KINETISENSE 3D CONCUSSION WHITE PAPER

Concussion is a significant problem, whether it is received through a high impact sport, a car crash, or other means. Difficult in detection and proper management, concussion has proven to have high human and financial cost. Kinetisense has developed a baselining and detection system that is highly cost effective and accurate, providing a valuable tool to address this important issue.

THE PROBLEM

Concussion is now one of the most widely discussed issues today in sport. Recent research is indicating that many athletes will sustain one or more concussions over the course of a playing career (1). In his research, Powell claims that "the repetitive trauma that is sustained by these individuals can have severe long term consequences to these athletes...Athletes who return to competitive activity too early after injury are potentially more vulnerable to injury recurrence, the consequences of which can be catastrophic. In response to these concerns, quantitative assessment tools which detect physical and cognitive impairment have become increasingly important in sports medicine (1)".

It is estimated that there are over 300,000 sports related concussions that occur each year in the United States alone (2). A study by Gessel et. al postulates that "the rate of sport-related concussion is anticipated to rise as sports involvement increases at the collegiate and high school levels (3)".

There are a variety of assessment protocol that have been developed as a sideline assessment tool to give insight if an individual is suspected to be concussed and whether they are safe to return to play. Many of these assessments, such as the SCAT 3 and BESS, incorporate balance and postural sway as a means of determining brain injury and whether the individual is fit to return to play (4,5).

Balance, posture, and sway testing has been validated for identifying neurologic impairment after concussion through many published studies (6) Many of the current sideline concussion analysis protocols such as the SCAT3 and BESS use postural sway in the analysis of baseline and subsequent assessment in concussed individuals. These tests have their limitations in that they are analyzed visually with reduce interexaminer reliability and lack objectivity (7). These tests do not allow for the accurate assessment of human biomechanics in all 3 planes and no objective data is produced in regards to quantifying postural sway.

Proper concussion analysis requires an efficient, affordable tool that provides objective motion analysis. There is a need for acquiring reproducible data for baseline testing and follow up assessments that can be administered by clinicians, trainers, coaches etc. Current assessment protocols lack interexaminer reliability and the ability to capture objective and comparative data.

THE SOLUTION

Recent validation of the Microsoft Kinect camera compared to gold standard force plate and Vicon camera systems has created the opportunity to develop an accurate, inexpensive method of collecting balance and posture data (8,9). Kinetisense has been validated in an unpublished third party university study to be more accurate than conventional joint ROM analysis tools such as the goniometer and inclinometer and of similar accuracy to the Vicon system.

The proprietary algorithms of Kinetisense increase the tracking accuracy of motion capture by up to 30% over that of the Microsoft Kinect SDK, allowing for accurate joint analysis, posture analysis and sway analysis in the frontal, sagittal and transverse views. Camera speed is 30 frames per second and is processed in real time, significantly improved over Kinect V1 (15-30 fps).

Kinetisense has been designed to provide an affordable means of acquiring 3-D joint, posture and sway analysis. The Kinetisense software provides real-time analysis and easy to understand reporting for motion capture in all planes. The real-time representation of human motion data and the increased inter and intra-examiner reliability in assessment separates Kinetisense from other analysis tools.

The 3D capture of joint and body position replaces the need for wearable sensors that are both timely and difficult to place on the body. Wearable sensor placement is often not reproducible between sessions, thus affecting the reliability of assessment.

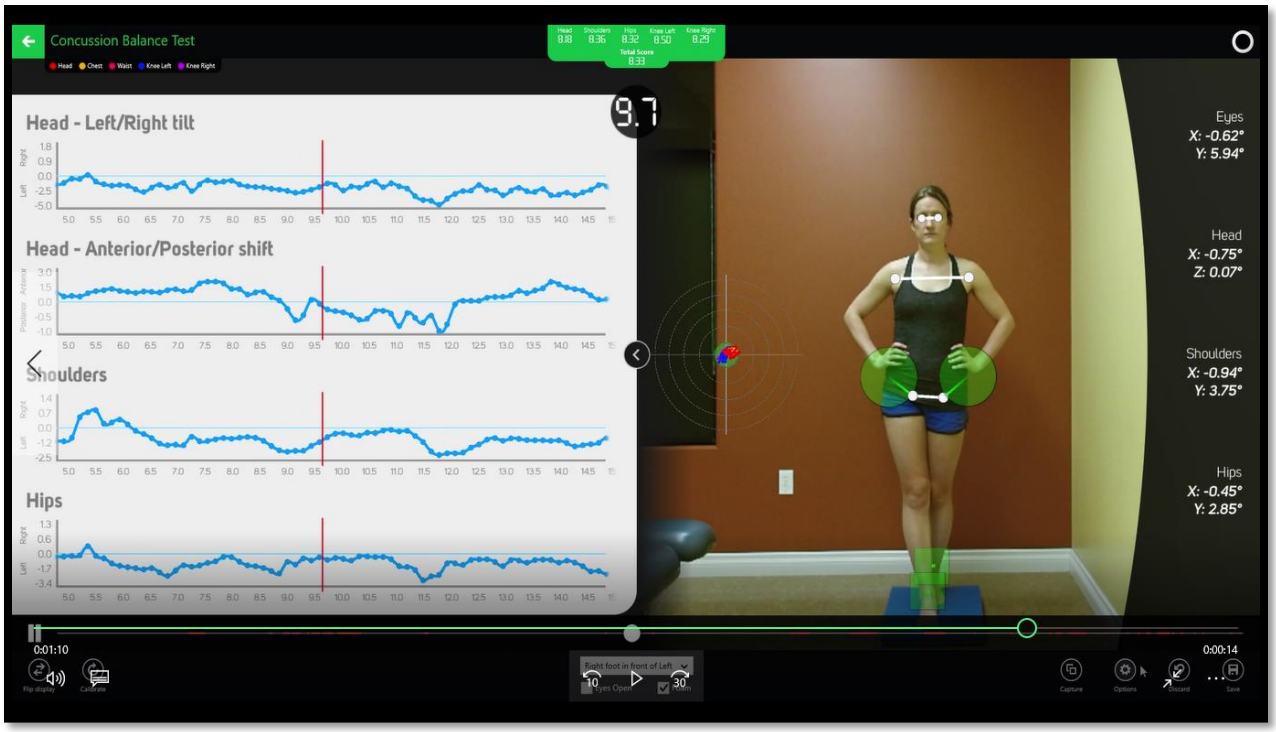
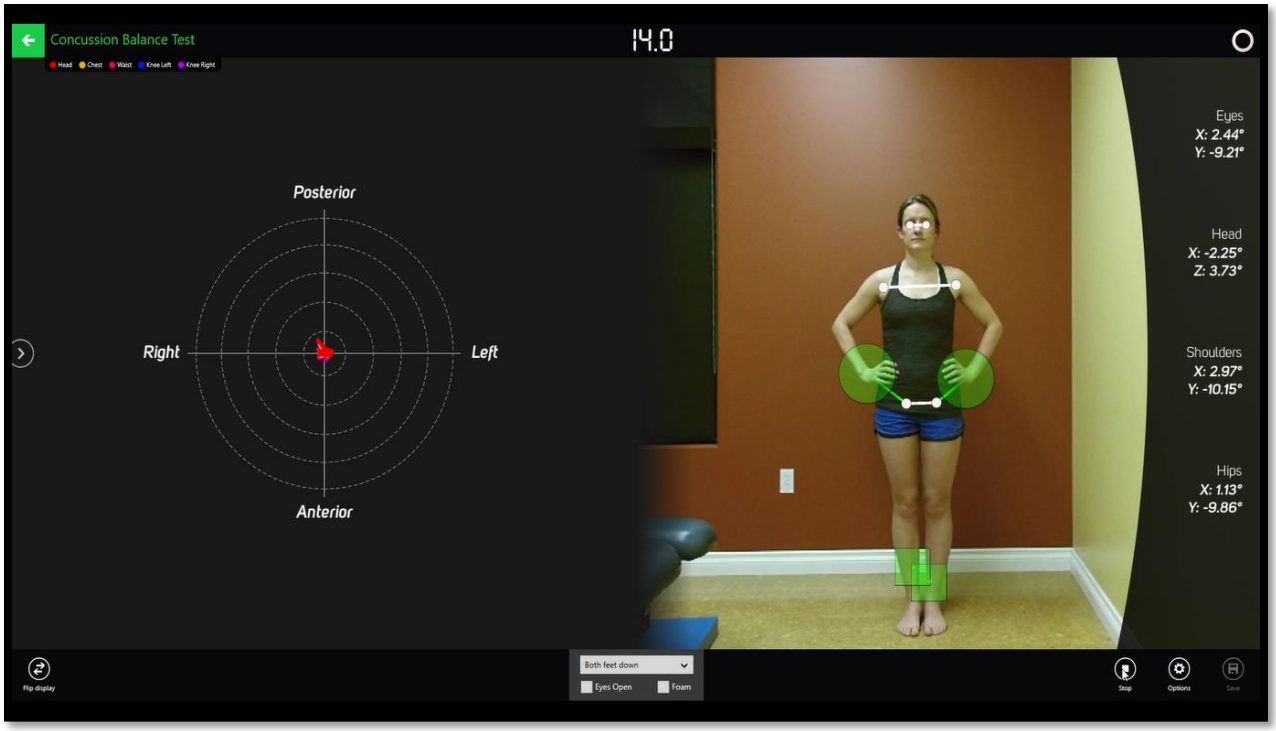


FIGURE 1. The Kinetisense system allows for the accurate joint and axis motion analysis of the body by acquiring data in the frontal, sagittal and transverse plane. This data is acquired without the use of wearable sensors and with a single front facing Kinect camera.



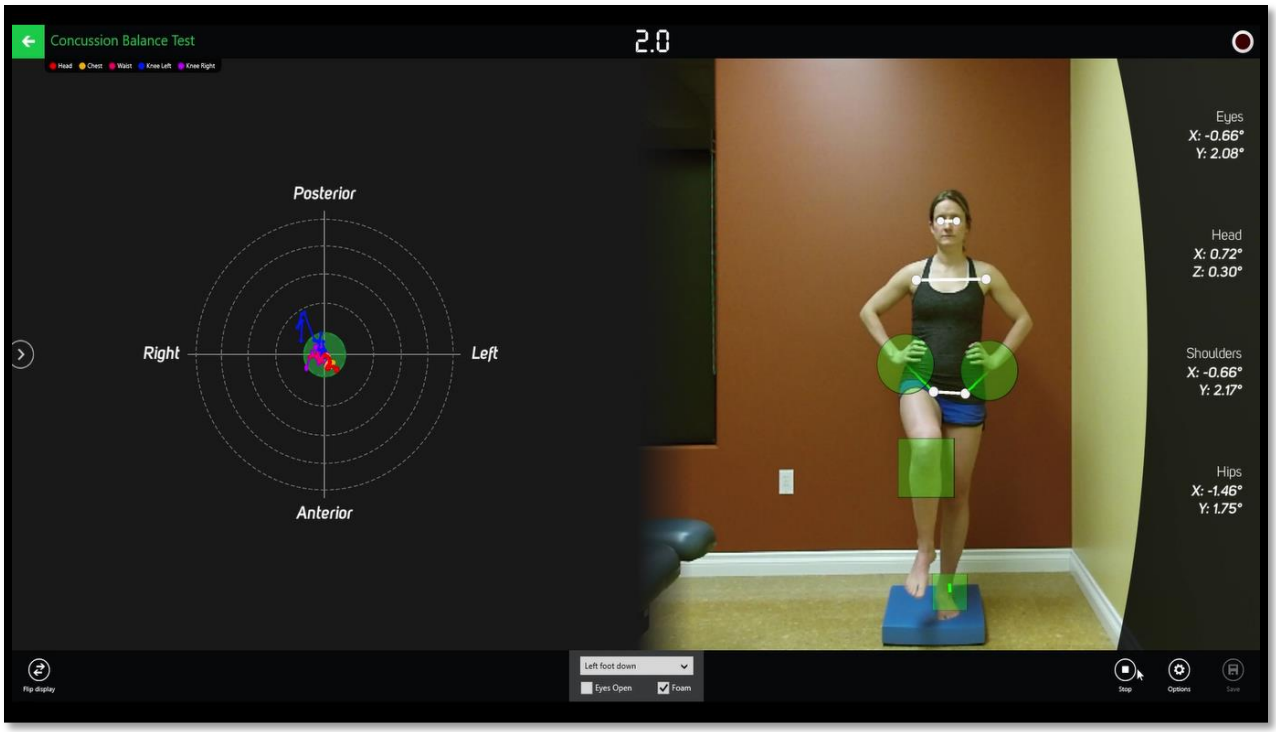


FIGURE 2 AND 3. Demonstrate transverse view center of body sway tracing.

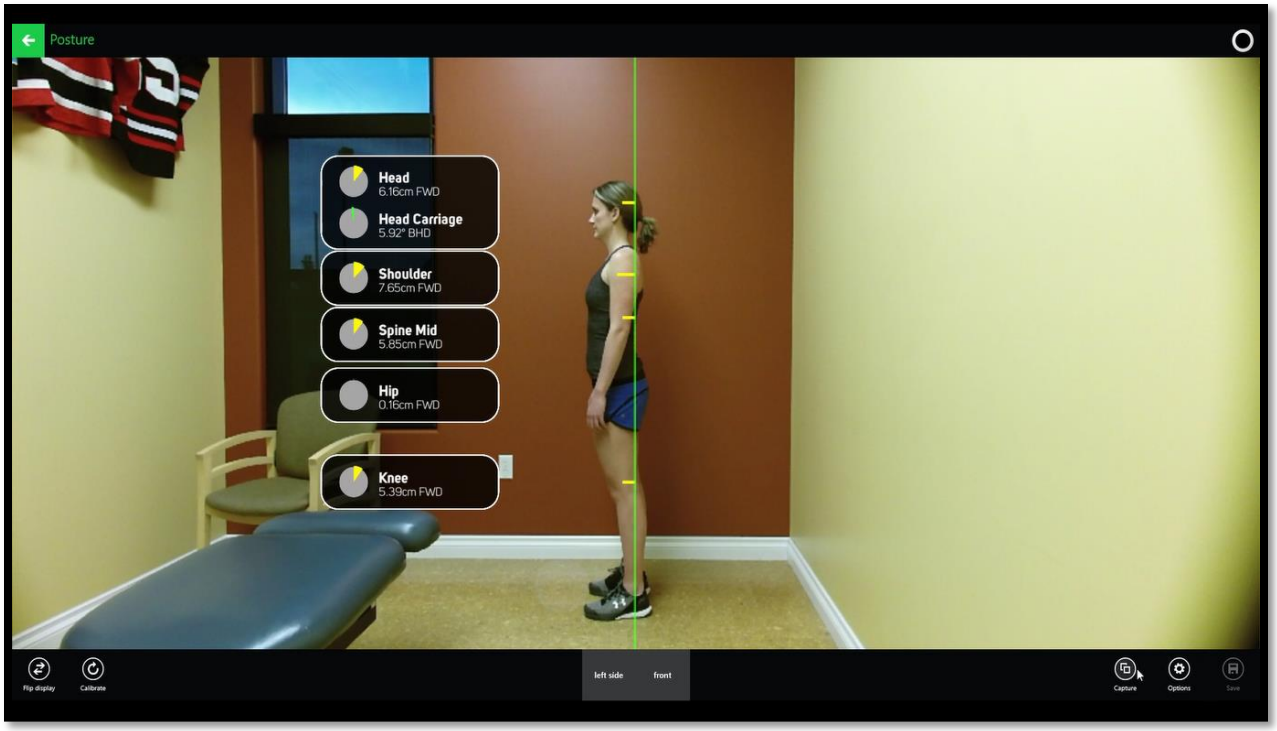


FIGURE 4. Demonstrates the sagittal sway capture as compared to plumb line. The data is presented in real-time.

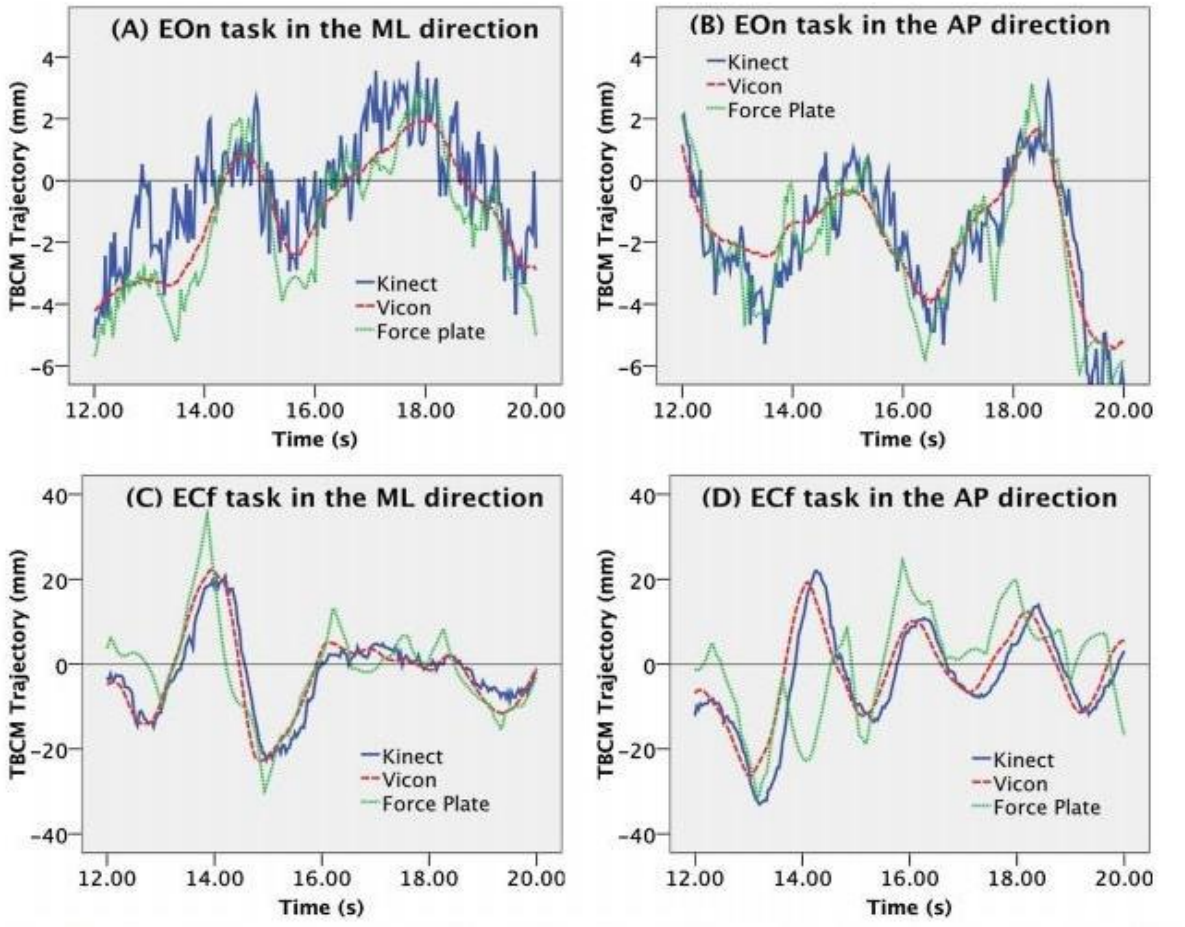
The accuracy, ease of use and objectivity of the Kinetisense system makes it an ideal tool for the clinical and sideline assessment of sport concussion. The Kinetisense system allows for a means of efficiently acquiring baseline posture and sway data that can be compared with analysis of a potentially concussed individual. The Kinetisense software will provide immediate data on the following:

1. Baseline postural sway of the 1-leg balance test (eyes open/eyes closed) in the sagittal, frontal and transverse planes.
2. Baseline postural sway of the tandem balance test in the sagittal, frontal, and transverse planes.
3. Storage of the baseline data in the HIPAA compliant Microsoft Azure Cloud system.
4. Acquisition of follow up postural sway in the event of a specific concussion, both within clinical setting and at the sideline of competition.
5. A “play or no play” recommendation based on the deviations of sway of the respective tests as compared to baseline.
6. Monitoring improvements in postural sway over the course of concussion rehabilitation, giving the practitioner insight on the different phases of treatment and when the individual is fit to return to play.
7. Data analysis of the finger to nose tracking test which is a component of the SCAT3 assessment.

HAS THE ACCURACY OF KINETISENSE BEEN VALIDATED?

The Microsoft Kinect camera and associated sdk has been validated as a tool for postural and balance assessment in peer reviewed scientific literature (8,9). It has shown reliability in measurement and inter-reliability in assessment and re-assessment.

A study by Yeung et. al compared the accuracy in postural sway between the Vicon system, force plate and the Kinect SDK for four different balance assessments including [1] Standing eyes open, [2] Standing eyes closed, [3] Standing eyes open on foam, and [4] Standing eyes closed on foam. The results of this test found that the Kinect SDK was comparable in accuracy to both the Vicon system and force plate analysis of body sway in all 4 of the positions listed above. According to this study "Overall, Kinect is a cost-effective alternative to a motion capture and force plate system for clinical assessment of TBCM sway (8)". The results are depicted below in the following graphs...



"To conclude, this study compared three TBCM sway assessment tools: a Kinect system, a motion capture system, and a force plate. The Kinect system demonstrated comparable intra-session reliability and accuracy in TBCM sway measurements to the motion capture system and the force plate. The Kinect and Vicon systems demonstrated comparable reliability (in terms of ICC2,1 and CV) and were sensitive to different tasks (EOn, EOf, ECn, ECf) (8)."

A study by Clark et.al found that the Kinect SDK provides "the ability to differentiate postural control strategies using an inexpensive, portable and widely available system could provide clinical and research benefits in a variety of patient populations. Our results suggest that the Microsoft Kinect provides anatomical landmark displacement and trunk angle data which possesses excellent concurrent validity when compared to data obtained from a 3D camera based motion analysis system (9)."

REFERENCES

1. Powell JW. Cerebral concussion: causes, effects, and risks in sports. J Athl Train 2001;36(3):307–11.
2. McCrea M, Hammeke T, Olsen G, Leo P, Guskiewicz K. Unreported concussion in high school football players: implications for prevention. Clin J Sport Med. 2004;14(1):13–17.
3. Gessel LM, Fields SK, Collins CL, Dick RW, Comstock RD. Concussions among United States high school and collegiate athletes. J Athl Train. 2007;42(4):495–503.
4. Riemann, B. L., & Guskiewicz, K. M. (2000). Effects of mild head injury on postural stability as measured through clinical balance testing. *Journal of athletic training*, *35*(1), 19.
5. Guskiewicz, K. M. (2011). Balance assessment in the management of sport-related concussion. *Clinics in sports medicine*, *30*(1), 89-102.
6 **.** Guskiewicz, K. M. (2003). Assessment of postural stability following sport-related concussion. *Current Sports medicine reports*, *2*(1), 24-30.
7. Ruhe, A., Fejer, R., Gänsslen, A., & Klein, W. (2014). Assessing Postural Stability in the Concussed Athlete What to Do, What to Expect, and When. Sports Health: A Multidisciplinary Approach, 1941738114541238.
8. Yeung, L. F., Cheng, K. C., Fong, C. H., Lee, W. C., & Tong, K. Y. (2014). Evaluation of the Microsoft Kinect as a clinical assessment tool of body sway. Gait & posture, 40(4), 532-538.
9. Clark, R. A., Pua, Y. H., Fortin, K., Ritchie, C., Webster, K. E., Denehy, L., & Bryant, A. L. (2012). Validity of the Microsoft Kinect for assessment of postural control. Gait & posture, 36(3), 372-37