and in the table below. Based on the values found for the healthy group, the 10 movements chosen seem to be effective to induce a large range of motion for each angle. As expected, for the synosthose group, the pronation/supination ARRoM, especially due to the lack of supination, was really smaller than that of the healthy group. The other ARRoMs were not significantly different. The analysis of each movement individually suggest that the lack of supination is not compensated by one rotation in particular since in some cases the abduction was different (e.g.: when pouring) and, in other cases, the external/internal rotation (e.g. when turning a key).

Discussion: In the present study, only the pronation/supination ARRoM was affected by the synosthose. The same methodology applied to shoulder pathologies might be more relevant to attest for the interest of the ARRoMs to estimate the consequences of UX pathologies on the patient's life. Regarding the choice of the daily life movements, some movements studied in the current investigation could be neglected since their range of motion is included in other movements. Conversely, other movements which have not been considered here might also be included. The choice of the daily life movements to analyse, based on the range of motion they induce on each UX degree of freedom, should then be pursued further. When done, a standardized protocol and standardized parameters, the angle ARRoMs, could be used to better characterize the effect of UX pathologies on patients' life.

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O043

A protocol to assess upper limb movements during stroke rehabilitation

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Summary: In stroke rehabilitation, upper limb exercises are important to regain independence but there is currently no established method for measuring movement of the upper limb. This work describes the preliminary development of a model using a 3D motion analysis system and low cost inertial sensors, and demonstrates its performance on a set of appropriate movement tasks. This will allow quantitative assessment of rehabilitation outcomes.

Conclusions: A 3D biomechanical model was developed to measure upper limb motion using both XsensTM (Motion Technologies, Netherlands) and ViconTM (Oxford Metrics, Oxford, UK) systems. Data from a small set of movements, including pronation/supination of the forearm, were collected with the wearable sensors and compared with the Vicon measurements. After analysis, good correlation (r = 0.85) was found in the angular graphs measured with Xsens compared with the ones computed with the Vicon system.

Introduction: 33% of stroke survivors are severely disabled due to loss of upper limb function [1]. Standard treatment by physiotherapy involves patients performing repetitive, daily exercises. The goal of this research was to validate a simple measurement technique, to obtain detailed analysis of upper limb joint motion performing standard movements involved in rehabilitation. This would inform patients and physiotherapists about progress, increasing the motivation of the patients to pursue their exercises, and improving consistency in assessment and outcomes.

Patients/Materials and Methods: A controlled trial was carried out to track and measure upper limb movements in three dimensions. The trial comprised six typical movement patterns [2], each repeated three times, to assess upper limb motion. A 12-camera Vicon (MX F40) system was used to capture the movements. 39 (9 mm) passive reflective markers were placed on the right and left upper limbs, the trunk, and pelvis. In addition, 5 Xsens sensors (3-D accelerometers, gyroscopes, magnetometers) were placed on the same segments (Figure 1); these were also tracked by Vicon through markers placed on the sensors. Relative motion of each segment was calculated using both systems, and the results compared.

Figure 1. Marker/Sensor placement.

Results: Initial results show a correlation (r = 0.85) between the pronation/supination angles measured by the Xsens system on the forearm segment and the angles generated by the upper limb model developed in Vicon (Figures 2, 3).

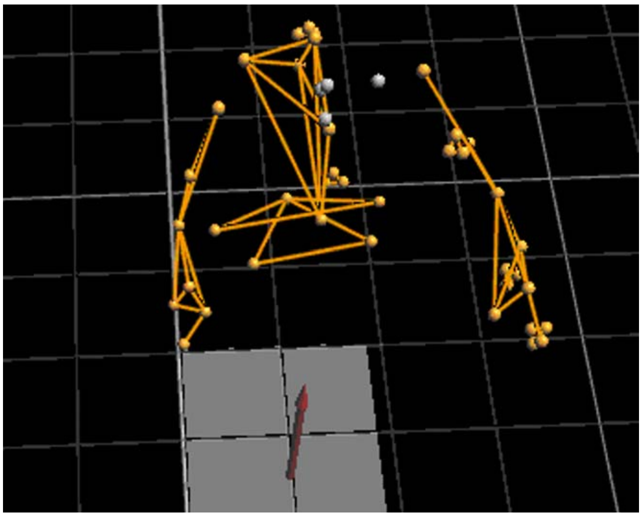

Figure 2. Upper limb model (in Vicon).

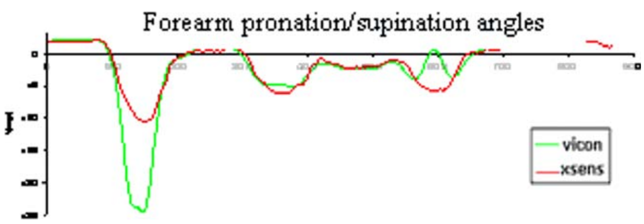

Figure 3. Forearm pronation/supination angles.

Discussion: Analysing the movement of the upper limb is difficult due to the variability and complexity of the mechanics available to complete any given task. Nonetheless, cyclic movement has shown to be clinically useful in assessing impairment and deviation from normal. Applying this repetitive method of analysis to the upper limb has allowed comparison between 2 measurement systems, with good agreement. This indicates the usefulness and reliability of the Xsens system to track movements making it a potential candidate to be integrated in a home-based rehabilitation system. Further validation of the Xsens graphs with the Vicon system is currently in process.

References

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O044

Changes in upper limb isometric strength and error tracking following training using functional electrical stimulation

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Summary: Based on existing motor control theory, an intervention involving a robot, ILC and FES was developed and tested on five chronic stroke patients. Improvements were seen in isometric strength and error tracking.

Conclusions: ILC mediated by FES enabled five chronic stroke subjects to accurately track a range of trajectories. Over time this related to an improvement in motor control reflected by increasing accuracy observed in unassisted tracking, and in isometric strength.

Introduction: Current opinion in motor learning, reinforced by clinical evidence, supports the use of FES and robot therapy to improve motor control [1–3]. ILC is a technique applicable to processes which repeatedly perform a task with a view to sequentially improving accuracy such as trajectory following in robots. The aim of this study is to test the feasibility of applying ILC to neurological rehabilitation.

Patients/Materials and Methods: 5 hemiplegic stroke subjects underwent screening tests, and baseline assessments including isometric strength. Subjects used a robotic workstation to track 2 dimensional trajectories, over 18 intervention sessions within a 3 month period. At the beginning and end of each intervention session the ability of the stroke subject to track four trajectories without any FES or robot assistance was assessed. During the treatment sessions, ILC was used to modulate the FES applied to their triceps muscles in terms of timing and amplitude to improve tracking performance, whilst encouraging a maximal voluntary contribution to the task. Assessments of isometric muscle strength in six directions from a mid position were repeated after the eighteen sessions and for two subjects after an additional seven sessions.

Results: Improvements in isometric strength were seen for all individual subjects after the intervention, with significant improvements for five out of six directions. Unassisted performance of the tracking tasks improved significantly for 3 out of the 4 tasks across the group. Subjects who performed poorly on the initial visit, showed the biggest improvements in tracking.

Discussion: Analysis of the variability of the results may assist in the identification of good responders. Future work with the existing system includes assessing the potential for use with other neurological conditions, such as cerebral palsy and incomplete spinal cord injury. A subsequent study will develop a system for reaching in three dimensions and include opening the wrist and hand using ‘Smart glove’ as a position sensor.

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Oral Session 8: Quality assurance

O045

Validity of the gait deviation index (GDI) calculated with non-native control data

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Summary: The validity of the GDI calculated from non-native control data is shown through comparisons with the Gillette Gait Index (GGI) and Gillette Functional Assessment Questionnaire (FAQ).

Conclusions: Preliminary findings from this study suggest that absolute GDI values calculated with different control data are not comparable.

Introduction: The GDI is a new measure summarising specific kinematic gait information into a single number. The GDI is the scaled difference between a subject's 15 ‘gait features’ (mutually independent joint rotation patterns) and a control data set [1]. To date, validation of the GDI has concentrated on comparisons of the GDI to the GGI and FAQ from a native data set [2]. Face validity on non-native data has been demonstrated through comparison with an observational gait scale [3] and pre/post operation results of 3 subjects [4]. The aims of this study were: to provide further evidence regarding the validity of the GDI calculated from non-native data; to investigate whether GDI values calculated with different control data can be compared.

Patients/Materials and Methods: Representative strides were identified from 143 subjects with Cerebral Palsy for whom both an FAQ level and kinematic data had been collected at SCH, between 2005 and 2008. The GGI was calculated for each subject using an internally developed program. The GDI was calculated using a spreadsheet supplied by Schwartz [2], using SCH control data ($n = 56$), and recalculated using supplied control data (Gc $n = 166$). As the GGI represents a distance squared, GGI values were transformed when comparisons with GDI were made: $GGI^* = \ln(\sqrt{GGI})$ [2].