SECOND GENERATION DEVICE FOR ACTIVE AND PASSIVE EVALUATION OF PROPRIOCEPTION

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ABSTRACT

This paper presents a 2nd generation proprioception device for use in the evaluation of normal, pathologic and repaired / rehabilitated shoulders. This device is designed to be portable, inexpensive and easy to use.

INTRODUCTION

This report presents a second-generation proprioception evaluation device. Proprioception is the ability to know where a section of the body is in the absence of cues such as vision or feel. Of particular interest clinically is the shoulder, which can normally be rotated accurately without having to look at the arm. This ability to know where the arm is rotationally and move it to a desired position is known to decay due to injury. The success or surgery and / or rehabilitation has been monitored by evaluating shoulder proprioception. Athletes are another significant pool of subjects, as there is the thought that a reduction is proprioception ability is an early effect of shoulder problems in pitchers, quarterbacks, etc.

The evaluation of shoulder proprioception may be broken into two general categories: Active motor rotation to determine the threshold to detection of passive arm movement (TTDPM) and passive motor rotation allowing subject position re-positioning. Both systems generally place the upper arm horizontally and the lower arm vertically, with the subject's hand or forearm being held on a positioning strut. The forearm is then pivoted, producing a rotation of the shoulder through the glenohumeral joint. In the active motor rotation mode, the device produces an arm rotation of a set angular velocity. The subject then pushes a button when motion is sensed, and the angle of motion recorded (TTDPM). In the passive monitoring mode, the arm is rotated to a set position and returned to the initial position (position re-position). The subject then rotates to the arm to as close to the set position as they are able to, and the difference in angles are monitored.

The bulk of current devices for this usage are bulky, often modified from Cybex ® or similar machine. It is the desire of the clinicians and physical therapists to have an inexpensive device that can be moved from the clinic to the athletic center or even the playing field. The device should be able to perform in either the active or passive modes as noted above. The mechanism of usage should be easily taught so many operators can use the device. As always, low cost is important. As important is the noise and vibration level of the device, as there must be no external cues for the subject to follow. Ideally, the device should be of use on subjects of a wide range of weights, and have the ability to monitor other joints than simply the shoulder (particularly the knee).

This paper presents the second-generation of a portable, inexpensive, and easy to use proprioception device that can be used on the shoulder or knee, as well as other joints. It is quiet and has very low vibration, and can evaluate proprioception in either an active or passive mode.

FIRST GENERATION DEVICE:

This device consists of a 16" X 16" X 16" metal frame mounted on a table. A stepper motor is attached via a belt to a 3/4" diameter shaft that extends beyond two sides of the box. The motor is designed to work in one direction, so the two ends of the shaft are in place for the right and left arms of a subject.

The optimal rotational speed of the motor is 1.8 degrees / second. At speeds of 2.5 deg/sec and above, unacceptable levels of sound and vibration were evident. At speed below approximately 1 deg/sec, the motor became more difficult to control accurately.

The holding torque of the motor is 3.3 lb-in. This torque serves to hold the subject's arm during the testing without movement due to the arm's weight. This value is adequate for most subjects, but not for heavy subjects. This torque also limits the usefulness for other joints (such as the knee).

As a custom device, the interface was built specifically to link this device to a desktop PC, and does not lend itself to ease of use. The communication device requires computer software specific to the device, and has limited potential for modification.

The device is designed solely for active testing, during which the motor rotates the arm and subject stops the motor when motion is sensed. There is no passive evaluation of arm motion available.

SECOND GENERATION DEVICE

The new device being presented has a number of significant advances as compared to the first generation. These improvements are both in operations similar to the first generation device and in the realm of additional uses.

The device will use the same mounting frame, which is being attached to a movable platform. The new motor operates in either direction, so only a single ended shaft is required, reducing the bulk and making the device easier to use in the clinical setting.

The new motor can operate quietly from less than 0.001 deg/sec to over 400 deg/sec. The device can be operated well beyond these limits with further adjustments to the drivers. This allows a wide range of rotational speeds to be applied to the arm, and extends the operational usage to other joints such as the knee that require higher rates of rotational speed. The low noise will make sound and vibration isolation easier. This is critical, as any cue might alert the subject to device motion.

The holding torque for the new motor is over 320 lb-in so there should be no slippage, even for subjects with heavy arms. This holding torque is also reasonable when evaluating knee proprioception.

A rotary encoder will be attached to the shaft, with a sensitivity of 0.144 degrees. The device will monitor speed, angle and time. This will monitor the accuracy of the stepper motor in the active mode. The encoder will also be used for passive analysis of proprioception. The stepper motor will rotate the joint to a set position and then return to the initial position. The shaft will then be allowed to freely rotate as the subject attempts to rotate the joint to the "set" position. The encoder will record the initial and set positions as well as the final position selected by the subject.

The new control system is based on LabVIEW and a laptop computer interface card. These will allow for rapid and easy modification of the device operation as well as producing an easy to use desktop interface for the operators. The device will be able to be easily transported to sites outside the clinic.

As this abstract is being written, the device is in its final stages of construction, and reports of its usage will be reported on during the presentation.

DISCUSSION AND CONCLUSIONS:

The 2nd generation proprioception device will initially be used to evaluate subjects recovering from shoulder surgery. Based upon this work, modifications will be made to optimize the device. The new device will then take its place as the tool of choice for proprioception studies both inside the Orthopaedic clinic and at other sites.

The new proprioception device is a significant improvement on the original device. It will accurately monitor active proprioception at speeds adequate for both shoulder and knee studies where a subject is asked to stop the device when motion is first noted (TTDPM). Passive motion will also be tested, with the device recording the ability of a subject to repeat a specific motion (position – reposition). The low noise and vibration levels of the new device will make it easier to isolate the subject from external cues to motion. Finally, the new computer interface will allow for portability and ease of use for those expected to be using the device.