**Supplementary Table S1: COSMIN checklist, Box B, reliability (copied from [www.cosmin.nl](http://www.cosmin.nl); the cosmin checklist with a 4-point rating scale)**

### Box B. Reliability: relative measures (including test-retest reliability, inter-rater reliability and intra-rater reliability)

<table>
<thead>
<tr>
<th>Design requirements</th>
<th>excellent</th>
<th>good</th>
<th>fair</th>
<th>poor</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Was the percentage of missing items given?</td>
<td>Percentage of missing items described</td>
<td>Percentage of missing items NOT described</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Was there a description of how missing items were handled?</td>
<td>Described how missing items were handled</td>
<td>Not described but it can be deduced how missing items were handled</td>
<td>Not clear how missing items were handled</td>
<td></td>
</tr>
<tr>
<td>3. Was the sample size included in the analysis adequate?</td>
<td>Adequate sample size (≥100)</td>
<td>Good sample size (50-99)</td>
<td>Moderate sample size (30-49)</td>
<td>Small sample size (&lt;30)</td>
</tr>
<tr>
<td>4. Were at least two measurements available?</td>
<td>At least two measurements</td>
<td>Only one measurement</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Were the administrations independent?</td>
<td>Independent measurements</td>
<td>Assumable that the measurements were independent</td>
<td>Doubtful whether the measurements were independent</td>
<td>Measurements NOT independent</td>
</tr>
<tr>
<td>6. Was the time interval stated?</td>
<td>Time interval stated</td>
<td>Time interval NOT stated</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Were patients stable in the interim period on the construct to be measured?</td>
<td>Patients were stable (evidence provided)</td>
<td>Assumable that patients were stable</td>
<td>Unclear if patients were stable</td>
<td>Patients were NOT stable</td>
</tr>
<tr>
<td>Number</td>
<td>Question</td>
<td>Time interval appropriate</td>
<td>Doubtful whether time interval was appropriate</td>
<td>Time interval NOT appropriate</td>
</tr>
<tr>
<td>--------</td>
<td>--------------------------------------------------------------------------</td>
<td>---------------------------</td>
<td>-----------------------------------------------</td>
<td>-------------------------------</td>
</tr>
<tr>
<td>8</td>
<td>Was the time interval appropriate?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Were the test conditions similar for both measurements? e.g. type of administration, environment, instructions</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Were there any important flaws in the design or methods of the study?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Statistical methods</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>for continuous scores: Was an intraclass correlation coefficient (ICC) calculated?</td>
<td>ICC calculated</td>
<td>ICC calculated but model or formula of the ICC not described or not optimal. Pearson or Spearman correlation coefficient calculated WITH evidence provided that no systematic change has occurred</td>
<td>No ICC or Pearson or Spearman correlations calculated</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Pearson or Spearman correlation coefficient calculated WITHOUT evidence provided that no systematic change has occurred or WITH evidence that systematic change has occurred</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>for dichotomous/nominal/ordinal scores: Was kappa calculated?</td>
<td>Kappa calculated</td>
<td></td>
<td>Only percentage agreement calculated</td>
</tr>
<tr>
<td></td>
<td>for ordinal scores: Was a weighted kappa calculated?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>------------------------------------------------------</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>Weighted Kappa calculated</td>
<td>Unweighted Kappa calculated</td>
<td>Only percentage agreement calculated</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>Weighting scheme described</td>
<td>Weighting scheme NOT described</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Supplementary material: measurement protocol by E.A.A Rameckers and K.J.F.M. Dekkers

Protocol “measurement of Muscle Strength, Range of Motion, spasticity for the upper extremity”.
E.A.A. Rameckers PhD
K.J.F.M. Dekkers PhD Candidate
Version V3, translated version
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Introduction

This protocol is developed by dr. E.A.A. Rameckers, pediatric physical therapist and researcher, working at Adelante rehabilitation centre. The goal of this protocol is to standardize the upper limb and hand measurements in children with Unilateral Cerebral Palsy. By standardizing the measurements, the outcomes of the measurements can be used for research.
Overall protocol
This standardized protocol with detailed descriptions of all procedures and measurements must be used for all measurements. Before using this protocol, you must perform a training of 4 hours with Rameckers PhD and/or Dekkers PhD Candidate. Before every test moment, it is recommended to study and practice this protocol.

Prior to testing, the following items must be measured/determined:
- Body weight, with a calibrated weighting scale.
- Total length with a soft tapeline.
- Length of the upper arm, front tip of the acromion - epicondylus medialis, with a soft tapeline.
- Length of the lower arm, proximal edge of the radial head – distal edge radius. with a soft tapeline.
- Length of the hand, middle of the line between distal edge radius/ulna - distal tip middle finger, with a soft tapeline.
- MACS level, based on the classification used by the child's neurologist or paediatrician.
- GMFCS level, based on the classification used by the child's neurologist or paediatrician.

For each measurement, the child is seated in an upright position in a chair with back support and armrests. Feet are placed on the floor or on a footrest.
For all measurements, the armrests of the chair are used to support the arm while testing.
Initial posture is neutral position (zero degrees) in the wrist joint and 90 degrees flexion in the elbow joint (if possible).

Both the affected hand (AH) and non-affected hand (NAH) are measured. NAH is measured before the AH.
Each measurement is performed three consecutive times. Between each measurement, the child must have at least 30 seconds of rest.
The deviation between the outcomes of the three measurements needs to be within 25% difference (of the highest score), to avoid measurement errors. If a deviation >25% occurs, a fourth measurement is needed, and the best three of the four measurements are noted.

By verbal encouragement, the child is stimulated to deliver maximum muscle strength in 4-5 seconds. The verbal encouragement is “hard, harder, hardest”, in a timespan of +3-4 seconds. After 1-2 seconds of delivering maximum muscle strength, the comment “stop” is given to the child.
Active Range of Motion (AROM), Angle of Catch, passive range of motion (PROM) measurements

AROM, PROM and the Angle of Catch are measured according to “Handleiding standaard lichamelijk onderzoek bij kinderen met een centraal motorische paresis”. See this book for a detailed description of the measurements.

Isometric Arm Strength

The Hand-Held Dynamometer (HHD) it is used to get an exact registration of the maximum isometric muscle strength of relevant muscle groups which are used in most daily activities, like holding and transferring objects.

**Instrument:**
Hand Held Dynamometer, type microfet 2 (Hoggan Scientific, LLC, Salt Lake City UT, USA).

![Hand Held Dynamometer](image)

**Method:**
The make method is used in which the child provides maximal effort against a stationary measurement instrument.

**Measurements:**
- Wrist extension with extended fingers
- Wrist extension with flexed fingers
- Wrist flexion
- Elbow flexion
- Elbow extension

Note: The HHD and the joint may not move during the measurement.

Protocol Measurement of Muscle Strength, Range of Motion, spasticity for the upper extremity
E.A.A. Rameckers PhD, K.J.F.M. Dekkers PhD Candidate, Version V3, translated version, Adelante and Revant Rehabilitation Center, The Netherlands
**Wrist extension with extended fingers**

**Goal:** measuring maximum isometric muscle strength of the extended finger and wrist extensors muscle groups.

**Initial posture of the child**
Forearm is resting on the armrest, arm in pronation. The hand and wrist hanging over the edge of the armrest (elbow ± 90 degrees flexion, wrists 0 degrees).

**Initial posture of the tester**
Tester is in standing position, with the HHD in 1 hand and the other hand is fixating the forearm of the child on the armrest.

**Placing of the HHD:**
The HHD is placed on the dorsal side of the hand, at approx. 1/3 of the dorsal side of the hand (one finger proximal of the MCP).
Wrist extension with flexed fingers

**Goal:** measuring maximum isometric muscle strength of the flexed finger and wrist extensors muscle groups.

**Initial posture of the child**
Forearm is resting on the armrest, arm in pronation. The hand and wrist hanging over the edge of the armrest (elbow + 90 degrees flexion, wrists 0 degrees).

**Initial posture of the tester**
Tester is in standing position, with the HHD in 1 hand and the other hand is fixating the forearm of the child on the armrest.

**Placing of the HHD:**
The HHD is placed on the dorsal side of the hand, at approx. 1/3 of the dorsal side of the hand (one finger proximal of the MCP).
Wrist flexion

Goal: measuring maximum isometric muscle strength of the wrist flexor muscle groups.

Initial posture of the child
Forearm is resting on the armrest, arm in pronation. The hand and wrist hanging over the edge of the armrest (elbow ± 90 degrees flexion, wrists 0 degrees).

Initial posture of the tester
Tester is in sitting position, with the HHD in one hand, which is resting on the knee of the tester. The foot of the supportive leg must be on the ground or on a step. The other hand is fixating the forearm of the child on the armrest.

Placing of the HHD:
The HHD is placed on the palmar side of the hand at approx. 1/3 of the palm (one finger proximal of the MCP).
Elbow flexion

Goal: measuring maximum isometric muscle strength of the elbow flexor muscle groups.

Initial posture of the child
Forearm is resting on the armrest, arm in supination. When this position is not possible, place the arm in maximal supination. The hand and wrist hanging over the edge of the armrest (elbow + 90 degrees flexion, wrists 0 degrees).

Initial posture of the tester
Tester is in standing position, with the HHD in both hand and an elbow fixating the shoulder of the child on the backrest.

Placing of the HHD:
The HHD is placed on the palmar side of the forearm, approx. three fingers proximal of the wrist-joint.
Elbow extension

**Goal:** measuring maximum isometric muscle strength of the elbow extensors muscle groups.

**Initial posture of the child**
Elbow is resting on the armrest, arm in pronation. The forearm, hand and wrist hanging over the edge of the armrest (elbow +- 90 degrees flexion, wrists 0 degrees).

**Initial posture of the tester**
Tester is in sitting position, with the HHD in 1 hand which is resting on the knee of the tester. The foot of supportive leg must be on the ground/step. The other hand is supporting the elbow. Elbow fixating is an option if the child is lifting the elbow during testing.

**Placing of the HHD:**
The HHD is placed on the palmar side of the forearm, approx. three fingers proximal of the wrist.

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*Protocol Measurement of Muscle Strength, Range of Motion, spasticity for the upper extremity*

E.A.A. Rameckers PhD, K.J.F.M. Dekkers PhD Candidate, Version V3, translated version, Adelante and Revant Rehabilitation Center, The Netherlands
Isometric Grip and pinch Strength Measurement (E-Link system)

With the -link Evaluation System, the isometric grip and pinch strength is measured, which are used in a lot of upper extremity activities, like grasping, holding and transferring (small) objects.

**Instrument:**
Biometric E-Link Evaluation System (Biometrics Ltd, Gwent UK).

**Measurements:**
- Grip strength
- Pinch strength

**Notes**
- Before every set of measurements, it is necessary to calibrate the E-link by:
  - Perform a zero-level at an unloaded grip or pinch dynamometer
  - Set the setting to kgs.
- Store the measurements on the E-link computer AND on the scoring form!
Grip Strength

**Goal**: measuring maximum isometric grip strength.

**Initial posture of the child**
Forearm is resting on the armrest, arm in neutral position (0 degrees pro-supination). When this position is not possible, place the arm in maximum supination. The hand and wrist hanging over the edge of the armrest (elbow ± 90 degrees flexion, wrists 0 degrees), holding the grip dynamometer.

**Initial posture of the tester**
Tester is sitting next to the child, operating the computer.

**Setting the E-link**
The handle position of the grip dynamometer was adapted to hand size, according to the E-link guideline of positioning. Adjust the width of the handle of the dynamometer to the hand size of the child, in such a way that it feels comfortable for the child (ask the child). When there is doubt, try other positions of the handle. In general; the middle finger bone (phalanx) of the middle finger needs to be positioned in an angle of 90 degrees while covering the handle. Before every set of measurements, let the child try the handgrip dynamometer.
**Pinch Strength**

**Goal:** measuring maximum isometric (key) pinch strength.

**Initial posture of the child**
Forearm is resting on the armrest, arm neutral position, dorsal side thumb up/visible. The hand and wrist hanging over the edge of the armrest (elbow ± 90 degrees flexion, wrists 0 degrees), holding the pinch dynamometer with a (lateral) key pinch

**Initial posture of the tester**
Tester is sitting next to the child, operating the computer.

Note: often the thumb will slide of the sensor. Some practice may prevent this movement.