	Sway score	No. of Errors	Time to 1st fall (secs)
Trial 1	1.10	0	0.00
Trial 2	1.00	0	0.00
Average	1.05	0.00	0.00

When reviewing these results, the clinician first focused on whether or not the athlete was able to complete the test. Next, the clinician examined both errors and sway scores and compared that information to age norms. This athlete was able to complete the test, did not have any errors on testing and her sway scores were in the 95th percentile and 50th to 75th percentile for Condition 7 and Condition 8, respectively. She did not have any complain of dizziness during the testing. After discussion with her physician, she was released to the return to play progression with her soccer team's athletic trainer.

COBALT can be used for screening purposes and can assist the clinician with direction on appropriate treatment planning. COBALT results can assist with return to play decisions based on postural control and balance. The results can also help direct appropriate treatment planning during the recovery process from concussion. Repeat COBALT results can document the progress the athlete is making in therapy. They can be used to evaluate performance compared to functional demands related to high level sports.

Appendix

	Age Group	Percentiles						
		5	10	25	50	75	90	95
SwayC7Avg	10-12	2.350	2.240	1.900	1.460	1.140	.940	.850
	13-15	1.991	1.8.4	1.530	1.210	.985	.770	.679
	16-18	2.028	1.830	1.395	1.030	.830	.706	.639
	19-25	1.819	1.718	1.370	1.200	.995	.808	.649

	Age Group	Percentiles						
		5	10	25	50	75	90	95
SwayC8Avg	10-12	2.371	2.234	2.010	1.640	1.360	1.170	1.023
	13-15	2.051	1.892	1.520	1.295	1.045	.899	.799
	16-18	1.880	1.760	1.440	1.195	1.003	.740	.683
	19-25	1.664	1.527	1.375	1.180	.990	.803	.722

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