

clinical agreement ( $\rho = 0.916$ , LoA =  $-2.042 \pm 12.859$  degrees). In Figure 1 Bland and Altman show large variation of differences.

**Discussion:** In this study the validity of a commercial video analysis software for sagittal kinematics of the knee was examined. Correlation between the systems was high however clinical agreement was poor. The study highlighted a number of technical issues that included: (a) The possible need for higher speed cameras (>50 fps) as the current frame rate was inadequate for movement analysis. (b) Automatic tracking was unreliable under current video capture conditions and the analysis needed to be monitored manually frame by frame greatly increasing processing time and the potential for error due to the re-setting of angles. (c) The recommended high visibility stickers needed to be quite large (25 mm dia.) to be successfully tracked with size an issue for reliable placement on joints. Accurate tracking of the hip and ankle was not possible due to the limitations and these would need to be addressed before future work is done on validating the software for use in a clinical setting.

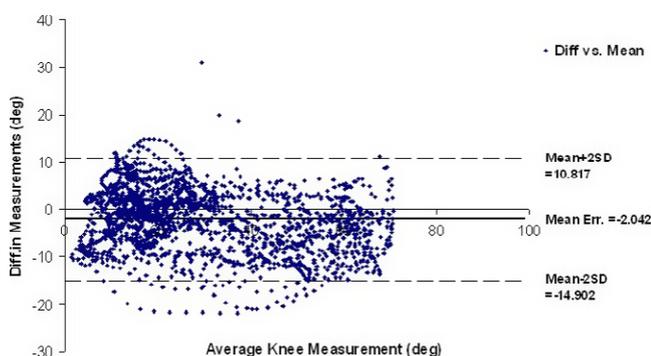


Figure 1. Bland and Altman graph.

#### References

- [1] McLean SG et al. Br. J. Sports Med. 2005; 39: 355–362.
- [2] Gissot AS et al. Gait and Posture 2007; 26: 603–606.
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#### O047

##### Comparison of the kinematic data from three different Vicon® systems

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**Summary:** This study aimed to ascertain the differences in the kinematic data acquired from three opto-electronic Vicon® systems; 612, MX-F40 and MX-13. The static parameters examined were the determination of known fixed marker coordinates, inter-marker distances and inter-marker angles. The analysis of dynamic data during walking comprised a number of joint angle parameters from specific points during the gait cycle and the pattern of joint angle curves produced by Polygon® throughout each complete stride. Data generated by the Vicon® systems were compared and assessed for agreement.

**Conclusions:** The results of this investigation propose that kinematic data cannot be compared among the three Vicon® systems and that further research into the existing differences is essential.

**Introduction:** Gait analysis technology is continuously evolving, one of the major catalysts of which is the Vicon® Company. Infrared motion cameras are employed within the clinical setting to capture and process movement data to allow the kinematic parameters of gait to be quantified [1]. Vicon® opto-electronic motion analysis systems are frequently upgraded in order to increase accuracy and enhance performance of these instruments. However, it is unknown if, with the developments in technology, the motion data produced by the new systems can be directly compared to that of the older generation technologies.

**Materials and Methods:** This prospective experimental crossover study used the Vicon® 612 (8 cameras) and MX-F40 (8 cameras) opto-electronic systems to simultaneously capture data in one gait laboratory. The Vicon® MX-13 (12 cameras) was based in an adjacent laboratory and data independently recorded. Static data was captured by all three systems using an L-frame and the coordinates and inter-marker distances were compared. A prosthetic knee with preset flexion and extension angles allowed for static angular data acquisition and the angles calculated were compared to the known values and contrasted among the three systems. 40 normal subjects (20 male and 20 female), were recruited and consented to participate in the study. Randomisation of the laboratory in which each subject started was undertaken and static and dynamic motion (gait) was captured accordingly. Joint angle parameters in all three planes were determined by coordinate calculation and graphical representation. All data were examined for inter-system variation. Significance levels were set to  $\leq 0.05$ .

**Results:** Although static angle determination displayed good agreement among all three systems, continuity of coordinate calculation and joint angle progression during walking, revealed significant variation among systems ( $p < 0.05$ ). Considerable differences were also noted for simultaneously captured data (612 and MX-F40) in both the normalised pattern and peaks recorded (Figure 1).

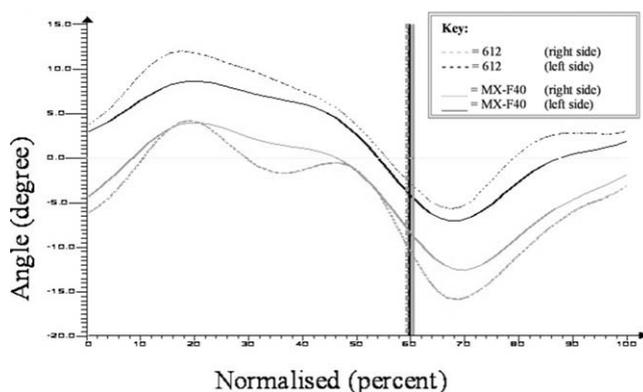


Figure 1. Differences in data capture between the 612 and MX-F40.

**Discussion:** In deduction from the results of this study, worrying differences exist in the data that was simultaneously recorded and processed by the 612 and MX-F40 Vicon® systems. Differences were also apparent between the 612/MX-F40 and MX-13 systems. Overall, it can be stated with confidence that kinematic data cannot be compared among systems. It is therefore suggested that advanced investigation into the variations that exist in the kinematic data produced by these three Vicon® systems is vital in order that the underlying differences in motion calculation can be

resolved. Until this is achieved, clinical gait data captured by one of the above systems can only be compared with data captured by the same system to ensure patient care is maintained.

#### References

- [1] Everett T, Trew M. Human Movement: An Introductory Text. 5th Edition. Churchill and Livingstone; 2006.

#### O048

##### Sensitivity of the OLGA and VCM models to erroneous marker placement in 3D-gait analysis

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**Summary:** In this study the sensitivity to variations in marker placement was determined using two models for 3D-gait analysis [Optimized lower limb gait analysis (OLGA) versus Vicon clinical manager (VCM)]. In general, gait variables were sensitive to marker placement of 10 mm resulting in errors larger than the normal variability during gait. The sensitivity was especially high for the knee and thigh markers. OLGA was less sensitive and therefore more reliable than the VCM model.

**Conclusions:** Precise and consistent marker placement, particularly for the knee and thigh markers is very important. Based on the sensitivity to marker displacement, the OLGA model should be preferred to VCM for 3D-gait analysis.

**Introduction:** A primary requirement of 3D-gait analysis for use in clinical practice is reliability of the collected gait data. Incorrect marker placement is known as an important source of error. To reduce the impact of these errors in marker placement, an optimization technique known as the OLGA model was developed. Charlton et al [1] tested this model for inter-observer repeatability and concluded that the repeatability of OLGA was better than the VCM model. However, to determine the markers and directions of displacements that are most sensitive to errors, it is important to apply a standard displacement instead of relying on natural variation. The purpose of the present study was to use a standard marker displacement to assess the sensitivity to errors in marker placement of the OLGA model compared to the VCM model in a large group of subjects.

**Patients/Materials and Methods:** Twenty healthy adults underwent six sessions of gait analysis. For the first session, the modified Helen Hayes marker set [2] was used. For the following sessions, marker displacements of 10 mm of either the thigh, knee or shank markers in anterior/posterior direction or the knee and ASIS markers in vertical direction were applied. Kinematic and kinetic data were collected using a six-camera motion capturing system (Vicon, 100 Hz) in combination with a force plate (Kistler, 2400 Hz). To determine the sensitivity, the root mean square (RMS) values of the kinematic and kinetic gait variables were calculated with respect to the (first) session with normal marker configuration. The sensitivity was compared to the normal walking variability in this population.

**Results:** For all hip, knee and ankle angles and hip moments OLGA showed lower RMS values compared to VCM in joint angles and knee moments (all  $p < 0.05$ ). The RMS in both models and the difference in RMS between the models were higher than the normal variability. For kinematic data, errors and differences

in errors were most pronounced in the frontal and transverse plane. For instance, the RMS for the anterior knee marker displacement session was 9.8 degrees using VCM, 3.5 degrees using OLGA, while the normal variability was 0.8 degrees for varus/valgus rotation in knee. With OLGA there was less cross-talk in the frontal plane. In knee moments, the sensitivity was most obvious in the sagittal plane. Knee and thigh marker displacements in anterior/posterior direction caused the largest RMS values in kinematic and kinetic data.

**Discussion:** The VCM model and the OLGA model used in 3D gait analysis are both sensitive to marker displacement, but the sensitivity was significantly reduced when using the OLGA model. This is in line with the findings of Charlton et al [1] who found a better repeatability for OLGA. In addition, the present study showed that the reduction in sensitivity by OLGA was larger than the normal variability, indicating that the reduction was relevant. Furthermore, special attention should be given to the precise and consistent placement of the knee and thigh markers in anterior/posterior direction since the sensitivity was especially high for these marker displacements.

#### References

- [1] Charlton et al. (2004). Repeatability of an optimised lower body model. *Gait and Posture* 20(2): 213–221.  
[2] Davis et al. (1991). A gait analysis data collection and reduction technique. *Human Movement Sciences* 10: 575–587.

## Oral Session 9: Normal & pathological gait

#### O049

##### Ageing and gait variability – a population-based study of older adults

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**Summary:** Age was associated with greater step-to-step variability in temporal and spatial gait measures in this large cross-sectional population-based study. Results suggest that speed is an intermediate in the pathway between age and step time and double support phase time (DSP) whereas step width appears to be largely independent of gait speed.

**Conclusions:** These are the first results describing associations between age and a range of temporal and spatial gait variability measures in a large population-based sample. They show that gait variability is positively associated with age.

**Introduction:** Greater gait variability may be associated with risk of falling and with clinical diseases such as Parkinson's disease [1,2]. However, few studies have examined how variability changes with age in older populations. The study of how gait variability is affected by age may lead to a better understanding of the mechanisms underlying falls in older people and allow preventative interventions to be targeted at appropriate age groups. Accordingly, the aim of this cross sectional study was to examine associations between age and measures of gait variability in a population-based sample of older adults.

**Patients/Materials and Methods:** Men and women aged 60–86 years (n = 410) were randomly selected from the Southern