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. Kinetisisense 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 one of the most widely discussed issues today in sport. Recent research indicates that athletes who receive a concussion are not always properly diagnosed and are allowed to continue to play [1]. Athletes who continue to play when concussed have an increased risk of injury recurrence and are at an increased risk of severe and long term health consequences [1]. Identification and diagnosis of a concussion is extremely important leading sport medicine specialists to use quantitative assessment tools to help detect physical and cognitive impairments [1].

It is estimated that there are between 1.6 to 3.8 million sports and recreational related concussions occur each year in the United States alone [2]. A study by Lincoln et. al postulates that the incidence of sport related concussions will continue to increase as our understanding and education based around concussions increase [3].

There are a variety of assessment protocols that have been developed as a sideline assessment tools 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 5 and BESS Test Protocol, 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 [6]. Many of the current sideline concussion analysis protocols such as the SCAT5 and the BESS Test Protocol use postural sway in the analysis of baseline and subsequent

assessment in concussed individuals. These tests have their limitations in that they are analyzed subjectively through visual observation with reduced interexaminer reliability and lack objectivity [7]. These tests do not allow for the accurate assessment of human biomechanics in all three planes of movement and no objective data is produced in regards to quantifying postural sway.

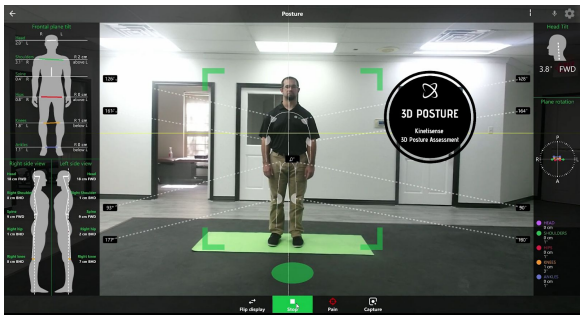

Figure 1. **Kinetisense Posture Module.** *The Posture module displays deviations in all three planes of motion.*

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, and more. Current assessment protocols lack interexaminer reliability and the ability to capture objective and comparative data.

THE SOLUTION

Validation of the Microsoft Kinect sensor compared to the 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 in the frontal, sagittal and transverse planes. The Kinect sensor speed is 30 frames per second (FPS) and is processed in real time, significantly improved over the 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.

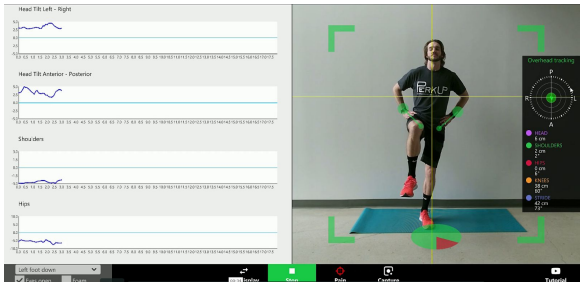

Figure 2. **Kinetisense Balance Module.** *The Kinetisense® system allows for the accurate joint and axis motion analysis of the body by acquiring data in the frontal, sagittal and transverse plane.*

This data is acquired without the use of wearable sensors and with a single front facing Kinect sensor.

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.

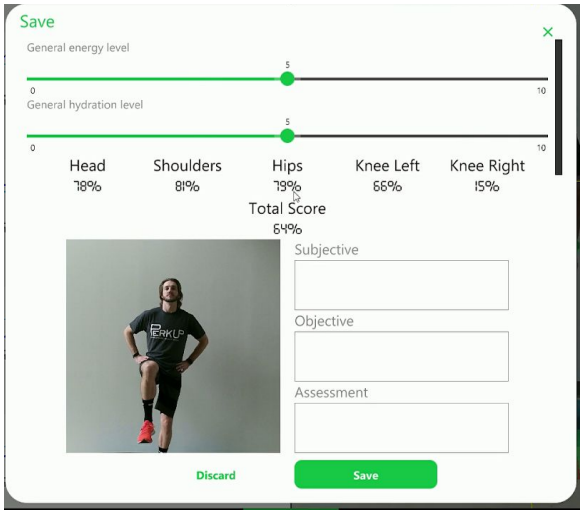

Figure 3. **Kinetisense Balance Score Card.** *Upon completion of a balance assessment, a score card will show up displaying the scores in the various regions of the body measured during the assessment.*

The accuracy, ease of use and objectivity of the Kinetisense system makes it an ideal tool for clinical and sideline assessments 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:

1. Baseline postural sway of the single leg balance test, eyes open or 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 HIPPA 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 SCAT5 assessment.

HAS THE ACCURACY OF KINETISENSE BEEN VALIDATED?

The Microsoft Kinect sensor 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 sway between the Vicon system, force plate and the Kinect SDK for four different balance assessments including standing eyes open, standing eyes closed, standing eyes open on foam, and standing eyes closed on foam [1, 2, 3, 4]. 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 four of the positions listed above. According to this study,

Yeung et. al. determined that the Kinect is a cost-effective alternative to a motion capture and force plate system for clinical assessment of TBCM sway with the results depicted in the graph below.

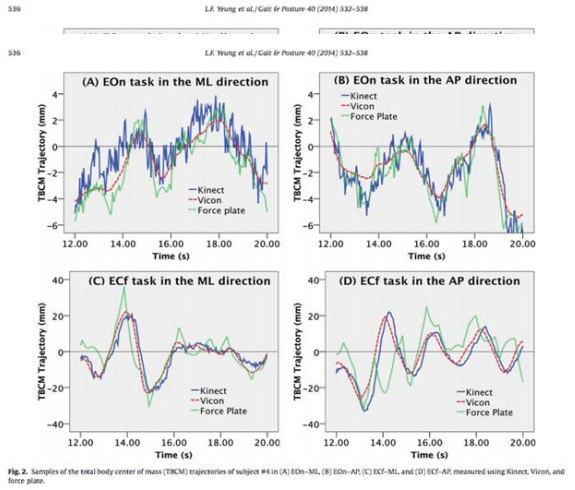

Figure 4. **Vicon and Kinect Comparison.** *This graph displays the comparison between the Kinect sensor and the Vicon system.*

The study compared the Kinect system, a motion capture system and a force plate to assess TBCM sway. There was comparable intra-session reliability and accuracy in TBCM sway between the Kinect system and the force plate and motion capture system [8]. Between the Kinect and Vicon systems, there was also comparable reliability in relation to ICC2, 1 and CV and were sensitive to different tasks, such as EOn, EOf, ECn, and 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 [9]. Our research suggests 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. MacGillvray, H. (2014). Where is the awareness in concussion: Can concussed players really assume the risk in a concussed state? *Jeffrey S. Moorad Sports Law Journal, 21*(2), 529-576.

2. LaRoche, A., Nelson, L., Connelly, P., Walter, K., &McCrea, M. (2016). Sports-related concussion reporting and state legislative effects. *Clinical Journal of Sports Medicine: Official Journal of the Candian Academy of Sports Medicine, 26*(1), 33-39.

3. Lincoln, A., Caswell, S., Almquist, J., Dunn, R., Norris, J., & Hinton, R. (2011). Trends in concussion incidence in high school sports: A prospective 11-year study. *The Journal of Sports Medicine, 39*(5), 958-963.

4. Nikolaou, Z. (2018). Electrophysiological and SCAT5 characteristics of contact vs non-contact sports athletes. *University of Stirling, Scotland.*

5. Guskiewicz, K. M. (2011). Balance assessment in the management of sports-related concussion. *Clinics in Sports Medicine, 30*(1), 89-102.

6. Murray, N., Salvatore, A., Powell, D., & Reed-Jones, R. (2014). Reliability and validity evidence of multiple balance assessments in athletes with a concussion. *Journal of Athletic Training, 49*(4), 540-549.

7. Ruhe, A., Fejer, R., Gansslen, A., & Klein, W. (2014). Assessing postural stability in the concussed athlete: What to do, what to expect, and when. *Sports Health: A Multidisciplinary Approach, 6*(5), 427-233.

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), 372-337.