Kinetisense 3D Gait Risk of Fall System

Dr. Ryan D Comeau BSc, DC, ACC
Benjamin Kroon BSc (Kin)

The Kinetisense® Risk of Fall Gait Analysis System

The Problem

Falls and related injuries are a leading cause of mortality and morbidity in elderly individuals. Falls are considered as a serious problem affecting the elderly population, a known cause of injury, and a contributing factor to reduced quality of life, death, and financial strain on the healthcare system. Balance and risk of fall has been shown to be directly correlated with quality of life in the elderly population. In one study, Karinkanta and colleagues found that dynamic balance is an independent predictor of a standardized quality of life estimate (1).

Falls are considered to be the second leading cause of unintentional injury deaths worldwide, with an estimated 684 000 individuals dying from falls globally each 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). According to Burt et. al. “Thirty percent 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 thought to be responsible for more than 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, and hip fracture survivors experience a 10–15% decrease in life expectancy” (6).

Gait has been validated as an accurate means of assessing the risk of falls. Much of the research in this area has focused on the many different parameters of gait and how changes to one or more parameters may alter fall risk. Specifically, it has been reported that variations in gait parameters such as walking speed, stride length, and time spent in double-leg support are all associated with risk of falls in the geriatric population (7).

Previous studies have shown that older individuals tend to walk more slowly and have a shorter stride length relative to younger subjects (8). It has been suggested that “A reduction in hip extension, partially compensated for by an increase in anterior pelvic tilt, may be a primary mechanism underlying the decrease in stride length and walking speed in elderly people” (9). Slower gait velocity in particular

has been identified as an indicator of fall risk in this population (10, 11, 12). Research conducted by Luukinen et al. demonstrated that a slow walking speed of less than 0.77 m/s is an independent risk factor for recurrent falls (13). Shorter stride length has also been found to be linked with risk of fall. Research from MacAulay et al. and Thaler-Kall et al. found that stride length can be used to differentiate between elderly fallers and non-fallers (14, 15)

During walking, older individuals have been found to spend more time in double-leg support relative to younger individuals (8). This response is thought to be a part of a gait strategy used by the elderly to help maintain their dynamic balance and stabilize their inefficient gait control (16, 17). Double-support phase duration has however been shown to be an independent predictor of falls in older adults, and has been found to be a variable that would be useful for distinguishing potential fallers from non-fallers (12, 17, 18). One particular study performed by Kwon et al. found a statistically significant difference between elderly fallers and non-fallers in time spent in double-limb support, with fallers spending an average of 26.6% of the gait cycle in double-limb support (17).

According to Hamacher et al., reliable and clinically applicable methods for the identification of elderly individuals with an unstable gait are essential for effective implementation of preventive strategies (19). There is a lack of objective analysis tools that can reproducibly analyze and identify those in the geriatric population 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 still require “eyeballing” gait pattern deviations as well. There is a need for an objective, efficient and affordable tool that can analyze gait and provide information on all joints and joint axes of the body in the frontal, sagittal and transverse plane. Additionally, there is a need for a tool that can analyze multiple gait parameters so that specific rehabilitation and stabilization protocols can be implemented. The proper assessment of risk factors associated with falls is key in providing timely and specialized rehabilitation.

In summary, early detection in the “risk of fall” of a geriatric patient is required in order to mitigate the potential injury, loss of quality of life and possibility of death. Clinically, there are few systems and tools that are portable, affordable, efficient, and objective that can serve as an assessment tool. Often, practitioners must rely on subjective assessments for their analysis.

The Solution

Kinetisense has created a novel markerless motion capture system that uses the Intel Realsense 3D depth sensor. The “risk of fall” module analyzes multiple gait parameters that have been found to be indicative of functionality and subsequently one's risk of fall. The portable system consists of a laptop (with appropriate specs), the Intel Realsense 415 sensor, and the Kinetisense software.

The proprietary algorithms of Kinetisense increase the accuracy of motion capture over that of the Microsoft Kinect SDK, allowing for accurate joint identification and biomechanical analysis in the frontal, sagittal and transverse planes. Kinetisense® has extended the accuracy of the Kinect SDK in the following way:

1. The use of tri-planar depth/infrared data to enhance the tracking accuracy of joints by greater than 30% accuracy as compared to the Microsoft Kinect 2 sensor/SDK.

2. Increased frame speed capture to a constant 90 frames per second versus the 15-30 frames per second of the Microsoft Kinect 2 sensor/SDK.

3. The proprietary Kinetisense “Motion Capture Engine”, which removes “outlier” biomechanical data in real time.

4. Advanced Artificial Intelligence provides enhanced joint location and movement tracking accuracy.

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 lack efficiency and are difficult to place on the body. Wearable sensor placement is often not reproducible between sessions, thus affecting the reliability of assessment.

Clinical Applications

1. Risk of Fall Assessment Baseline

The system should be used for all patients over the age of 65 to assess the risk of fall and determine if the patient requires intervention such as therapy, environmental modifications or assisted living.

2. Addition of Ototoxic Medication or Multiple Medication (prescription)

There are numerous commonly prescribed medications that are considered to be “ototoxic” and affect proprioception and balance. Taking more than 5 prescription medications (even non-ototoxic) is seen as an increased risk factor for geriatric falls.

3. Triaging for the Level of Assisted Care

The data provided by the system can give valuable insight into the level of assisted living that is required for the individual and the respective timelines of these living modifications.

4. Trend Data of Functional Improvement/Regression

The system provides valuable historical data over multiple assessments of the individual's improvement or decline in function, as well as the rate of functional change over time.

5. Fitting of Assisted Walking Device Such as a “Walker” or a “Cane”

The system provides information on compensatory movement patterns, and which assisted aids will create a more symmetric gait pattern.

The System

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 Intel Realsense sensor.

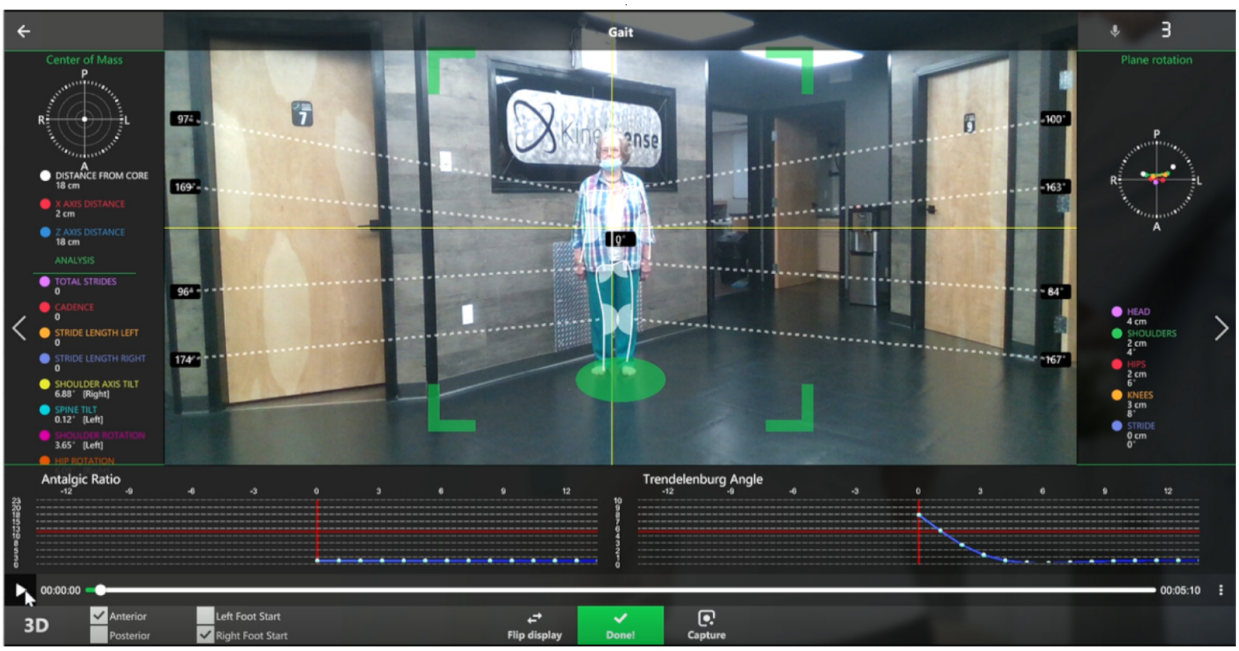


Fig 2.
The Kinetisense risk of fall gait system analyzes biomechanics and displays the data in real-time.

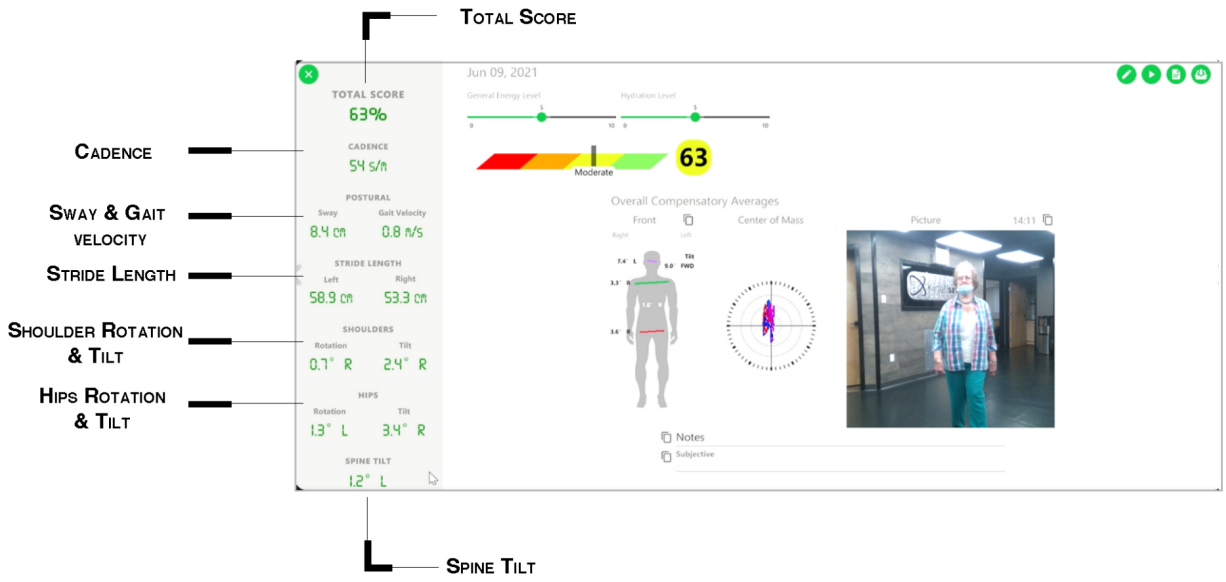


Fig. 3.

Figure 3 demonstrates the data outputs of the assessment.

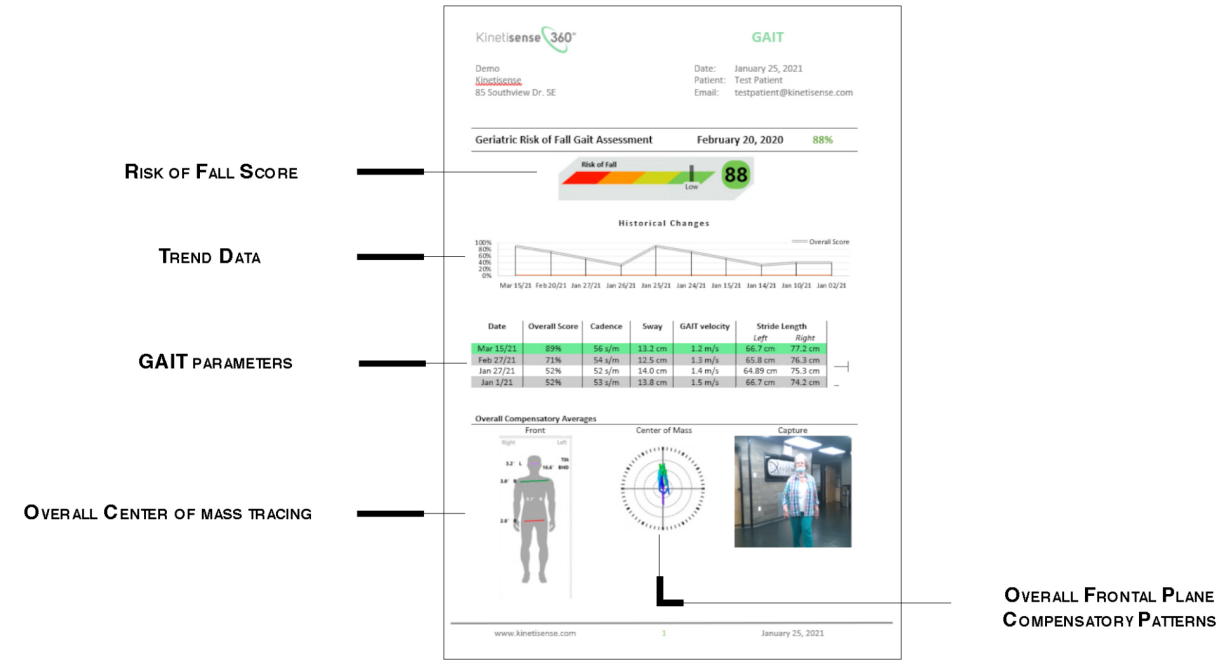


Fig. 4

Figure 4 represents the report that is generated by the system.

The accuracy, ease of use and objectivity of the Kinetisense® system makes it an ideal tool for the clinical assessment of gait, the Kinetisense® system allows for a means of efficiently acquiring baseline gait analysis and reassessment. The system will provide immediate data on the following:

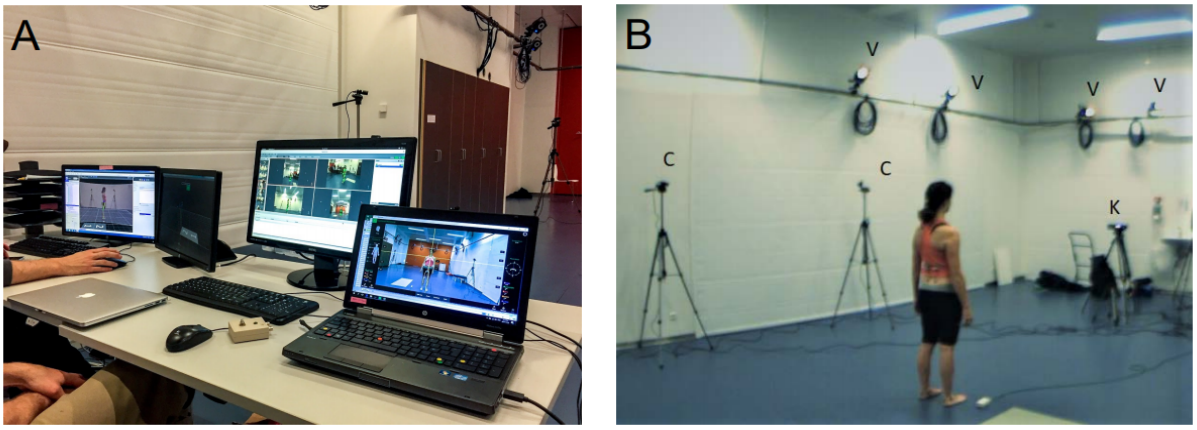
1. Overall Risk of Fall Percentage Score.
2. Overall Functional Score.
3. Average Cadence.
4. Average Stride Length, left and right.
5. Gait Velocity.
6. Average Compensatory Shoulder Axis Tilt.
7. Average compensatory hip axis tilt (Trendelenburg).
8. Center of Mass Trace (CoM).
9. Trend data of overall gait improvements/regressions.

University Validation on the Accuracy of the Kinetisense System

The Kinetisense markerless motion system and associated SDK have been validated for accuracy as a biomechanical analysis tool in a variety of studies. It has shown reliability in measurement and inter-reliability in assessment and reassessment.

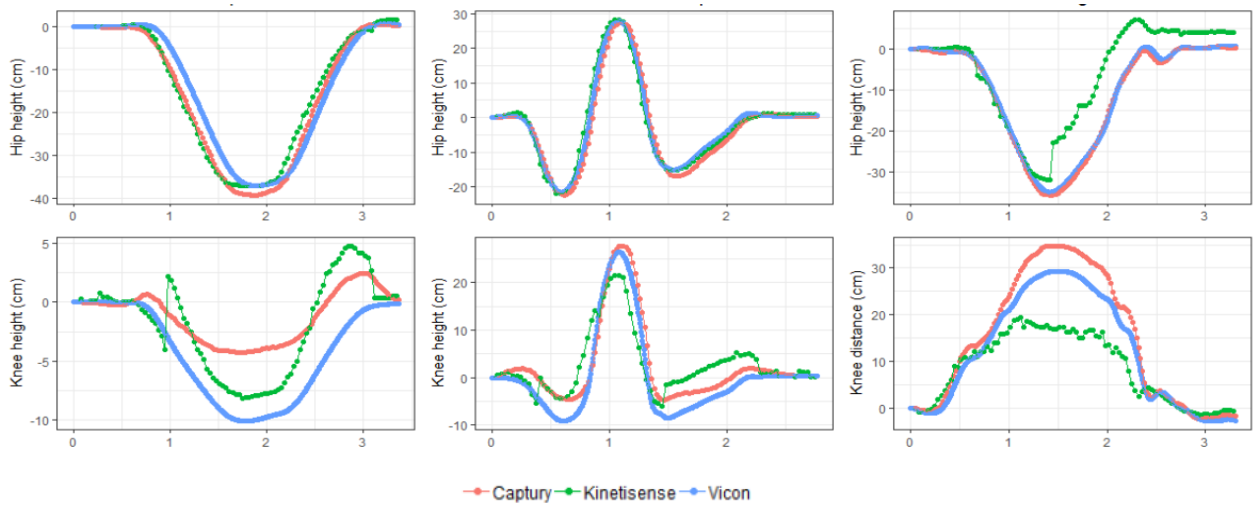
A study by Harsted et.al. entitled “The performance of two in-clinic markerless motion capture systems compared to a laboratory standard” found that Kinetisense showed good accuracy when compared to the Vicon marker-based system. This study concluded that the Kinetisense markerless system was “found to be sufficiently similar to the laboratory standard” of the Vicon system (20).

Biomechanical laboratory setup



A: From left to right Vicon (2 monitors), Captury, and Kinetisense

B: The subject standing in the center of the capturing volume of all three systems. Hardware from the three systems are marked with C (Captury), K (Kinetisense), and V (Vicon).



A third party University study conducted at the University of Calgary compared the accuracy of the Kinetisense system to the Vicon research system. The study compared the accuracy of the Kinetisense markerless system to the Vicon research system and force plate technology.

In conclusion the study suggests that “Kinetisense may be a valid alternative to expensive and cumbersome force plate or multi-camera motion analysis systems for clinical assessment. The objective scoring provided by the 3D tool improves upon current clinical standards that rely on scoring sheets or subjective interpretation of 2D video. The ease of set-up and the quick turnaround of objective balance data allow the clinician to fully dedicate themselves to interacting with and assessing the patient. Instead of calibrating cameras, placing markers, and processing data the clinician can spend their time working with the patient to interpret the results, discuss their progress, and develop training plans”.

A third party validation study conducted by Dr. Jon Doan from the University of Lethbridge compared the accuracy of the Kinetisense system to the Vicon research system. In this study 24 healthy young adults performed 8 different actions, each to two different levels (specific normal range deflection, maximal deflection) and at one of two different clinically relevant camera-subject distances, inside the shared calibration volume of the Kinetisense and VICON Peak motion capture systems. Bland-Altman agreement analysis was used to compare perceived and maximum joint angles from the Kinetisense system and the VICON Peak.

The results of this study showed that the “Kinetisense measures are valid compared to VICON-Peak measures, based on Bland-Altman agreement analysis”.

Conclusion

The Kinetisense Gait 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 gait, allowing for specific rehabilitation of the areas of the body where abnormal gait persists.

The Kinetisense system allows 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 healthcare in regard to geriatric falls and injury.

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