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An interactive exercise biofeedback Android application utilizing a single inertial measurement unit to support joint replacement rehabilitation.

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***Abstract*— Boomerang Ortho is an Android application developed with the aim to better support patients in their exercise rehabilitation program following total knee replacement. The use of a single inertial measurement unit (IMU) attached to the lower leg allows for classification of exercise technique, real-time biofeedback, and both self and remote monitoring of patient data. The prototype application for demonstration is currently undergoing pilot testing prior to an assessment of impact on clinical outcome.**

I. Background & Related Work

Joint arthroplasty is widely regarded as a successful intervention in the management of end-stage joint degeneration from osteoarthritis. Rehabilitation from this surgery begins in hospital and continues in the home environment with an emphasis on self-management. The majority of patients are given an exercise programme to do at home as part of their rehabilitation, yet without supervision, patients report poor technique or low adherence and therefore do not maximise their potential [1]. Previous work has assessed how IMUs can be used to classify exercise performance and accurately distinguish correct versus incorrect technique [2]. It has also been shown that using a single sensor does not reduce the accuracy of classification. This ability to accurately classify using a single sensor provides the basis of an application to provide real-time biofeedback through a tablet application for commonly prescribed exercises after knee replacement.

II. Design Features

Boomerang Ortho has been developed as an Android application for a tablet computer, with a single IMU (Shimmer), placed in a sleeve on the shank of the user, streaming via Bluetooth. An on-screen avatar mirrors the movements during the patient's exercises, repetitions are counted and feedback is provided at the end of the set of exercises regarding technique. Regular patient reported outcomes such as pain and mood are captured on every exercise session and can be tracked over time alongside adherence and rep-by-rep classification. Hence providing more meaningful and objective data in a timely manner to the clinician, allowing for data-driven decisions regarding patient care. The application also offers self-monitoring of progress to the user, and contains all the relevant educational material of the healthcare provider's choice, in both text and video format.

Figure 1. User setup with sensor placed on shin & avatar illustrated.

III. Application evaluation

The demonstration prototype application is being implemented in a clinical population of both total and unicompartmental knee replacement patients in a leading private hospital in Dublin. Initially this is in the form of a pilot study, evaluating usability and accuracy in a mixed-methods approach, with outcomes including the System Usability Scale [3] and user version of the mobile application rating scale (uMARS) [4]. Refinements will be made based on feedback from both clinicians and patients, and a real-world accuracy of classification will be known at this time. Following the development of a final prototype, it is expected that a wider deployment will take place evaluating the use of the application over a six-week period, investigating the impact on clinical outcome.

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