Development of a Wearable Motion Capture Suit and Virtual Reality Biofeedback System for the Instruction and Analysis of Sports Rehabilitation Exercises

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INTRODUCTION

Exercise therapy involves the practice of specific controlled body movements aimed at restoring musculoskeletal function and retraining optimal movement patterns. Prescription of sports rehabilitation exercises for athletes is aimed at restoring physical function following injury and/or performance enhancement for their particular sport. Exercise will usually be prescribed by a clinician or exercise scientist following an examination or treatment session and subsequently practiced supervised in the clinic. An athlete must typically rely on his/her memory or printed handouts as how to perform the unsupervised home exercise programme. Currently there is no method to ensure that the exercise programme is adhered to as advised and performed in the correct biomechanical manner. Clinicians must also rely on the athlete's self report to assess how often they performed the exercise programme. We have developed a virtual rehabilitation system designed to both guide and record an athlete as they perform their exercise programme to be used either in the clinic or home setting by an athlete.

SYSTEM DESIGN

Our virtual rehabilitation system has a full body motion capture suit integrated with a game engine designed to process this data for both real-time feedback and offline analysis. Nine Xsens inertial motion tracking sensors (Xsens Technologies, The Netherlands) were embedded in a lightweight suit using adjustable elastic straps along with one sensor fixed to the side of the head (Fig 1). All sensors are connected to a wearable hub which sends data to the game engine via bluetooth. The game engine has capacity to 1) record and store an expert profile for any exercise programme, 2) guide an athlete through an exercise using an avatar on screen for visual demonstration and audio instruction and feedback to correct inappropriate movements and 3) provide offline following exercise by examining the recorded movement capture data. The following case study will demonstrate how the offline analysis can be interpreted to assess an athlete current physical function.

Figure 1

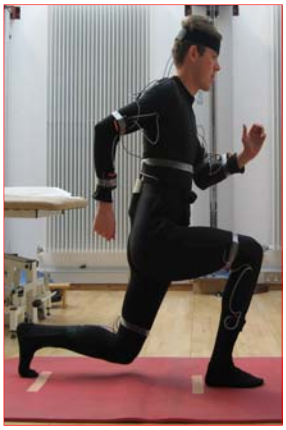


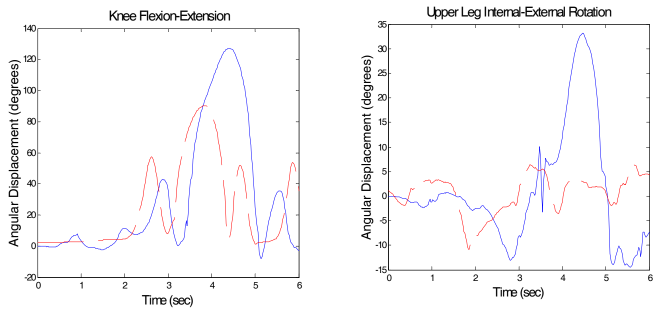
Figure 2

CASE STUDY

To demonstrate the offline analysis mode of the system we compared injured and non-injured athletes as they performed a lunge exercise (Fig 2). The injured athlete suffered a medial ligament injury to the right knee five weeks previous to testing and the non-injured athlete had had no history of injury to the lower limbs in the previous 2 years. Both athletes wore the motion capture suit and performed the lunges following calibration of the system. We examined the trunk, right thigh and right shank sensor data for offline analysis. From these we derived the knee flexion-extension, thigh internal-external rotation and trunk flexion-extension angular profiles.

RESULTS

Graphical representation of angular displacements during the lunge exercise are displayed below. These graphs demonstrate greater neuromuscular control in the non-injured subject through quicker progression and less postural deviation during this dynamic exercise.



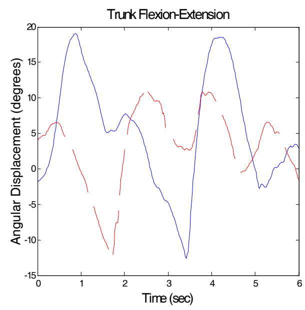
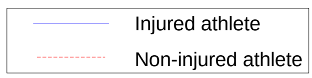


Fig. 3. Knee flexion, thigh internal rotation and trunk flexion are positive in the graphs.



CONCLUSION

The virtual rehabilitation system developed can have may benefits in the prescription of exercise therapy both in the supervised clinical setting and between treatment sessions as the athlete performs their unsupervised home exercise programme. Such a system could be used:

1) to provide biofeedback during the exercise session
2) to increase compliance with the exercise programme
3) as an objective measure of performance during exercise
4) to store exercise performance for offline analysis
5) to map performance progression over time

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