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VISUALISATION TO AID THE INTERPRETATION OF 3D GAIT DATA IN AFO TUNING FOR STROKE

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SUMMARY
Visualisation software has been developed to aid the interpretation of 3D biomechanical gait data in the context of AFO tuning for stroke patients. This paper reports preliminary findings of a clinical RCT currently underway to examine the effect of the visualisation software on patient outcomes following AFO provision. Both the software and the clinical RCT are described, with provisional results showing immediate improvements in walking velocity and overall step length for the first patients in both sides of the trial (n=8).

INTRODUCTION
Patient compliance with their treatment has been shown to improve with better understanding of their treatment and effective communication with clinicians [1] and this is likely to lead to a better chance of improved treatment outcomes [2]. During rehabilitation sessions, clinicians are expected to comprehend and communicate complex biomechanical concepts to patients to aid their understanding, help improve motivation and assist with goal setting. When it comes to biomechanics it is thought that those studying physiotherapy "are happier studying material that is interactive and widely illustrated with animations and drawings" [3] rather than equations, tables and graphs. This is supported by the findings of Macdonald et al. [4] who found that animated visuals can be used to explain complex biomechanical data to groups of both clinicians and older adults.

This study tests the hypothesis that by designing and building a series of visualisations to help interpret 3D biomechanical gait data, and arranging them in a software package, patient outcomes could be improved.

METHODS
A software package was developed to test this hypothesis in the context of fitting and tuning ankle-foot orthoses (AFOs) with stroke patients. The visualisation software was designed with two key audiences; patients and clinicians. It aims to help clinicians (orthotists and physiotherapists) arrive at a clinical decision regarding the most suitable height of heel wedge for each patient to use with their AFO. It aims to help the patients understand their treatment, and provide a means for measuring their gait rehabilitation progress.

During the design phase of the software, close consultation with bioengineers, physiotherapists and orthotists suggested that only a small, very specific, subset of gait parameters were necessary for making clinical decisions and measuring progress for AFO tuning. The selected parameters were shank-to-vertical angle at mid-stance (SVA_{mid}), maximum thigh-to-vertical angle (TVA_{max}), second vertical GRF peak magnitude (FZ_2) [5], sagittal hip and knee moments during late stance, step length, cadence, step length symmetry, and gait velocity. The visualisation software was designed to read 3D motion data from a standard file format (.c3d).

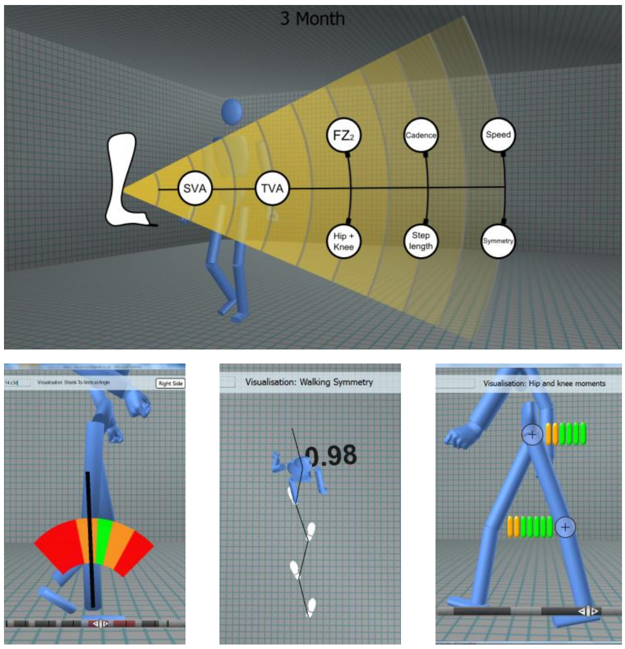

Figure 1: Sample visualisations; main menu, SVA, step length symmetry, and knee and hip moments

The software is currently being tested in the context of a clinical trial (ISRCTN52126764). The trial is a single-blind RCT which compares the use of the software in AFO tuning against standard care (AFO tuning using observation alone). Participants will have experienced a recent hemiplegia (1-12 months) and will have been identified by their care team as being suitable candidates for a custom-made rigid AFO. 3D gait measures are taken from all participants at baseline, AFO fitting/tuning (7 days post-baseline), 3 months and 6 months. 3D motion data is captured with an eight-camera Vicon 612 system (Oxford Metrics, UK). In addition to 3D gait measures EuroQol (EQ-5D-5L) quality of life questionnaires, the modified Rivermead Mobility Index and modified Ashworth Scale (gastrocnemius and soleus of affected limb) are also used [6].

The results of the first eight participants to be recruited to the study are presented here, with five males and three females, a mean age of 57 (16) years and 3.5 (3) weeks post-stroke.

RESULTS AND DISCUSSION

Initial improvements in participant walking velocity are shown in Figure 2. As participant numbers were low at the time of writing, between-group comparisons will be carried out as recruitment improves and the data becomes available. All but one participant experienced an immediate improvement in their walking velocity when given an AFO tuned specifically for them.

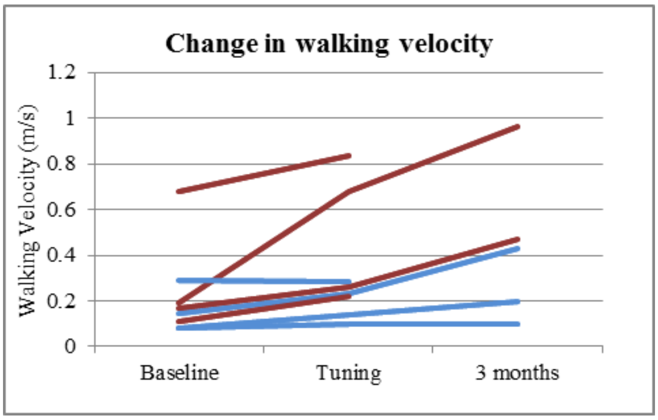

Figure 2: Changes in walking velocity. Visualisation group in red, non-visualisation group in blue.

Table 1 shows that across this group of eight participants significant improvements in walking velocity and overall step length were observed. There was also a trend towards an improvement in step length symmetry, although this was not statistically significant. It is thought that the symmetry improvement is due to the AFO increasing stability during single-leg stance on the affected limb, thus allowing sufficient time for a longer non-affected limb step. Kinematic results show a slight improvement in SVA_{mid} for the participants when they are provided with their AFO, with a shift from 6.6 (6.3) to 11.5 (3.6) which is closer to published target values of 10-12° inclination [7]. Slight improvements in TVA_{max} and knee flexion angles were also observed.

This study is part of a larger project (the **en**vis**age** project) where different versions of this visualisation software are currently being used to assess the use of biomechanics visualisation with different patient groups. These different software versions allow the use of different 3D motion capture systems, using different graphical techniques and visualising different biomechanical parameters. These versions of the software are being tested in a variety of home, community and hospital settings.

While the complexities of 3D gait analysis for research purposes are advantageous, those same complexities can also act as a hindrance in many point-of-care clinical situations. This study represents an attempt to make 3D biomechanical data more accessible and understandable to unfamiliar audiences.

CONCLUSIONS

New biomechanics visualisation software has been developed to make standard 3D motion data more clinically useful for AFO tuning with stroke patients. This is currently being tested in a clinical RCT. Greater numbers of participants will be required to show if the use of the developed biomechanics visualisation provides improved patient outcomes compared with standard care. The preliminary data presented shows that both groups have experienced improvement across a number of gait parameters.

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Table 1: Summary spatiotemporal and kinematic parameters for all participants (n=8)

Spatiotemporal parameters					
Walking velocity (m/s)		Symmetry ratio		Overall step length (m)	
Baseline	Tuning	Baseline	Tuning	Baseline	Tuning
0.22 (0.2)†	0.36 (0.3)†	0.65 (0.2)	0.74 (0.2)	0.28 (0.1)†	0.37 (0.1)†
Kinematic parameters					
SVA_{mid} (°)		TVA_{max} (°)		Knee flexion at TVA_{max} (°)	
Baseline	Tuning	Baseline	Tuning	Baseline	Tuning
6.6 (6.3)	11.5 (3.6)	4.6 (9.1)	6.3 (9.9)	11.7 (12.7)	13.1 (8.6)

† Statistically significant change ($p<0.05$) with Wilcoxon Signed Rank Test