**Additional file 7: Table S3: Characteristics of included studies (assessed body region, assessed ICF-CY categories, used instruments and technologies and measured parameters)**

| First author, year | Assessed body region | Assessed ICF-CY categories | Instruments / Technologies | Measured parameters | GMFCS amb. / non amb. | MACS | Comparison | | Pre/post inter-vention | Reliability |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | between groups | with clinical measure | | |
| Androwis, 2015 (36) | Lower extremity | -Muscle tone / Motor reflex function | -sEMG<br>-6DOF single position sensor<br>-Force sensor- | -Knee ROM<br>-Angular peak velocity<br>-Angular peak acceleration<br>-EMG data | ✗ | ✗ | ✗ | ✗ | ✗ | ✗ |
| Beattie, 2016 (37) | Lower extremity | -Muscle tone / Motor reflex function | -sEMG<br>-Video | -Mean number of active muscles during rest, quick stretch and volitional movement | I-III | ✗ | ✓ | ✗ | ✗ | ✗ |
| Lebiedowska, 2004 (38) | Lower extremity | -Muscle power function<br>-Muscle tone / Motor reflex function<br>-Gait pattern function<br>-Walking | -sEMG<br>-Electrogoniometer<br>-Force platforms<br>-3D motion capture system<br>-Force transducer | -Maximum voluntary isometric knee flexion and extension torques<br>-Co-contraction of antagonist during knee flexion and extension<br>-Knee tendon reflexes<br>-Resistance of knee joint during slow passive movement<br>-Torque of catch<br>-Kinematic gait parameters in the sagittal plane of knee range of motion<br>-Walking velocity | amb. | ✗ | ✓ | ✗ | ✗ | ✗ |
| Abel, 2003 (39) | Lower extremity | -Gait pattern | -3D motion capture system | -Variability of ankle trajectory during swing | amb. | ✗ | ✓ | ✓ | ✗ | ✗ |
| Davids, 1999 (40) | Lower extremity | -Gait pattern | -3D motion capture system | -Normalized dynamic base of support (step width)<br>-Step profile Step length/step width<br>-Total body maximal lateral acceleration | amb. | ✗ | ✓ | ✗ | ✗ | ✗ |
| Petrarca, 2017 (41) | Lower extremity | -Gait pattern | -3D motion capture system | -Kinematic data<br>-Movement pattern during gait and jumping | amb. | ✗ | ✗ | ✗ | ✗ | ✗ |
| Sangeux, 2016 (42) | Lower extremity | -Gait pattern | -3D motion capture system | -Variablity of kinematic data – Overall Gait Variability Measure (OGVM) | I-III | ✗ | ✓ | ✗ | ✗ | ✗ |
| Berg, 1969 (43) | Lower extremity Upper extremity | -Control of voluntary movement function | -sEMG<br>-Needle EMG | -Level of EMG activity during rest and activity<br>-Frequency spectrum | amb.& non amb | ✗ | ✗ | ✗ | ✓ | ✗ |
| Kukke, 2011 (44) | Upper extremity | -Muscle tone / Motor reflex function<br>-Control of voluntary movement function<br>-Involuntary movement function | -sEMG<br>-Jointed elbow brace belt-driven by a strong motor<br>-Optical position encoder | -Mean elbow extension velocity<br>-Peak elbow extension velocity<br>-Mean triceps sEMG (overflow)<br>-Mean biceps sEMG | ✗ | ✗ | ✓ | ✗ | ✗ | ✗ |

**Table 3 (continued):**

| First author, year | Assessed body region | Assessed ICF-CY categories | Instruments / Technologies | Measured parameters | GMFCS amb. / non amb. | MACS | Comparison | | Pre/post inter-vention | Reliability |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | between groups | with clinical measure | | |
| Chu, 2009 (45) | Upper extremity | -Muscle power function | -Force loadcell<br>-Biodex chair with arm device | -Force variability<br>-Signal dependence of noise (increase of variablity with force level) | ✗ | ✗ | ✓ | ✗ | ✗ | ✗ |
| Van Doornik, 2009 (46) | Upper extremity | -Muscle tone / Motor reflex function | -sEMG<br>-Force sensor<br>-Electrogoniometer<br>-Biodex chair<br>-Custom built apparatus to apply manual perturbations to elbow joint | -Correlation between elbow angle and sEMG activity<br>-sEMG activity during sinsuoidal perturbation<br>-Dependency of EMG with velocity or position | ✗ | ✗ | ✗ | ✗ | ✗ | ✗ |
| Young, 2011 (47) | Upper extremity | -Control of voluntary movement function | -Biodex chair<br>-Custom built apparatus to held shoulder abducted 90 degree and elbow flexed 90 degree<br>-sEMG<br>-Software to track a target by activating biceps and triceps | -Co-contraction (% of MVC)<br>-Tracking error | ✗ | ✗ | ✓ | ✓ | ✓ | ✗ |
| Niku, 1985 (48) | Upper extremity | -Control of voluntary movement function<br>-Involuntary movement function | -Potentiometer<br>-Electrogoniometer<br>-Rigid and a flexible elbow brace<br>-Motion pattern generator, generating sinusoidal motions | -Movement frequency spectrum during:<br>*a visual tracking tests of sinusoidal motion<br>*a freewheeling test (move as fast as possible) | ✗ | ✗ | ✓ | ✗ | ✗ | ✗ |
| Chu, 2013 (49) | Upper extremity | -Control of voluntary movement function | -Manipulandum rotating around a single axis (elbow rotation on a table, movement restricted to horizontal plane),<br>-Optical position encoder<br>-Software: showing movement of shuffelboard | -Mean velocity<br>-Intrinsic variabilty (Standard deviation of maximum velocity | ✗ | ✗ | ✓ | ✗ | ✗ | ✗ |
| Chu, 2016 (50) | Upper extremity | - Control of voluntary movement function | -Manipulandum rotating around a single axis (elbow rotation on a table, movement restricted to horizontal plane)<br>-Optical position encoder<br>-Software: showing movement of bal | -Performance error: distance error of virtual bal to target<br>-Reduction of performance error<br>-T- Cost (tolerance, costs with respect to optimal performance): Difference in mean error of location between the actual data and the ideal data<br>-Timing error<br>-Release time window | ✗ | ✗ | ✓ | ✗ | ✗ | ✗ |

**Table 3 (continued):**

| First author, year | Assessed body region | Assessed ICF-CY categories | Instruments / Technologies | Measured parameters | GMFCS amb. / non amb. | MACS | Comparison | | Pre/post inter-vention | Reliability |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | between groups | with clinical measure | | |
| Gordon, 2006 (51) | Upper extremity | -Muscle tone / Motor reflex function<br>-Control of voluntary movement function<br>-Involuntary movement function<br>-Hand and arm use | -sEMG<br>-Rigidtiy analyzer<br>-3D-motion capture system | -Total joint excursion (shoulder, elbow, wrist) of the resting arm (kinematic overflow)<br>Reaching performance:<br>-Peak velocity<br>-Wrist path ratio (curvature)<br>-End point error (overshoot or undershoot)<br>-Hold distance | ✗ | ✗ | ✓ | ✓ | ✗ | ✗ |
| Butler, 2010 (52) | Upper extremity | -Control of voluntary movement function<br>-Lifting and carrying objects | -3D motion capture system | -Movement time<br>-Movement time of different phases of Reach & Grasp cyle (i.e. reach forward and grasp, transport to mouth, transport back and release)<br>-Index of curvature during reach<br>-Peak velocity<br>-Number of movement units during the Reach & Gasp cycle (i.e. number of acceleration–decelerations in the velocity profile of the wrist marker) | ✗ | I-III | ✓ | ✓ | ✗ | ✗ |
| Butler, 2012 (53) | Upper extremity | -Control of voluntary movement function<br>-Lifting and carrying objects | -3D motion capture system | -Movement time<br>-Index of curvature during reach<br>-Number of movement units during the Reach & Gasp cycle (i.e. number of acceleration–decelerations in the velocity profile of the wrist marker)<br>-Angular velocity of elbow extension during reach<br>-Ratio of the peak velocity during two phases<br>-Peadiatric Upper Limb Motion Index (PULMI) | ✗ | I-III | ✓ | ✓ | ✗ | ✓ |
| Damiano, 2010 (54) | Upper extremity | -Control of voluntary movement function<br>-Involuntary movement function<br>-Hand and arm use | -3D motion capture system | -Reach velocity<br>-Path length<br>-Overflow to non-moving limb<br>-Ability to maintain a static arm posture | ✗ | II-IV | ✓ | ✗ | ✗ | ✗ |

**Table 3 (continued):**

| First author, year | Assessed body region | Assessed ICF-CY categories | Instruments / Technologies | Measured parameters | GMFCS amb. / non amb. | MACS | Comparison | | Pre/post inter-vention | Reliability |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | between groups | with clinical measure | | |
| De Campos, 2014 (55) | Upper extremity | -Control of voluntary movement function<br>-Lifting and carrying objects | -3D motion capture system | -Intralimb coordination: shoulder flexion/elbow extension correlation<br>-Reach time<br>-Hold time<br>-Hand orientation error | ✗ | I-III | ✓ | ✓ | ✗ | ✗ |
| Kukke, 2016 (56) | | | | -Hand aperture<br>-Movement time (between start of reach, hand-object contact time, object lift off time);<br>-Atypical kinematics score (global score to summarize deviations from typical movement) | ✗ | I-III | ✓ | ✓ | ✗ | ✗ |
| Elliott, 2011 (57) | Upper extremity | -Control of voluntary movement function<br>-Hand and arm use | -3D motion capture system | -Movement time<br>-Directness index (ratio of actual path versus shortest path)<br>-Normalized jerk<br>-% time in primary movement<br>-% normalised jerk in primary movement | ✗ | ✗ | ✓ | ✗ | ✓ | ✗ |
| Sanger, 2006 (58) | Upper extremity | -Control of voluntary movement function<br>-Hand and arm use | -3D motion capture system | Measure of variability:<br>*Signal-to-noise ratio (ratio of first principal component of the joint velocity time serie to the sum of the remaining 10 components)<br>Measure of trajectory:<br>*Index of curvature<br>*Mean jerk during finger-to-nose task | ✗ | ✗ | ✓ | ✓ | ✗ | ✗ |
| Malfait, 2007 (59) | Upper extremity | -Control of voluntary movement function<br>-Hand and arm use | -3D motion capture system<br>-sEMG | - Average co-contraction over flexion/extension (finger-to-nose):<br>*Dot product of the sEMG between biceps/triceps<br>*Minimum value of sEMG between bicpes/triceps<br>-EMG activation levels during each phases<br>-Duration of whole movement circle<br>-Duration of phases:<br>*Acceleration/deceleration<br>*Pause<br>-Maximum flexion/extension velocity<br>-Maximum elbow rotation<br>-Coefficient of variation of each measure | II-V | ✗ | ✓ | ✓ | ✗ | ✗ |

**Table 3 (continued):**

| First author, year | Assessed body region | Assessed ICF-CY categories | Instruments / Technologies | Measured parameters | GMFCS amb. / non amb. | MACS | Comparison | | Pre/post inter-vention | Reliability |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | between groups | with clinical measure | | |
| Pons, 2017 (60) | Upper extremity | -Control of voluntary movement function<br>-Involuntary movement function<br>-Hand an arm use | -3D motion capture system | -Index of dystonia (kinematic measure of overflow) during 'drinking' task)<br>-Target accuracy (reach-and-point task):<br>*Hold distance<br>*End point error<br>During 5 functional upper extremity tasks and 4 reach-to-graps tasks:<br>*Movement duration<br>*Average and maximum linear velocity<br>*Index of curvature<br>*Joint angles | I-IV | I-III | ✓ | ✓ | ✗ | ✗ |
| Kawamura, 2012 (61) | Upper extremity | -Involuntary movement function | -3D motion capture system | -Kinematic dystonia measure (kinematic overflow: summation of joint angle movement of wrist, elbow and shoulder) | I-V | I-IV | ✓ | ✓ | ✗ | ✓ |
| Legros, 2004 (62) | Upper extremity | -Involuntary movement function | -Three-axis piezoceramic accelerometer | -Integral/area under the curve of acceleration power spectrum during rest and posture | ✗ | ✗ | ✓ | ✓ | ✓ | ✓ |
| Sanger, 2007 (63) | Upper extremity | -Control of voluntary movement function<br>-Hand and arm use | -Shape Tape | -Maximal velocity of outward reaching | ✗ | ✗ | ✗ | ✗ | ✓ | ✗ |
| Liyanagamage, 2017 (64) | Upper extremity | -Control of voluntary movement function | -sEMG | -Movement time<br>-Throughput (ratio of index of difficulty to movement time calculated by Fitts' Law)<br>-Muscle use (ratio of EMG in the vibrated muscle to non-vibrated muscle) | ✗ | ✗ | ✓ | ✗ | ✓ | ✗ |
| Nwaobi, 1987 (65) Nwaobi, 1987 (66) | Upper extremity | -Control of voluntary movement function<br>-Hand and arm use | -sEMG<br>-Touch activiated switch | -Movement time<br>-sEMG activity | ✗ | ✗ | ✗ | ✗ | ✓ | ✓ |
| Sanger, 2005 (67) | Upper extremity | -Control of voluntary movement function<br>-Hand and arm use | -Touch activated switch (three different sizes) | -Movement time<br>-Slope of regession lines of movement time on the logarithme of button width (Fitt's law)<br>-Slope of regression lines of speed on button width<br>-Slope and intercept of rgression lines of log variance on log mean speed | ✗ | ✗ | ✓ | ✗ | ✗ | ✗ |

**Table 3 (continued):**

| First author, year | Assessed body region | Assessed ICF-CY categories | Instruments / Technologies | Measured parameters | GMFCS amb. / non amb. | MACS | Comparison | | Pre/post inter-vention | Reliability |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | between groups | with clinical measure | | |
| Rabhi, 2018 (68) | Upper extremity | -Control of voluntary movement function<br>-Moving around using equipment | -Virtual environment simulating the wheelchair navigation | -Performance indices of user's path (path length, performance time, speed, number/duration of collisions, number of stops, succesfully passed targed points<br>-Performance indices from joystick (average amplitude, average speed) | V | ✗ | ✗ | ✗ | ✗ | ✗ |
| Bertucco, 2014 (69)<br>Bertucco, 2015 (70) | Upper extremity / fingers | -Control of voluntary movement function<br>-Fine hand use | -Touchscreen tablet<br>-Custom made app – game to assess tradeoff between movement time and accuracy (Fitt's Law)) | -Success rate<br>-Movement time<br>- Intercept and slope of linear regression of movement time as function of Indices of Difficulties (Fitt's law)<br>-Index of performance (1/slope of regression)<br>-Throughput (ratio of index of difficulty to movement time calculated by Fitts' Law) | ✗ | ✗ | ✓ | ✓ | ✗ | ✗ |
| Young, 2011 (71)<br>Young, 2013 (72)<br>Young, 2014 (73) | Upper extremity / fingers | -Control of voluntary movement function<br>-Involuntary movement function | -sEMG<br>-Software tracking a target by isometrically activating of intrinsic muscles | -Tracking error<br>-Overflow (EMG) | ✗ | ✗ | ✓ | ✓ | ✓ | ✗ |
| Bhanpuri, 2015, (74) | Upper extremity / fingers | -Control of voluntary movement function<br>-Involuntary movement function | -sEMG<br>-Software tracking a target by isometrically activating of intrinsic muscles | -Tracking error in step tracking task and continuous task<br>-Overflow (sEMG) error in step tracking task and continuous task | ✗ | ✗ | ✗ | ✗ | ✓ | ✗ |
| Lunardini, 2016 (75) | Upper extremity /fingers | -Control of voluntary movement function<br>-Fine hand use | -3D motion capture system<br>-sEMG | -Accuracy error<br>-Speed<br>-Task correlation index (relative contribution of muscle activity correlated with 8-figure task) | ✗ | ✗ | ✗ | ✗ | ✓ | ✗ |
| Bertucco, 2019, (76) | Upper extremity /fingers | -Control of voluntary movement function<br>-Fine hand use | -Touchscreen tablet<br>-sEMG | -Accuracy error<br>-Speed<br>-Ratio between error and speed<br>-Spatial variability<br>-Temporal variability<br>-Task correlation index (relative contribution of muscle activity correlated with 8-figure task) | ✗ | ✗ | ✓ | ✗ | ✓ | ✗ |

**Table 3 (continued):**

| First author, year | Assessed body region | Assessed ICF-CY categories | Instruments / Technologies | Measured parameters | GMFCS amb. / non amb. | MACS | Comparison | | Pre/post inter-vention | Reliability |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | between groups | with clinical measure | | |
| Choi, 2011 (77) | Upper extremity /fingers | -Control of voluntary movement function<br>-Fine hand use | -Virtual handwriting training system, with PC connected to a haptic device that can provide force feedback | -Segmented movement time of transition and stroke-drawing<br>-Total movement time<br>-Time on-paper/Time in-air<br>-Deviation of written trajectory from the ideal path | ✗ | ✗ | ✗ | ✗ | ✗ | ✗ |
| Nicholson, 2001 (78) | Trunk<br>Upper extremity | -Control of voluntary movement function<br>-Hand and arm use | -3D motion capture system | -Proximal stability at the trunk and distal stability at the wrist and hand<br>-Variation in movements between attempts of a particulair body part during reaching task in particular plane<br>-Smoothness trajectory of reach (visual comparision to normative data) | ✗ | ✗ | ✗ | ✗ | ✗ | ✗ |
| Garavaglia, 2017 (79) | Trunk<br>Upper extremity | -Control of voluntary movement function<br>-Hand and arm use<br>-Maintaining a body position | -3D motion capture system | -Joint angles (thorax, shoulder, elbow, wrist)<br>Fingernail position | ✗ | ✗ | ✗ | ✗ | ✗ | ✗ |
| Cimolin, 2009 (80) | Trunk<br>Head<br>Upper extremity | -Involuntary movement function<br>-Maintaining a body position | -3D motion capture system<br>-System for acquisition of pressure distribution placed on the seatback ond on headback of adaptive seating sytstem | -Trajectories of markers of head and trunk: Difference between initial position and end position after extensor thrust<br>-Initial position in anterior and vertical direction<br>-ROM of head, trunk and upper limb (difference between initial position and maximum valued during extensor thrust)<br>-Average jerk (smothness of movement) extensor thrust<br>-Peak of force on seatback and headpack during extensor thrust | V | ✗ | ✗ | ✗ | ✓ | ✗ |
| Man, 2007 (81) | Head | - Control of voluntary movement function | -Camera Mouse<br>-Head-mouse emulator switch<br>-Cross scanner (i.e. mouse-like pointer interface software) activiated by eye movement;<br>-Eye Gaze tracker<br>-Software: Point and-click test, based on the principle of Fitt's Law | -Movement time<br>-Accuracy rate | ✗ | ✗ | ✗ | ✗ | ✗ | ✗ |

**Table 3 (continued):**

| First author, year | Assessed body region | Assessed ICF-CY categories | Instruments / Technologies | Measured parameters | GMFCS amb. / non amb. | MACS | Comparison | | Pre/post inter-vention | Reliability |
|---|---|---|---|---|---|---|---|---|---|---|
| Raya, 2010 (82) | Head | -Involuntary movement function | -Intertial sensor<br>-Software to control mouse pointer by inertial sensor | -Amplitude and frequency of movement<br>-Power spectral density versus time<br>-Standard deviations of angular head velocity | V | ✘ | ✘ | ✘ | ✘ | ✘ |
| Saavedra, 2010 (83) | Head | -Involuntary movement function<br>-Maintaining a body position | -3D motion capture system | -Head movement (sway parameters in sagittal and frontal plane)<br>-Head displacement (RMS) with eyes closed and open | I-III | ✘ | ✓ | ✘ | ✘ | ✘ |
| Yamamoto, 2019 (84) | Head | -Involuntary movement function<br>-Maintaining a body position | -2D motion capture system | -Head segment angle (side-bending)<br>-Head angular velocity | V | V | ✘ | ✘ | ✘ | ✘ |

sEMG=surface electromyography; DOF=Degree of freedom; ROM=Range of Motion; OGVM= Overall Gait Variability Measure; MVC=maximum voluntary contraction; PULMI)=Peadiatric Upper Limb Motion Index ; %=percentage; RMS=Root mean amb=ambulatory; non amb.=non ambulatory; GMFCS=Gross motor functioning classification system; MACS=Manual Ability Classification System

✘ = information not available; ✓ = information available;