

Developing a novel portable pressure bladder and magnetic tracking system for quantifying manual shoulder examination

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INTRODUCTION

Examination of the shoulder involves applying manual forces to the glenohumeral joint to assess stiffness, and laxity to estimate the level of, or potential for, instability. Current clinical standards are subjective, relying on clinician's "feel" of the joint of stiffness or compliance. There are currently no simple, clinical tools to quantify shoulder manual examination. This project aims to present the development of a clinically friendly, portable assessment tool to quantify manually applied forces to the shoulder during examination and manual therapy treatments.

METHODS

To monitor compressive forces applied by a clinician, a custom-shaped pneumatic pressure bladder attached to a molded thermoplastic "orthosis" is used, (Figure 1&2). To measure the glenohumeral displacements resulting from direct manual loading, two small magnetic tracking sensors are used. The bladder connects to an electronic pressure transducer via a vinyl tube. Pressure data are digitized by a USB-DAQ board using a laptop computer and synchronized with the sensor data. One sensor is attached to the root of the spine of the scapula, the second sensor is attached to the pressure bladder via the thermoplastic orthosis. The orthosis is designed to allow the clinician to perform the tests as naturally as possible. The subject is supine during testing which aids in stabilizing the scapular sensor against the scapula. Translational forces are applied perpendicular to the humerus at level of the humeral head to cause glenohumeral displacement along different cardinal planes (Figure 2). LabView graphical programming language compatible with both Mac and PC computers was used to create a clinician friendly interface using buttons, pull down menus and pop-up dialogs to allow the force and resulting motions to be recorded and analyzed. *Clinician Input:* To aid in the hardware and software design, demonstrations of the system at various stages of development were given to three experienced clinicians and their reactions and suggestions solicited. Their responses provided guidance in subsequent design iterations for both hardware and software and helped to define limitations of the system and how it would be used.

RESULTS AND DISCUSSION

To test the synchronization of displacement and pressure data, a stiffness calibration device was constructed (Figure 3) which consists of a spring loaded plunger with mounting points for the magnetic sensors to monitor compression of the spring. The operator compresses the device at the top using the hand-held pneumatic bladder. Stiffness is computed from the slope of the force vs. displacement response. Tests indicate that the calculated and actual stiffness are highly correlated suggesting excellent criterion validity, with repeatability within 2%.

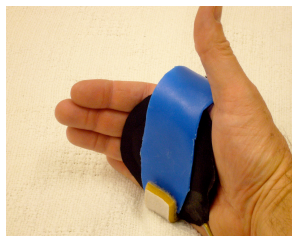


Fig 1. Custom-shaped pneumatic pressure bladder for compressive forces assessment

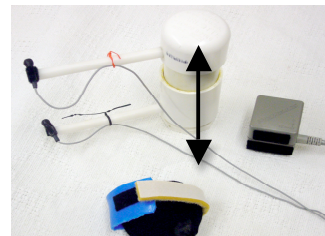


Fig 3. Spring loaded calibration device with two sensors. Arrow indicates loading direction.

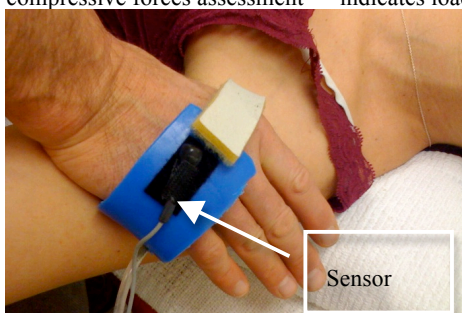


Fig 2 Position for testing posterior translation of the humerus head on the glenohumeral joint.

Figures 4a,4b,&4c, demonstrate the force displacement behavior of three subjects for one common test (posterior drawer test) The calculated stiffness of the normal shoulders of three subjects were similar at 3.10, 3.14 And 3.58 N/mm.

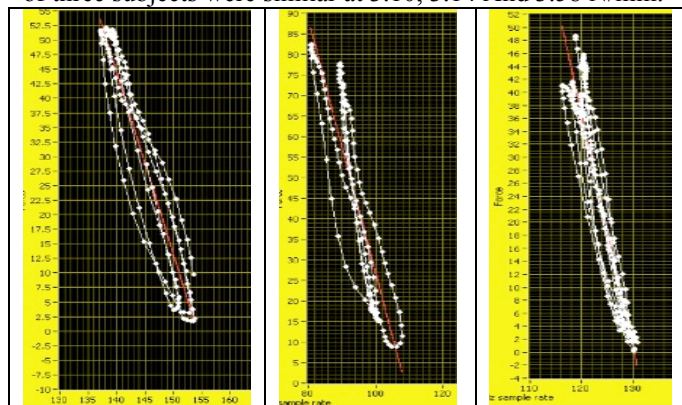


Fig.4a,b,c Force (Y) vs displacement (X) results for three normal shoulders

CONCLUSIONS

The bladder force sensor design has the advantages of being low cost, with customizable shape, conformable to the examiner's hand, and responds to compressive forces only. Preliminary results with limited subjects & clinician input suggest strong clinical application potential. Our next step includes recruitment of patients with shoulder impairments matched to normal controls to assess the ability of shoulder stiffness measures to discriminate between normal and pathological shoulders. This will permit computation of tissue stiffness, a fundamental aim of the project

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