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HUMAN GAIT USING LOCKED AND STANCE CONTROL MODE KNEE ANKLE FOOT ORTHOSES: OPTIMISING DATA ANALYSIS TECHNIQUES TO DETECT AND QUANTYIFY GAIT DEVIATIONS

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Preferred Presentation: Oral Presentation
If your abstract is not accepted as an oral do you wish to be considered for a poster?: Yes
Clinical Biomechanics Award: Yes
David Winter Young Investigator Awards: Yes
David Winter Award - presentation Preference: Oral
Emerging Scientific Award sponsored by Professor J De Luca: No
Promising Scientist Award sponsored by Motion Analysis: No

Introduction and Objectives: Knee-Ankle-Foot Orthoses (KAFOs) potentially benefit a large range of patient populations with quadriceps weakness and knee instability. In the UK the most common prescribed is a locked-knee device, where the knee is locked in extension at all times, which have been shown to introduce secondary gait deviations, such as vaulting, hip hiking and circumduction. Stance control KAFOs, which lock the knee during stance but permit flexion during swing have been shown to reduce gait deviations as well as increase walking speed and efficiency.[1] The Gait Deviation Index (GDI)[2] is a metric distilled from a walking dataset to indicate the extent to which a person's gait deviates from a control. To our knowledge the GDI has not previously been demonstrated to quantify the effects of assistive devices, such as KAFOs. In addition, calculation of the GDI has often required substantial manual processing of data, which is time consuming and subject to human error.

The aims of this study were to conduct a comparison of walking biomechanics whilst using a KAFO in both locked and stance control modes, and also to develop a data processing utility to automatically calculate and report the Gait Deviation Index, as well as more traditional kinematic and spatial temporal data.

Methods: Sessions used a 12 camera Vicon B10 motion capture system installed in a Computer Assisted Rehabilitation Environment (Motek Medical CAREN extended suite) with a Becker Orthopaedic PreStride 2007, which can be set to both locked or stance control mode, and adjusted to fit the majority of participants. It is worn with sandals to accommodate the bulk of the device.

The participants were age 25±6.03 years and screened to ensure that they had no conditions which would affect the results or endanger them then provided with a 15 minute acclimatisation period to ensure correct knee operation.

Each person completed a 30s trial in the following randomised conditions walking at a self-selected speed:

- Own footwear – used to generate control group data for GDI calculations
- KAFO footwear – used as the normal gait condition to mitigate any deviations caused by the footwear
- Locked mode
- Stance control mode

The analysis tool was created using Microsoft Excel 2010 and Schwartz's GDI template.(2) The template allowed a single step's GDI to be calculated, but the developed tool allowed up to 15 steps of kinematic, spatial temporal and GDI data for both legs to be found.

Heel velocity was used to calculate step and swing phase status - sensitivity adjustments were incorporated to mitigate heel movement during stance phase.

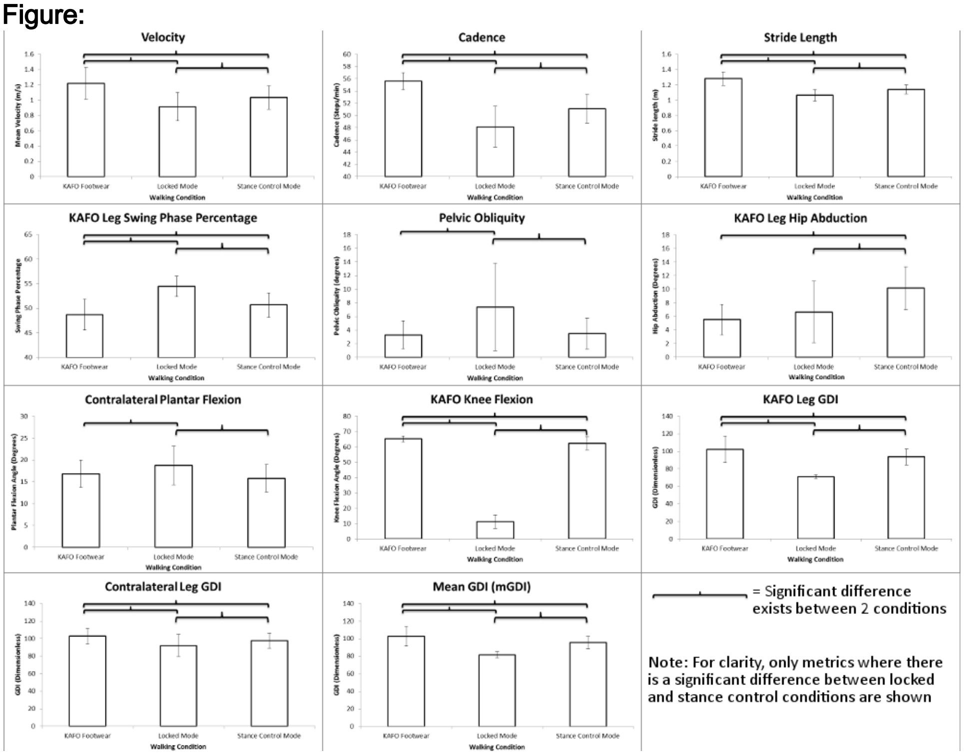
Steps with sample sizes outside of 0.5 std. dev. of the mean were excluded whilst valid steps were downsampled to ensure compatibility with the GDI calculator. This resulted in an output of a 16-metric analysis for each valid step.

Results were subjected to a K-S test to determine distribution. Where data was normally distributed an ANOVARM was used to determine significance, whilst data which was non-parametric was subjected to a Wilcoxon Signed Ranks test.

Results: Fig 1 shows velocity, cadence and stride length increase when going from locked to stance control to normal modes. Davis[3] and McMillan[4] found increases from locked to stance whilst Zissimopoulos[5] reported increases from stance to normal modes. The reduction in KAFO leg swing phase from locked to stance was also observed by Davis. Contralateral plantar flexion (vaulting) and pelvic obliquity (hip hiking) decrease from locked to stance mode whilst KAFO leg hip abduction (circumduction) and knee flexion increases from locked to stance to normal modes. Zissimopoulos found a similar reduction in pelvic obliquity.

All GDI metrics increase from locked to stance to own footwear trials – showing an increase as joint restriction decreases. This presents similar findings to Molloy [6] who used GDI to evaluate Cerebral Palsy patients and found a linear relationship between the GDI and the patient's GMFCS.

Figure:



Caption: Fig 1: Trial Data

Conclusion: Overall, the device presents improved spatial temporal and kinematic performance in stance mode compared to locked mode. There is, however, a reduction in performance from the normal trials to stance control mode, showing there are still gait deviations present.

The GDI score shows a linear relationship with the mode of the device – as the device becomes more restrictive the GDI decreases. This shows that the GDI may be considered a useful tool for quantifying the effect of devices.

The author found that the tool created allows processing to be cut down from 30-40 minutes per participant to 1-2 minutes. This presents a large potential time saving, easier access and lower likelihood for error.

References: [1]Arazpour et al., P&O Int, 37(5):411-414, 2013.
[2]Schwartz, Rozumalski, Gait & Pos, 28(3):351-357, 2008.
[3]Davis et al. P&O Int, 34(2):206-215, 2010.
[4] McMillan et al. J of P&O, 16(1):6-13, 2004.
[5] Zissimopoulos et al. J of Reh. R&D, 44(4):503-514, 2007.
[6] Molloy et al. Gait & Pos, 31(4):479-482, 2010.

Disclosure of Interest: None Declared