

THE DEVELOPMENT OF A DEVICE TO OBJECTIVELY MEASURE KNEE JOINT STIFFNESS

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INTRODUCTION

Stiffness of the joints subjectively can be described as resistance to movement, slowness in the mornings or after staying in a fixed position for a long period of time [1,2]. Objectively, stiffness can be defined as a resistance to motion measured within a normal range and plane of function [3]. With respect to knee joint stiffness, it still remains a significant topic of attention. It is an important clinical sign of musculoskeletal pathology, which if objectively quantified, may also prove a clinically relevant outcome measure for evaluating the efficacy of various rehabilitation approaches.

A cost effective knee joint stiffness measurement apparatus that incorporates a 'Torqsense' Rotary Torque Transducer has been designed and developed. This project aims to evaluate this device by measuring both active and passive torque generated at the knee joint.

METHODS

Modifications were applied to the knee stiffness device (KSD) to improve its aesthetics, its ergonomics and its safety from an operator and participant perspective (Figure 1). The departmental ethics committee approved the design and development of the device. A pilot study was designed using one subject to validate the device before any subject and patient recruitment. The pilot project was designed to investigate the use of 'Torqsense' technology within a clinical setting where the goal was to obtain an effective and objective measure of the active and passive mechanical function of the knee during flexion and extension. In particular, the cost effective device was validated by (i) measuring active knee torque at fixed knee joint positions during opposed knee flexion or extension, and (ii) measuring passive knee torque over a set range of motion (ROM) – 0° to 80°. Knee joint stiffness was calculated from the resultant torque-joint angle curve.

One subject participated in the preliminary evaluation. The subject wore on their right limb a brace to control knee joint position and ROM. The knee brace was strapped on to the subject's knee and not attached to the KSD. The test began with a warm up session consisting of 20 repetitions of full knee flexion / extension at a self generated speed to ensure the knee ligament and soft tissues were preconditioned before the commencement of the experiment. This was followed by passive and active knee torque measurements using the KSD. Two trials of passive knee flexion / extension were performed. Each trial consisted of 1 set of 5 cycles of passive knee flexion / extension. Between trials the knee brace was removed, reassembled and strapped on to the limb. This was followed by the performance of two trials of active muscle isometric strength measurement resisting knee flexion and knee extension at 80° respectively. Each trial consisted of 1 set of 5 cycles. Each cycle consisted of an active muscle isometric strength measurement test lasting 10s. Between trials the knee brace was removed,

reassembled and strapped on to the limb. Trials and cycles were compared. The data was then evaluated based on consistency of measurement (i.e. trial versus trial and cycle versus cycle comparisons).

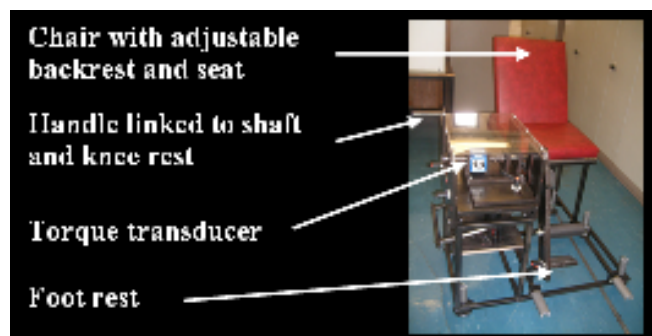


Figure 1: A knee joint stiffness testing apparatus.

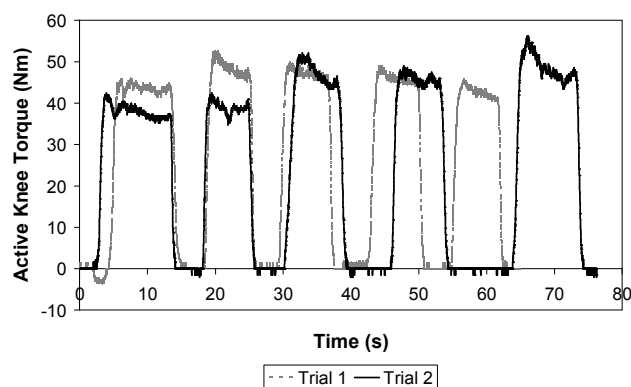


Figure 2: Active knee torque data sample from subject A with the knee fixed at 80° during opposed knee extension.

RESULTS AND DISCUSSION

Similar patterns of movement were observed between trials for both active and passive knee torque measurements. The passive knee torque measurements were small. Based on the number of cycles and trials the active knee torque measurements (Figure 2) on average (SD) were 48.75 (2.83) Nm and 48.44 (6.05) Nm respectively. While the methodology seems sound, the knee stiffness measurements were low with a difference between trials of 0.05 Nm/deg. The pilot study indicate the KSD has potential as a functional outcome measuring tool, however, more work is required to improve its accuracy and consistency of measurement before control and patient groups can be studied. Furthermore, the KSD will need to be validated against other methods of assessment.

REFERENCES

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