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A Soft Wearable Robotic Exoskeleton for Rehabilitation of the Frozen Shoulder

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Introduction
Adhesive capsulitis (or “frozen shoulder”), is a joint condition resulting in pain and reduction to range of motion (ROM). Contemporary treatments can be effective but currently suffer from a number of drawbacks, including: high cost, lengthy treatment; lack of specificity to each patient; and lack of consistent, repetitive treatment between clinics and therapists [1]. Researchers are thus working to combat these drawbacks by developing rehabilitation exoskeletons. Traditional exoskeletons however aren’t always suitable, being rigid and heavy. Soft robotics may be suitable to overcome all of the above problems, combining the best of robotics (consistency, specificity) while being affordable and wearable through lightweight, compliant materials and design.

Methods
A literature review on the current state of both soft robotics and the robotic rehabilitation field has been conducted. Important features and current capabilities of soft robots have been identified through comparison with traditional exoskeletons. This data will be used to choose both the methods of actuation and the control system (plus informing other design considerations) to be taken forward into a novel soft robotic design, the realisation of which will form the remainder of the project.

Results & Discussion
While electric actuated rigid exoskeletons were the most prominent of the previous generation due to their high power-to-weight ratio, their weight and noise makes them unsuitable for soft robotics. Pneumatic systems on the other hand forgo heavy motors and utilise compliant compression chambers, matching with the lightweight, wearable characteristics of soft robotics, as shown through O’Neill’s shoulder device [2]. Shape memory alloy (SMA) also looks promising [3], but requires further development by the field to be viable. Control systems have benefitted from the switch to soft robotics, allowing the development of sensing suits and lightweight sensors, with inertial measurement units (IMUs) receiving a lot of focus due to their affordability and adaptability.

Conclusion
A direction for the project has been presented, focusing on a pneumatic-based shoulder rehabilitation device, using IMUs as a primary sensor for feedback and control. There will be further detailed research into pneumatics, followed by CAD development to determine an appropriate and effective design. A prototype will be completed by the end of 2018.

References
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