Inter rater reliability of Strathclyde University Data Logging System (SUDALS) compared to a commercial data logger in recording the knee kinematics during the activities of daily living (ADL)

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INTRODUCTION
The rationale for a user-friendly system of flexible electrogoniometers has been previously established and the Strathclyde University data logging system (SUDALS) together with flexible electrogoniometers has been reported to be an accurate and reliable system for measuring the functional outcomes of the knee during various activities of daily living (ADL) [1]. However, prior to releasing the system for a routine clinical use, we decided to estimate the inter-rater reliability of the device by involving focus groups as part of the product development cycle [2] to obtain insight views on the clinical applicability of both the data acquisition systems for use with flexible electrogoniometer in measuring the knee kinematics during various ADL.

METHODS
Six health professional (3 physiotherapists and 3 research nurses) were trained in using both the data acquisition systems in conjunction with flexible electrogoniometers to collect data from two healthy male volunteers (ages 24 and 30 years) during various ADL’s such as level walking, getting in and out of a standard chair and deep squatting. The users were introduced to this study via standard operating procedures and a customised training CD. To eliminate the possibility of bias, it was ensured that all the six users did not have any previous experience of using the flexible electrogoniometers.

The system to be initially tested was randomly selected by the users and it was interfaced with the flexible electrogoniometer attached to the participants [1]. The subjects were then asked to perform the above mentioned ADL at their selected speed. Start and stop commands were given at the beginning and completion of each task and the event marking was taken into account by the FSR’s attached to the toes and heels of each subject and this information was used to select the start and end of the gait cycles of the activities recorded by the system. Following this, with all the sensors in-situ, the second system to be tested was interfaced with the sensors and the same procedure was repeated. All the data pertaining to the flexion/extension of the knee during ADL, recorded by both the systems were then downloaded to the PC and were further analysed.

RESULTS AND DISCUSSION
The data collected from SUDALS by all the six users from both the participant’s during the above mentioned ADL’s were filtered at the PC end using a 4th order low pass Butterworth filter with a cut-off frequency of 6 Hz. Also, the data obtained from each participant pertaining to each function were time normalised into 100 % points giving an angle versus percent of the movement trace. The same procedure was repeated for analysing the data collected using the commercially available system. The standard time normalized gait cycles of one of the participants obtained by SUDALS and commercial data logger during level walking by 3 different users are shown in figure 1to4. The inter-rater reliability of the results obtained from both the systems when used by different users on same participants on different occasions during various ADL’s was estimated using intra-class correlation coefficient (ICC) calculated using SPSS for windows (version 11). A ‘Two way random model – ICC [2,6]’ was used here in this study and the overall ICC values obtained for all the ADL’s performed by both the subjects are in the range of 0.8 to 0.99. The measurement error was also calculated using the relation; SEM = SD x √ (1-r), (where; SEM is the standard error of measurement, SD is the standard deviation and r is the reliability coefficient) for both the systems. Irrespective of the users, the SEM varied from 2° to 5° for activities such as level walking and squatting and for the activity of getting in and out of chair, the measurement error was slightly higher than 5°. Such errors could be the resultant of summation of errors due to the variability between the electrogoniometry measurements, which in turn can be due to the variability of the participants, sensors, the assessors attaching the electrogoniometers or due to the nature of the activity by itself [3, 4]. Nevertheless, the kinematic data collected from both the normal subjects, by all the assessors using both the data acquisition systems during all the ADL’s, seems to exhibit an overall good agreement in terms of the shape of the standard cycle curves of both the participants and the data is similar to those reported in the literature [1].

CONCLUSION
With few measurement errors due to the rater, participants and instrument variability, the overall flexible electrogoniometry system in conjunction with SUDALS showed good inter-rater reliability compared to the commercial system. By making use of standard protocols and by minimising the variability due to assessors and activities, flexible electrogoniometers together with the user-friendly data acquisition system can be used to assess the functional outcomes of the knee during ADL’s.
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REFERENCES
1. Indramohan.V.P et al, Validation of Strathclyde University data logging system (SUDALS); Journal of Medical Engineering and Technology, 33, 8, 650-655, 2009.