

Ranges of motion as basis for robot-assisted post-stroke rehabilitation

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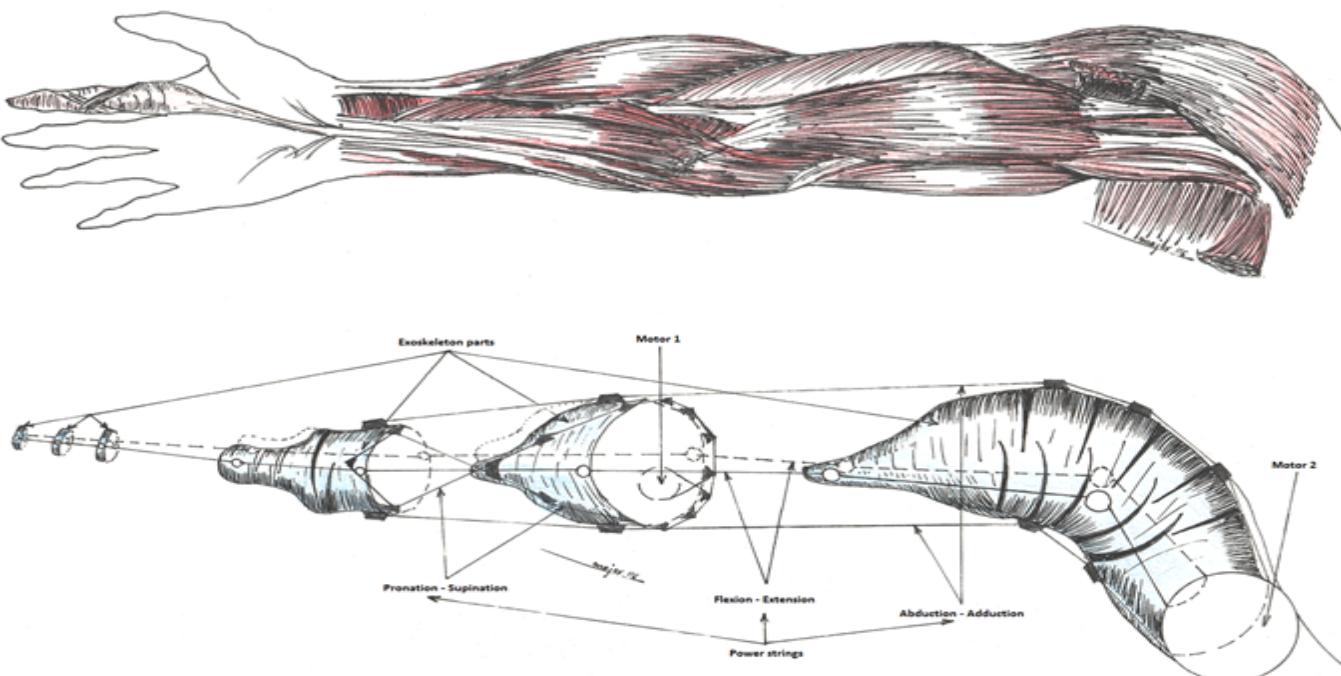
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Conceptual Model Proposal

Graphic 1s.

The first image illustrates the structural complexity of the human upper limb. The muscles and ligaments are omitted at the level of the hand given the complexity of the structure. The second image depicts a simplified imaginary exoskeleton-like structure, the main movements being assured by continuous power strings with the help of two electric motors. The muscular and bony structures are used as an underlying basis for the parts of the exoskeleton. Further strings might be added for the other fingers and additional movements, and a glove-like covering layer, which masks and conducts the strings.



Materials and method

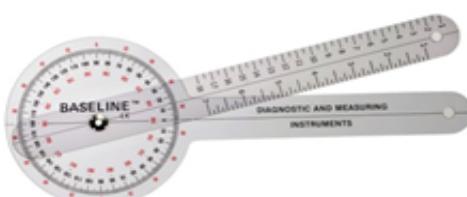


Fig. 1s. The goniometer was used to assess the angle of shoulder flexion, extension, abduction, adduction, elbow and wrist flexion and extension, forearm pronation-supination and flexion of the metacarpal-phalanx joint of the index.

Stepwise presentation of the measuring process

Fig. 2s – Shoulder abduction: Patient stands in front of the clinician with the upper limb in neutral position. The fulcrum of the goniometer is placed on the head of the humerus, the stationary arm is parallel to the sternum, and the moving arm is aligned with the midline of humerus. Then the patient abducts his upper limb.

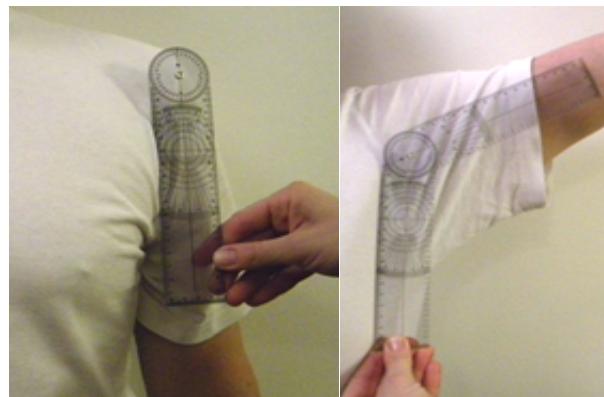


Fig. 3s – Shoulder extension: Patient in neutral position, the fulcrum of the goniometer is placed on the head of the humerus, the stationary arm is parallel with the mid-axillary line, and the moving arm is aligned with the midline of the humerus. The patient extends his upper limb.

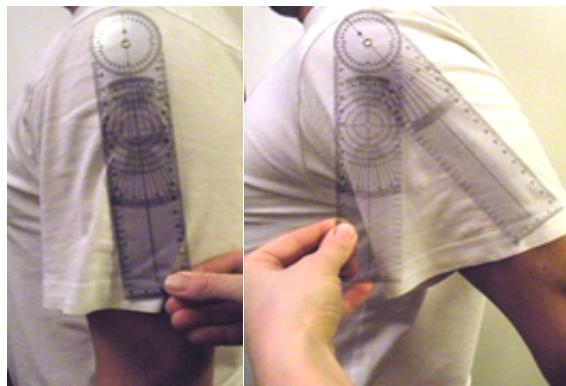


Fig. 4s – Shoulder flexion: The fulcrum of the goniometer is placed on the humeral head, the stationary arm is parallel with the mid-axillary line and the moving arm is aligned with the midline of the humerus. Patient flexes his arm.



Fig. 5s – Shoulder adduction: Neutral position, the examiner's hand is on the posterior aspect of the shoulder in order to stabilize the extra movements of the trunk. Patient will adduct his upper limb, the placement of the goniometer being the same as for abduction



Fig. 6s – Elbow flexion: Shoulder in 90° flexion, upper limb in supine position. The fulcrum over the lateral epicondyle of the humerus, the stationary arm of the goniometer parallel with the humerus, the mobile arm parallel with radius, then the patient flexes the elbow.

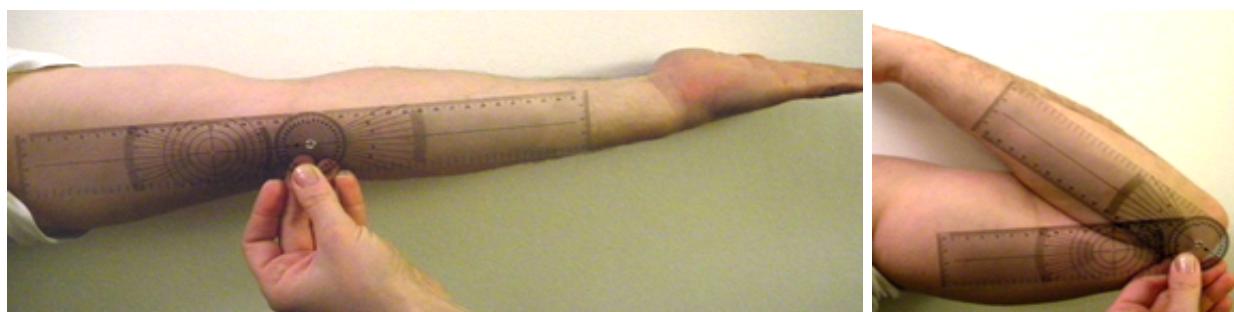


Fig. 7s – Forearm pronation: Elbow flexed to 90°, forearm in half-supine position and the patient holds an object in his hand (ex. Pencil). The fulcrum is lateral and proximal to the ulnar styloid process. The stable arm is parallel with the humeral mid-line and the mobile arm with the mid-line of the pencil at the end of pronation.

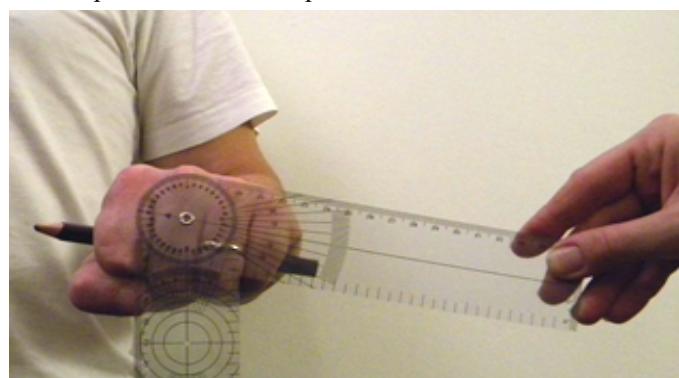


Fig. 8s – Forearm supination: Elbow flexed to 90°, forearm half-supine and the patient holds an object. Fulcrum is lateral and proximal to the ulnar styloid process. The stable arm is parallel with the humeral mid-line, and the mobile arm with the mid-line of the object at the end of supination.



Fig. 9s – Wrist extension: Elbow flexed to 90°, forearm in prone position. The forearm is stabilized and the fulcrum is placed on the olecranon, the stationary arm aligned with the ulna, the mobile arm with the lateral mid-line of the fifth carpal. The patient extends his wrist.



Fig. 10s – Wrist flexion: Elbow flexed to 90°, forearm in prone position. The forearm is stabilized and the fulcrum is placed on the olecranon, the stationary arm aligned with the ulna, the mobile arm with the lateral mid-line of the fifth carpal. The patient flexes his wrist.

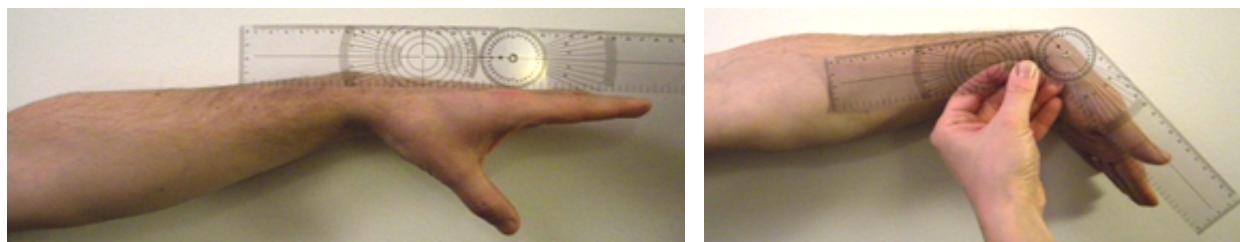


Fig. 11s - Metacarpophalangeal flexion - Forearm in prone position. The wrist is stabilized to avoid extra movements. The fulcrum is placed over the dorsal aspect of the metacarpophalangeal joint. The stationary arm is parallel with the mid-line of the metacarpal and the mobile arm is placed over the dorsal mid-line of the proximal phalanx. The patient flexes the finger.

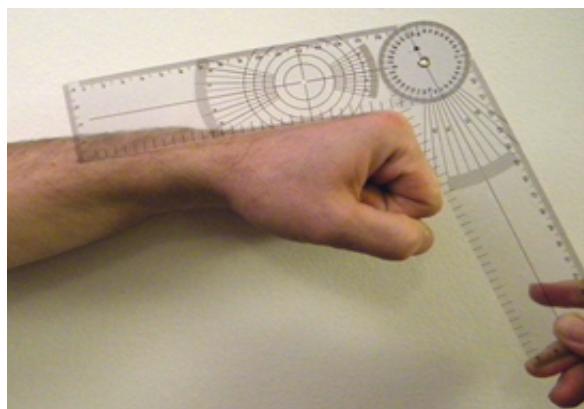


Fig. 12s - Proximal interphalangeal flexion - Forearm in prone position. The wrist is stabilized to avoid extra movements. The fulcrum is placed over the dorsal aspect of the proximal interphalangeal joint. The stationary arm is parallel with the mid-line of the first phalanx and the mobile arm is placed over the dorsal mid-line of the second phalanx. The patient flexes the two distal phalanges.

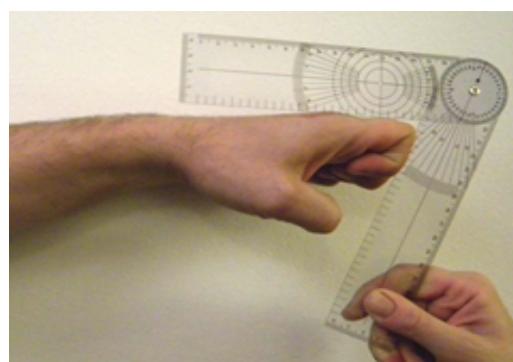
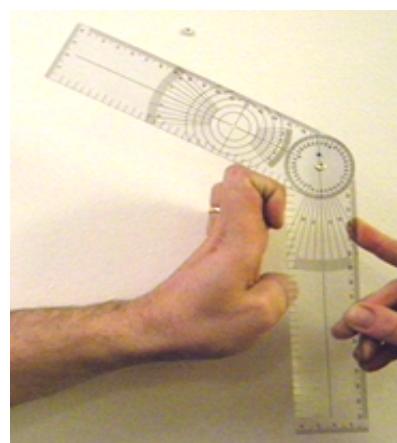
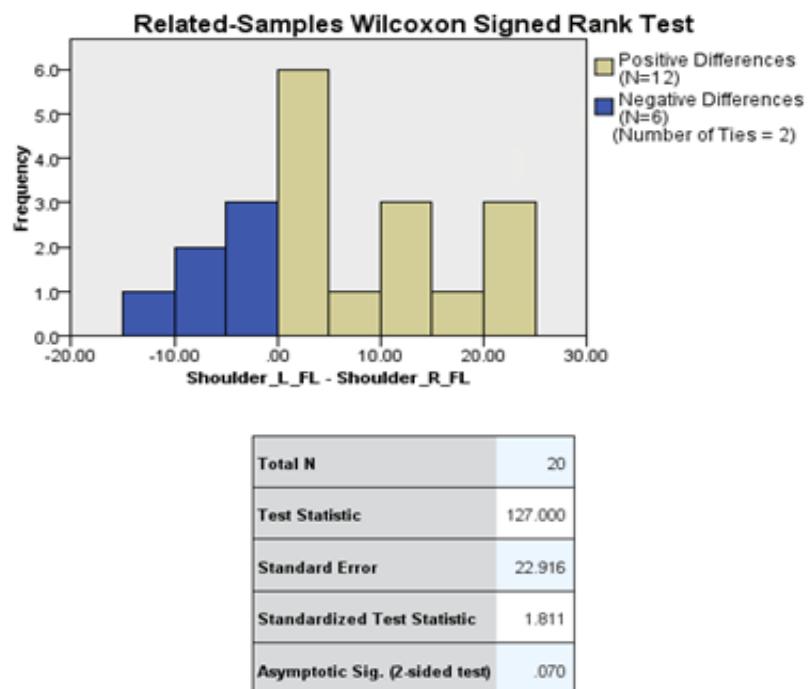


Fig. 13s - Distal interphalangeal flexion - Forearm in prone position. The wrist is stabilized to avoid extra movements. The center fulcrum is placed over the dorsal aspect of the distal interphalangeal joint. The stationary arm is parallel with the mid-line of the second phalanx and the mobile arm is placed over the dorsal mid-line of the third phalanx. The patient flexes the distal phalanx



Example for the data distribution of the measured angles



Graphic 2s.

Representation of the comparative distribution of angles for shoulder flexion; In the box below there's the p value returned by the Wilcoxon test