Feasibility of using the Leap Motion hand gesture sensor for tracking wrist fracture physiotherapy

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Abstract

Simple, repetitive physiotherapy exercises are required following a wrist fracture to restore function. However, failure to perform the exercises correctly and at the right frequency can affect the level of function restored. Despite this, the adherence to physiotherapy is poor. Here, we validate the accuracy of a low-cost hand gesture sensor for tracking wrist exercises. Our results highlight the potential for it to be used for patient guidance and feedback, thereby increasing adherence to physiotherapy.

Introduction

Distal wrist fracture is common with 71,000 adults estimated to sustain the injury each year in the UK[1]. Management can be surgical or non-surgical with subsequent immobilisation to allow healing. Physiotherapy following immobilisation of distal wrist fractures aims to regain range of motion, strength and functional activity[2]. Rehabilitation through a physiotherapist-led advice and exercise programme is known to improve functional activity, pain and patient satisfaction compared to no physiotherapy (natural recovery)[3]. Current management involves an initial physiotherapy appointment, followed by prescription of exercises to be performed by the patient at home. For this to be effective, patient engagement is required. However, currently there is no way of monitoring this.

The Leap Motion Controller (Leap Motion, Inc., CA, USA) is an infrared light detector developed as a means of hand gesture recognition[4]. The corresponding software applies algorithms to the sensor data detected from the hands and generates a 3D representation of contour, position and movement[5]. Current applications include gaming, education, maps and navigating the computer desktop. The technology lends itself to monitoring hand movement exercises used for wrist physiotherapy. However, no current research exists that investigates the feasibility and validity of using this technology.

This feasibility study aims to determine the possibility of developing a non-invasive and easy-to-use feedback device to measure frequency and accuracy of exercises used for rehabilitation following wrist fracture that patients can use at home. In particular, we investigate the use of the Leap Motion (LM), comparing the measured wrist joint angle in each plane to that measured by a Polhemus Liberty (PL) magnetic motion capture system (Polhemus, Inc., VM, USA). This is a high accuracy system with a quoted

positional root mean square (RMS) error of 0.76mm and an orientation RMS error of 0.15 degrees[5]. We hypothesised that the Leap Motion device would provide an accurate measure of frequency and trajectory of a variety of standard exercises used for rehabilitation following a wrist fracture.

Methods

Participants: Eleven healthy participants were recruited from staff and students of University of Warwick (Mean age: 30.7 years; 9 Male). Individuals at higher risk of injury from physical exertion: e.g. heart or respiratory problems, musculo-skeletal injuries, balance disorders were excluded from participation. All participants provided informed consent before continuing with the experiment.

Procedure: Participants were fitted with two active markers of the Liberty system using an elastic band; one marker placed at the back of hand and one placed on the forearm, 25mm back from the wrist joint. Sitting at a table, participants placed their arm into an arm-rest which moved freely with the exception of being fixed in the vertical direction. This assisted participants in keeping the arm stable over the Leap Motion sensor beam area whilst allowing the wrist to move freely. There were six movement types in total, performed in pairs totalling three conditions: 1). Flexion-Extension, 2). Pronation-Supination, 3). Ulnar-Radial deviation.

Participants moved smoothly between maximum angles of both movements, holding for approx. one second at the maximum and neutral positions (0 degrees joint angle). Each movement sequence was repeated five times within a trial. Five trials of each of the three conditions were performed, with the order of the conditions randomised across participants. Finally, participants completed the task for both left and right hands. This meant each participant completed 30 trials in total, with the experiment taking approximately one hour to complete. In addition to being able to request breaks at any point, participants were given a 2-3 minute break between each condition.

Analysis: The trajectory and peak angle of each movement were measured using the LM in synchrony with the PL motion capture system. We compare the mean and variability (standard deviation) of the peak angles within each trial. Results were statistically analysed using paired t-tests, to establish if there were any differences between the measures of the two systems.

Results

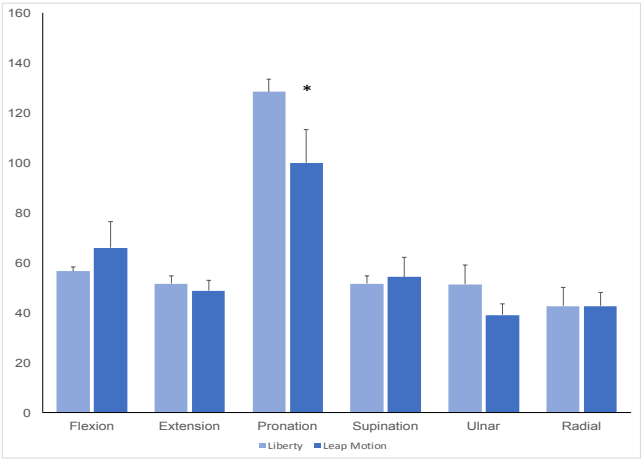

Figure 1. Comparison of mean peak angle measure over participants by Leap Motion infra-red sensor and Polhemus Liberty magnetic motion capture system. Only one movement type, Pronation, showed significantly different results (shown by *).

The mean peak angle measured by both the LM and PL systems matched closely, with all except one measure showing no significant differences (Pronation, p=.04). For this Pronation movement, we found that LM tended to underestimate the peak angle.

Discussion

This experiment has investigated the feasibility of using the LM sensor for accurately measuring a range of wrist exercises used for rehabilitation of function following wrist fracture. Initially, we investigated the ability to measure peak angle. This measure allows physiotherapists to monitor the change in range of motion of the wrist over time. In addition, identifying the peaks allows further measure of the number of repetitions the patient has performed. The LM performed well with measuring peak angle, but appeared to underestimate the Pronation measure. The most likely cause of this is that the algorithm loses track of the hand once it passes 90 degrees i.e. it is less able to fit the hand model to the image beyond this rotation. As this is effects only one type of movement, it is a minor limitation; future set ups could use two devices positioned perpendicular to each other to remedy this.

Conclusion

This study has shown that the low-cost Leap Motion sensor can accurately measure most wrist exercises used for physiotherapy. It is therefore a practical option for improving adherence to physiotherapy through the ability to monitor and provide feedback on exercise performance.

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