Implementing Gamification Techniques To Support Collection Of Longitudinal Kinematic Data For Use In A Clinical Setting

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***Abstract*— It is estimated that 30%-40% of medical interventions have no reported evidence base and another 20% of interventions delivered are ineffective, unnecessary, or cause harm. There is therefore a real need to quantitatively assess treatment effectiveness by providing clinicians with empirical data through real-time and longitudinal data collection, combined with data analytics.**

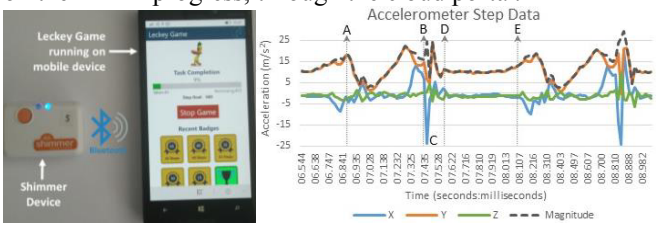
I. Introduction

Children with physical impairments, such as walking limitations, often require mobility aids or wheelchairs to compensate for these difficulties [1]. Physical mobility limitations, adversely affects the physical, cognitive and sensory development of a child, with adverse impacts on health and wellbeing [1]. Common limitations of physical motor disabilities are muscular strength, coordination difficulties and alterations in the gross and fine motor movements. [2]. Rehabilitative and assistive devices, such as mobility and postural aids, can restore or replace the loss of mobility caused by a disability. Nevertheless, it is estimated 30%-40% of medical interventions have no reported evidence base, and alarmingly, a further 20% of interventions delivered are ineffective, unnecessary, or may cause harm [3]. Currently, clinicians are under increasing pressure to provide evidence of the effectiveness of prescribed treatments and products. Many clinicians, however, do not have the time, skills or knowledge to provide this evidence. There is also very little published evidence of the effectiveness of mobility and postural aids and there is a lot of subjectivity around any evidence that is published. There is therefore a real need to provide clinicians with empirical data that evidences practice [3]. In addition, there is a need to quantitatively assess treatment efficacy, through real-time and longitudinal data collection, combined with data analytics.

II. Implementation

We consulted with a number of clinicians to determine what measures they use when treating a child with walking impairments. The advice they provided was to enable them to be able to view some gross measures of gait, recorded over a long term period outside of the clinic.

In order to gather the data, we created a gamified app that would collect accelerometer data and upload it to a cloud backend to allow clinicians to view, analyze and summarise the data. Leckey have a number of products that the developed gamification app will integrate with, to enable validation of the effectiveness of the product for the child. Figure 1.a shows the Shimmer (Shimmer 3, Shimmer research, Dublin) device connected via Bluetooth to a mobile app. When in use, the Shimmer device is attached to the child, either on the feet or lower back. The accelerometer data is transmitted in real-time to the app for processing. The number of steps was used as a metric for gamification. We use this metric to set goals and provide badges that are awarded when a goal has been achieved. The goals are set and updated by the clinician, based on the child's progress, through the cloud portal.



(A) (B)

Figure 1. (A) Shows the Shimmer device and a mobile phone running the Leckey Game app. The Shimmer device connects to the mobile app via Bluetooth. (B) Shows accelerometer data of 2 walking steps of the left foot, of an un-impaired adult. A: toe off. A to B: foot swing. C: heal strike. D to E: Left foot stationary, right foot moving.

When a session has been finished, the calibrated accelerometer data, with timestamps, is uploaded to the cloud backend where automatic analysis is carried out and summary information generated for the clinician to review. Figure 1.b. shows a sample of the accelerometer data from a Shimmer device attached to the left foot. From this data two distinct walking steps and the various stages of the footstep can be viewed, as annotated in Figure 1.b.

Future work will focus on developing the cloud portal to enable automatic analysis of the accelerometer data and provide a means for a clinician to review the child's progress. A trial will be undertaken with a cohort of children with walking limitations and clinicians.

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References

[1] J. Casey, L. McKeown, R. McDonald, and S. Martin, "Wheelchairs for children under 12 with physical impairments," *Cochrane Libr.*, no. 10, 2012.

[2] S. M. Montero and a Gómez-Conesa, "Technical devices in children with motor disabilities: a review.," *Disabil. Rehabil. Assist. Technol.*, vol. 9, no. 1, pp. 3–11, 2014.

[3] C. Imms, I. Novak, C. Kerr, N. Shields, M. Randall, A. Harvey, H. K. Graham, and D. Reddihough, "Improving allied health professionals' research implementation behaviours for children with cerebral palsy: protocol for a before-after study.," *Implement. Sci.*, vol. 10, no. 1, p. 202, 2015.