Validation of Kinetisense Balance and KAMS software to gold standard measurements.

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The project consisted of 3 primary objectives.

1. Kinetisense Balance Scoring System (KBSS) vs Centre of Pressure Measurement (Gold Standard)
2. Components of KBSS vs Vicon Motion Capture
3. KAMS Peak Joint Angles and Joint Positions vs Vicon Motion Capture

1. Kinetisense Balance Scoring System (KBSS) vs Centre of Pressure Measurement (Gold Standard)

- One Bertec force plate (1000Hz) was used to determine Centre of Pressure (CoP) location throughout each 20 second balance trial
- Mean Velocity (MV) of the CoP tracing has shown to be the most reliable measure of CoP for determining postural sway during static balance tasks (Lin, Seol, Nussbaum, & Madigan, 2008)

Spearman's rho correlation was used to determine validity, returning a value from 0 – 1, with 0 indicating no correlation, and 1 indicating perfect correlation. Spearman's rho operates on the basis of 'rank', since the scores from Kinetisense and the MV do not exist on the same scale. By ranking all 90 balance trials from best to worst as determined by the KBSS and the MV respectively, we can then answer the following question:

"If a trial ranks poorly according to the KBSS, does it also rank poorly according to MV? "

If the KBSS is a valid measure of whole-body balance and postural sway, we expect that the trials ranked by the KBSS would correlate well with the gold-standard measure, MV.

Table 1. Results of statistical test for validating KBSS against gold-standard MV.

No. of Trials	Spearman's rho	Sig.
90	0.762	< 0.001*

The results are very promising and there is strong evidence to indicate the KBSS is a valid measure of static balance and postural sway. The test showed statistically significant results ($p < 0.001$) for a strong correlation between KBSS and MV in terms of balance performance for all 90 trials ($r_s = 0.762$).

2. Components of KBSS vs Vicon Motion Capture

- Three key components of KBSS were compared between the Kinetisense software and the Vicon motion capture:
    - Average Tilt
    - Travelling Distance
    - %Time in Ring

Intraclass Correlation Coefficient (ICC 3,1) was used to assess the agreement between the two methods. ICC reports a value from 0 – 1, with 0 representing no correlation, and 1 representing perfect correlation with no measurement error.

The ICC will output a single value of correlation between the two measurement systems, in addition to a 95% Confidence Interval (95%CI). The 95%CI gives a representation of how confident we can be that our ICC value is a true representation of the between-system agreement.

Table 2. Results of ICC(3,1) used to determine the reliability of three component variables used to calculate the KBSS.

Variable	No. of Trials	ICC (3,1)	95%CI	Sig.
Avg. Tilt	89	0.688	0.560, 0.783	< 0.001*
Travel Distance	89	0.842	0.768, 0.893	< 0.001*
%Time in Ring 1	^38	0.744	0.560, 0.858	< 0.001*

^ Trials in which both the Kinetisense software and the Vicon system reported 100% of the trial spent within Ring 1 were not included. Including these values would wrongfully increase the ICC value.

The results suggest evidence of moderate to strong reliability for all three measures of postural sway as compared to the Vicon motion capture system. All results were shown to be statistically significant ($p < 0.001$).

3. KAMS Peak Joint Angles and Joint Positions vs Vicon Motion Capture

The Kinetisense Advanced Movement Screen assesses a patient's whole-body strength and mobility through a pre-defined set of 6 movement tasks. The patient receives a score for each task, and the score itself is dependent on his/her performance of various core movement patterns. The core movement patterns that were assessed for reliability are as follows:

- Trunk Lateral Flexion (Frontal plane)
- Lateral Hip Tilt (Frontal plane)
- Lateral Shoulder Tilt (Frontal plane)
- Hip Transverse Rotation
- Shoulder Transverse Rotation
- Relative Position of Shoulder, Elbow, and Wrist
- Relative Position of Knee and Ankle (Mediolateral)
- Vertical Jump Height

Each of the 6 movement tasks outlined in KAMS is scored by a specific combination of the above core movement patterns. Therefore, to validate the KAMS protocol, each of the core movements listed above were validated to the Vicon motion capture system, using Intraclass Correlation Coefficient (3,1) as described in section (2).

Table 3. Results of ICC(3,1) used to determine the reliability of KAMS core movement patterns. (AP = Anterior-posterior; ML = Medio-lateral; Vert = Vertical)

Movement	No. of Trials	ICC (3,1)	95%CI	Sig.
Trunk Lateral Flexion	14	0.626	0.165, 0.863	0.006*
Lateral Hip Tilt	15	0.451	-0.060, 0.774	0.04*
Lateral Shoulder Tilt	15	0.926	0.796, 0.975	< 0.001*
Hip Trans. Rotation	15	0.540	0.059, 0.818	0.015*
Shoulder Trans. Rotation	14	0.248	-0.305, 0.676	0.186
Shoulder/Elbow Position AP	15	0.473	-0.031, 0.786	0.032*
Shoulder/Elbow Position Vert.	15	0.956	0.875, 0.985	< 0.001*
Elbow/Wrist Position ML	15	0.914	0.763, 0.970	< 0.001*
Elbow/Wrist Position AP	15	0.607	0.157, 0.848	0.006*
Knee/Ankle ML	15	0.688	0.290, 0.883	0.002*

Vertical Jump Height	15	0.981	0.945, 0.994	< 0.001*

*indicates significant result to α = 0.05

	Statistically significant result is encouraging, but may require further analysis due to 'wide' 95% CI
	Statistically significant result and small 95%CI indicate evidence of strong correlation between systems

Often the waveform data that accompanied the joint angles matched up well between the two systems, however the Kinetisense software consistently underestimated the maximum and minimum values, despite tracking the movement pattern well.

Conclusion

To summarize, the Kinetisense Balance and KAMS modules were validated against gold-standard measurements CoP and Vicon motion capture. The balance score and the measurement variables used to determine the score showed promising results and suggest the Kinetisense software is a capable tool for balance and postural sway assessment. The KAMS measurement variables showed encouraging results, with 10 out of 11 parameters showing significant correlations between systems, however 4 of those 10 had relatively large 95%CI associated with the ICC (3,1) value. Still, the results presented in this report suggest the KAMS software is a promising tool, despite the need for caution when interpreting certain measurements.

References

Lin, D., Seol, H., Nussbaum, M. A., & Madigan, M. L. (2008). Reliability of COP-based postural sway measures and age-related differences. *Gait and Posture*, *28*(2), 337–342. https://doi.org/10.1016/j.gaitpost.2008.01.005