# Kinetisense Balance and Fall Risk Assessment System


Kinetisense

**The Kinetisense® Clinical Balance and Postural Sway Analysis Tool**

## The Problem

Falls and related injuries are the leading cause of mortality and morbidity in the elderly population. Falls are considered as a serious problem affecting the elderly population, a known cause of injury, a reduction in quality of life, death, and financial strain on the health care system. Balance and risk of fall has been shown to be directly correlated with quality of life in the elderly population. Karinkanta and colleagues state that "home-dwelling elderly women good muscle strength in lower limbs is crucial for proper body balance and that dynamic balance is an independent predictor of a standardized quality of life estimate (1)."

According to Tromp et. al falls are ranked as the second cause of accidental or unintentional injury deaths worldwide (per year) (2). "Balance and gait impairments in older people increase the risk of falls, which are the leading cause of accidental death and injury-related visits to emergency departments. Overall, fall-related injuries constitute a public health problem associated with high financial costs as well as human suffering. The extent of the problem will continue to expand as the number of older people is projected to increase dramatically over the next few decades" (3).

The World Health Organization claims that falls in the elderly population is an epidemic and proper assessment and correction is crucial (4). Falls in the elderly population continues to be a trend that continues to rise. According to Burt et. al. "Thirty per cent of persons over 65 years old and 50% of persons over 80 years old experience at least one fall each year" (5). A consequence of elderly falls is the increased risk of fracture, specifically hip fractures. Falls are responsible for more that 90 percent of all hip fractures (3). According to Weigelt "one-quarter of older people who sustain a hip fracture die within 6 months of the injury, hip fracture survivors experience a 10–15% decrease in life expectancy (6).

Balance, posture and sway has been validated as an accurate means of assessing the risk of falls. According to Dona "the deterioration in postural control was significantly associated with major risk of falls" (7). "Tests of postural stability can identify, independently of age, individuals living in the community who are at risk of falls and fall-related fractures" (8). In his research Wiesmeier found that "spontaneous sway measures seemed to mirror age-dependent changes of postural control in a reliable way" (9). Falls are often the consequence of the loss of proprioception and balance in the neuromuscular system as well as deconditioning of the stabilizing musculature of the trunk and limbs. "Advancing age has been found to increase the overall fall risk and is often associated with a decrease in physical activity" (10). "Postural control is the foundation of our ability to stand and to walk independently. Deterioration in postural stability in older people may contribute to falls incurred during activities of daily life. Impaired balance has been correlated with an increased risk of falls" (11). Research has found that a large amount of the elderly population that are vulnerable to falling are not aware of their risk, therefore intervention and postural rehabilitation and stabilization is not implemented in a timely manner. "Early identification for potential fallers plus the implementation of effective balance training in this population is essential to avoid falls" (12).

Melzer et, al states that "there is a crucial need to investigate postural instability in order to identify older people who are at risk of a falls-related injury or death, and to develop effective interventions for reducing balance impairment (13). There is a lack of objective analysis tools that can

reproducibly analyze balance and sway in the geriatric population and identify those that are at risk of falls. Current methods of assessment lack inter and intra examiner reliability or are costly and cumbersome to use. Many of the current methods of assessment require “eyeballing” deviations in posture and sway, other tools such as the force plate analyze foot pressure deviation only. There is a need for an objective, efficient and affordable tool that can analyze postural sway and balance of all joints and joint axis of the body in the frontal, sagittal and transverse plane. There is a need for a tool that can analyze the area of the body where there is a lack of balance and sway control so that specific rehabilitation and stabilization protocols to those areas can be implemented. Proper assessment of risk factors associated to falls is key in providing timely and specialized rehabilitation.

## The Solution

Kinetisense® has been validated by a third party Univeristy study to be more accurate than conventional ROM analysis tools such as the goniometer and inclinometer and of similar accuracy to the Vicon system. The proprietary algorithms of Kinetisense® increase the accuracy of motion capture over that of the Microsoft Kinect SDK, allowing for accurate joint analysis, posture analysis and sway analysis in the frontal, sagittal and transverse views. Kinetisense® has extended the accuracy of the Kinect SDK in the following way:

1. The use of raw depth/infrared data to enhance the tracking accuracy of some joints by ~30% more accuracy.

2. Increased frame speed capture to a constant 30 frames per second versus the 15-30 frames per second in the basic Microsoft Kinect 2 SDK.

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.

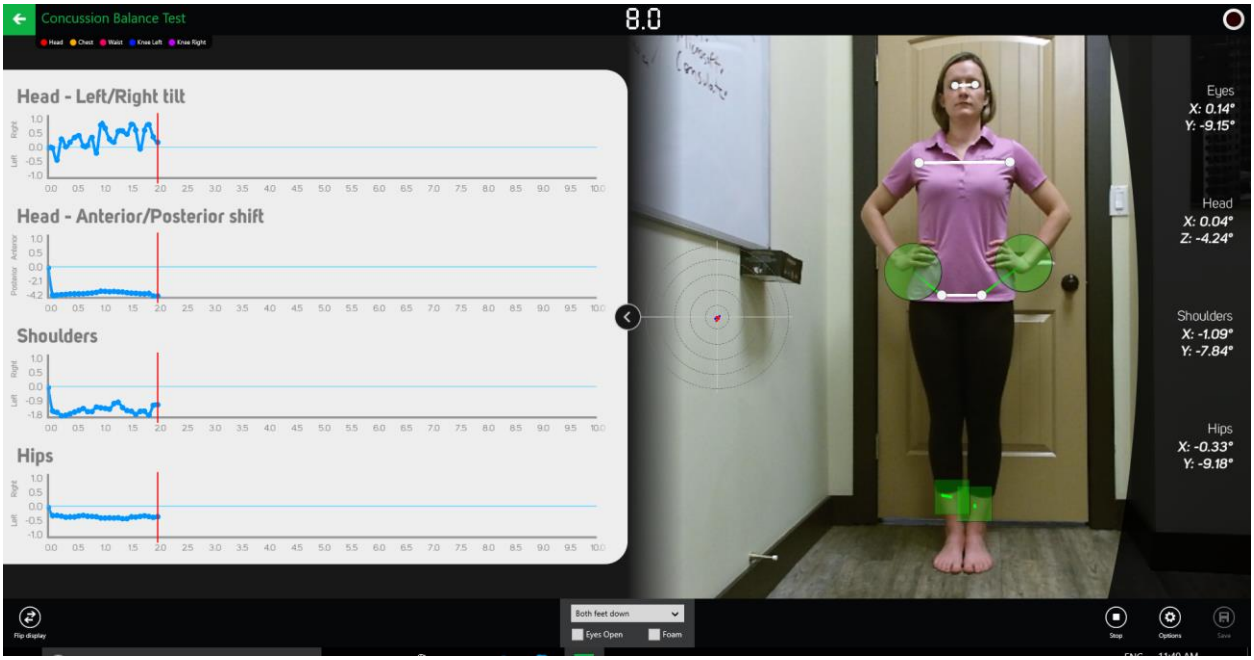

Fig 1.

*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.*

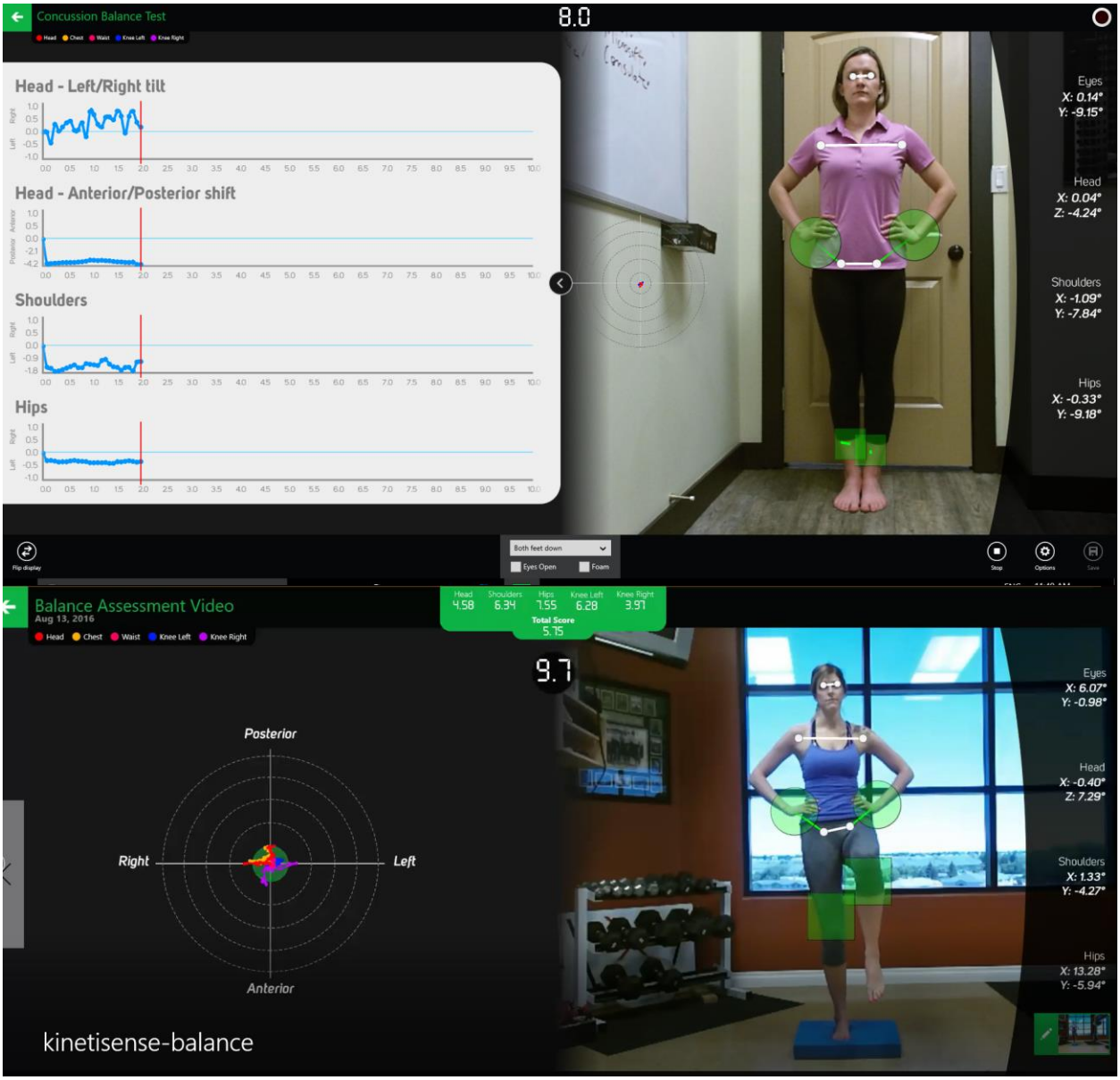
Concussion Balance Test
8.0
Head - Left/Right tilt
Head - Anterior/Posterior shift
Shoulders
Hips
Eyes
X: 0.14°
Y: -9.15°
Head
X: 0.04°
Z: -4.24°
Shoulders
X: -1.09°
Y: -7.84°
Hips
X: -0.33°
Y: -9.18°
Balance Assessment Video
Aug 13, 2016
Head Chest Waist Knee Left Knee Right
Head 4.58
Shoulders 6.34
Hips 7.55
Knee Left 6.28
Knee Right 3.97
Total Score
5.75
9.7
Posterior
Right
Left
Anterior
Eyes
X: 6.07°
Y: -0.98°
Head
X: -0.40°
Z: 7.29°
Shoulders
X: 1.33°
Y: -4.27°
Hips
X: 13.28°
Y: -5.94°
kinetisense-balance
Fig 2.


Fig. 3.

*Figures 2 and 3 demonstrate transverse view center of body sway tracing and frontal plane tilt in degrees.*

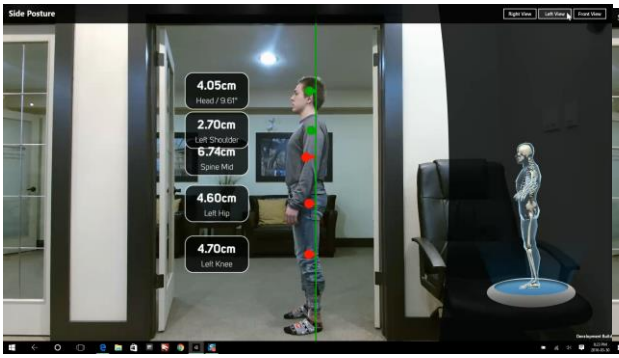


Fig. 4

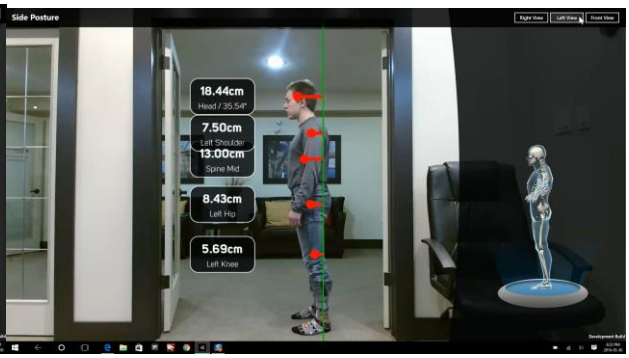


Fig. 5

*Figures 4 and 5 demonstrate the sagittal sway capture as compared to plumbline. 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 assessment of balance and postural sway, the Kinetisense® system allows for a means of efficiently acquiring baseline posture and sway data. The system 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. Scoring of posture stability is acquired by the system and presented in "easy to read" graphs and reports.

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. Monitoring improvements in postural sway over the course of rehabilitation, giving the practitioner insight on the different phases of treatment. Baseline data is easily compared to data acquired in follow-up assessments, thus the practitioner can track improvements or regressions in balance and correlate these findings with the risk of fall.

## University Validation on the Accuracy of the Kinect SDK

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

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” (14). The results are shown below in the following graphs...

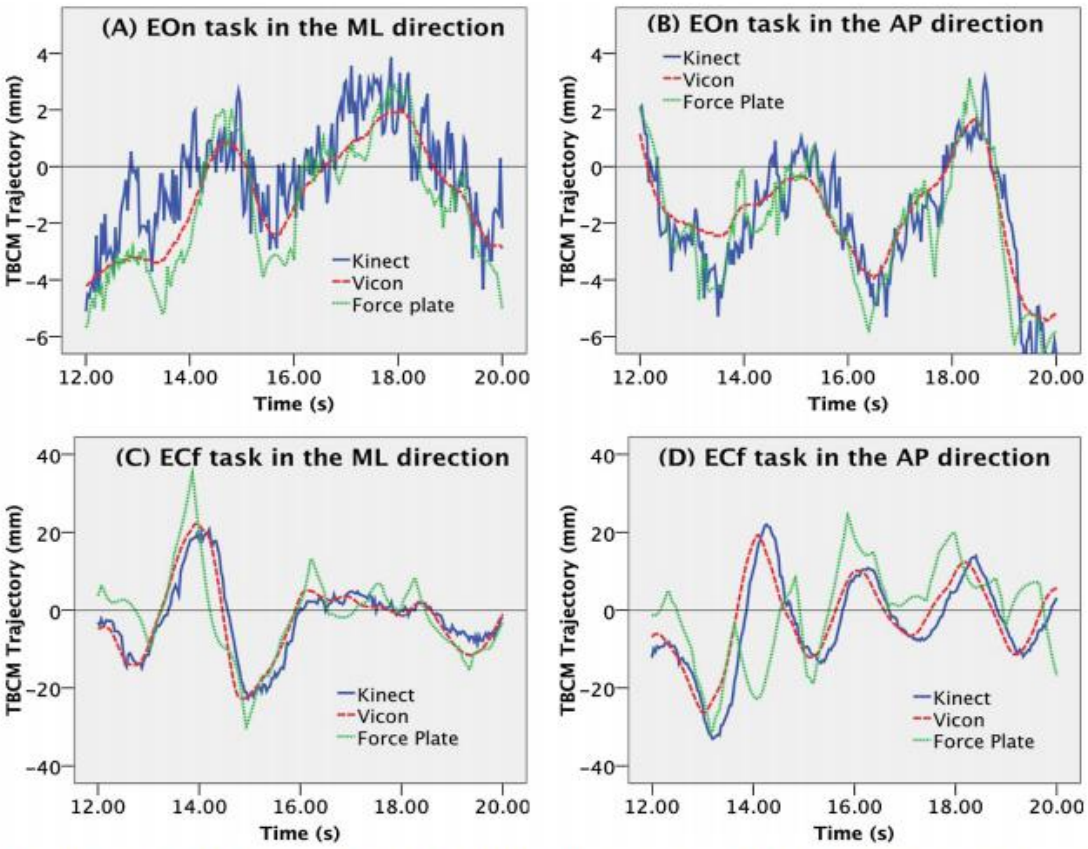


**Fig. 2.** Samples of the total body center of mass (TBCM) trajectories of subject #4 in (A) EOn–ML, (B) EOn–AP, (C) ECf–ML, and (D) ECf–AP, measured using Kinect, Vicon, and force plate.

"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)." (14).

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 misplacement and trunk angle data which possesses excellent concurrent validity when compared to data obtained from a 3D camera-based motion analysis system (15)".

**Conclusion**

The Kinetisense® Balance and Sway assessment system provides an objective, efficient and affordable solution for risk assessment of falls in the elderly population. The high inter and intra-examiner reliability of the Kinetisense® system allows for reproducible joint and joint axis assessment in the frontal, sagittal and transverse planes. Kinetisense® provides the advantage of analyzing joints and joint axis in the assessment of balance, allowing for specific rehabilitation of the areas of the body where abnormal sway persists.

The Kinetisense® system allows for health care providers to quickly identify risk factors associated with falls, and initiate the proper balance training program in a timely manner. This system will assess the individuals that are at greatest risk of falls, monitor changes in balance and postural sway with ageing, and reduce overall costs to health care in regards to geriatric falls and injury.

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