***Supplementary Material – Table 2***

**A Scoping Review of Scientific Concepts Concerning Motor Recovery After Stroke as Employed in Clinical Trials**

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**Table2.** The classification of the theoretical frameworks of the studies.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Reference** | **Declared theoretical framework** | **Reported references to theoretical framework** | **Treatment frameworks of motor control** | **Coherence between methods and theoretical model** | **Aim** | **Outcome measures** | **Coherence between aims and outcome measures** |
| **Declared** |  |  |  |  |  |  |  |
| Dipietro, L., et al. (2009) (1) | Human movements are generated by discrete building blocks of movement, often labeled submovements, which represent an ‘alphabet’ of primitive movements. Recovery seems to progress first by rapidly reacquiring the ‘‘alphabet’’, and then, over a longer time, by reacquiring the means to combine these elements into ‘‘words’’ or ‘‘phrases’’. | Duarte, J.E., et al. (2013) (2)*.* | Neuroanatomy | Covid-19: la divisione in zone e le FAQ di interesse per i negozi di ... | To explore whether untrained UL movements during motor recovery from stroke exhibit changes in smoothness and sub-movements, thereby investigating their nature. | - FMA-UE - Circle drawing quality | Dot clipart green, Dot green Transparent FREE for download on ... |
| Grimm, F., et al, (2016) (3) | Information on movement quality has therefore been incorporated as implicit closed-loop feedback in the virtual environment of an exoskeleton-based rehabilitation device. Specifically, the continuous visual feedback of the whole arm kinematics allowed the patients to adjust their movement quality online during each task; an approach closely resembling natural motor learning | Grimm, F., et al. (2016) (4) | Robotics | Dot clipart green, Dot green Transparent FREE for download on ... | To assess closed-loop task difficulty adaptation during VR reach-to-grasp UL training assisted with an exoskeleton in stroke rehabilitation. | - UL accuracy, temporal efficiency, ROM  -FMA-UE | Dot clipart green, Dot green Transparent FREE for download on ... |
| Grimm, F., et al. (2016) (4) | The three-dimensional visualization of the arm was applied during each task as an implicit online feedback of movement quality, since explicit information can disrupt motor learning in stroke patients. In the present feasibility study, we extended this line of research by incorporating information on movement quality as implicit closed-loop feedback in the virtual environment of an exoskeleton-based rehabilitation device suitable for severely affected stroke patients who require gravity-support to perform activities of daily living such as reach-to-grasp exercises.  an approach closely resembling natural motor learning. | Boyd, L.A., and Winstein, C.J. (2004) (5) | Robotics | Dot clipart green, Dot green Transparent FREE for download on ... | To test feasibility and clinical validity of VR visualization and closed-loop feedback of joint-specific movement in severely stroke patients.  To quantify the individual degree of UL natural movement restoration or compensation. | - FMA-UE  - UL ROM | Dot clipart green, Dot green Transparent FREE for download on ... |
| Longo, D., et al. (2022) (6) | The Muscle Shortening Maneuver (MSM), a physical therapy approach, was introduced by Grimaldi et al. in the eighties and is derived from Feldman’s λ model of motor control  According to the model, the nervous system is able to modify the equilibrium state of the neuromuscular system by changing its parameters, thus controlling movement | Melchiorre D., et al. (2014) (7);  Feldman, A.G. (1998) (8) | Neuroanatomy | Dot clipart green, Dot green Transparent FREE for download on ... | To investigate the hypothesis that MSM could influence the modulation of the TSRT.  To investigate the MSM as a rehabilitation technique to improve body functions and activities in individuals with limitations due to chronic stroke. | Montreal Spasticity Measure Device (EMG and goniometer) | Dot clipart green, Dot green Transparent FREE for download on ... |
| Petrarca, M., et al. (2011) (9) | High-intensity and task specific program of strengthening exercises and training and functional therapy resulted in improved strength and functional performance maintained over time. Motor learning principle based on Feldman’s Equilibrium point model. Ecological approach. | Feldman, A.G. (1986)  (10);  Pierro, M.M., et al. (2005) (11) | Ecological | Dot clipart green, Dot green Transparent FREE for download on ... | To move in the direction of a person-oriented decision-making process on gait rehabilitation by analyzing the recovery from stroke of a six-year-old boy over three years. | -kinetics and kinematics (Gait Analysis)  -GMFM  -PEDI | Dot clipart green, Dot green Transparent FREE for download on ... |
| Pollock, C.L., et al. (2014) (12) | Challenge Point Framework (CPF) Model;extrinsic feedback (visual feedback); knowledge of results (KR) and knowledge of performance (KP) | Guadagnoli, M.A., et al. (2004) (13) | Ecological | Dot clipart green, Dot green Transparent FREE for download on ... | To retrain of multidirectional stepping reactions may be informed by the CPF to improve balance function in people with stroke. | - Walking balance Community Balance and Mobility Scale  - ABC scale  - Kinematics (Gait analysis) | Dot clipart green, Dot green Transparent FREE for download on ... |
| Reinkensmeyer, D.J., et al. (2009) (14) | New use-dependent brain organization model:   - The model focuses on strokes that partially destroy the corticospinal system;   - The authors assume that motor control gains are caused by improvements in the ability to activate the spared portions of the corticospinal tract that activate motor neuron pools;   - they further assume that the motor system learns how to better activate spared corticospinal tracts by searching for optimal activation patterns using a stochastic local search process. The teaching signal that guides this search is a scalar measure of the movement success caused by the current activation pattern relative to the most successful, previously-tried activation pattern;   - the action of trying to move accounted for the practice-dependent arm movement recovery, independently of the specific ROM achieved or the level of assistance.   - it is the action of trying to move that automatically and inherently elicits the teaching signal required for the neural reorganization supporting the movement recovery, independently of the quantitative task feedback.  - The range and speed of the practiced movements do not alter the rate of recovery; all that matters is the magnitude of the teaching signal (in this case, peak force) achieved by the current pattern of activation. | Anderson, R.W. (1993) (15);  Williams R.J. (1992) (16);  Werfel, J., et al. (2005) (17);  Mazzoni, P., et al. (1991) (18);  Maier, M.A., et al. (1998) (19);  Fetz, E.E., et al. (1989) (20);  Ashe, J., (1997) (21) | Self-organization | Covid-19: la divisione in zone e le FAQ di interesse per i negozi di ... | To demonstrate that different dose-matched, UL rehabilitation training techniques can result in similar improvement in movement ability after stroke. | - strength (shoulder flexion/elbow extension)  - movement speed  - movement coordination | Covid-19: la divisione in zone e le FAQ di interesse per i negozi di ... |
| Rowe, J.B., et al. (2017) (22) | Success is known to encourage motivation, self-efficacy, and willingness to practice. Active assistance increases success, and therefore presumably activates these positive learning features. Alternately, active assistance might promote Hebbian plasticity by increasing the amount of proprioceptive input in a way that is time-correlated with attempted motor activity. | Duarte J.E., et al. (2013) (2);  Goodman, R.N., et al. (2014) (23);  Abe, M., et al. (2011) (24);  Reinkensmeyer D.J. (2003) (25) | Robotics | Dot clipart green, Dot green Transparent FREE for download on ... | To determine the therapeutic effects of high and low levels of robotic assistance during finger training | - BBT  - NHPT  - NIHSS  - FMA-UE  - ARAT  - Lateral Pinch Strength Test  - Motivation  - self efficacy | Dot clipart green, Dot green Transparent FREE for download on ... |
| Shaphe, A., et al. (2018) (26) | In a natural closed loop feedback control system, the physical motion of the body generates the visual cue in response to ambulation and in the absence of movement these cues are not generated. Visual inputs are most import external sensory cues regulating walking. | Goodman, R.N., et al. (2014) (23) | Robotics | Dot clipart green, Dot green Transparent FREE for download on ... | To investigate the efficacy closed loop visual cues incorporated augmented VR environment on functional gait and community ambulation in stroke patients. | - Gait Analysis  - SF-SIS | Dot clipart green, Dot green Transparent FREE for download on ... |
| Vilimovsky, T., et al. (2021) (27) | PAT (prism adaptation treatment) was delivered, by a physiotherapist, using the treatment protocol and equipment of the  Kessler Foundation Prism Adaptation Treatment (KF-PAT) |  | Ecological | Dot clipart green, Dot green Transparent FREE for download on ... | PAT reduced visuospatial symptoms of spatial neglect among patients in an inpatient setting providing intensive rehabilitation care.  PAT enhanced the recovery of spatial neglect. | - CBS  - Bells test  - Line bisection  - Scene copying test | Dot clipart green, Dot green Transparent FREE for download on ... |
| **Not Declared** |  |  |  |  |  |  |  |
| De Bruyn, N., et al. (2021) (28) | N.D. |  | Neuroanatomy |  | To investigate differences in therapy-induced resting-state functional connectivity changes between additional sensorimotor therapy compared with motor therapy in the early-phase post stroke | - fMRI | Dot clipart green, Dot green Transparent FREE for download on ... |
| Doost, M.Y., et al. (2021) (29) | N.D. |  | Ecological |  | To investigate whether training under the robotic active-assisted mode improves bimanual motor skill learning more than training under the active mode in stroke patients. | - Speed  -accuracy | Dot clipart green, Dot green Transparent FREE for download on ... |
| García-Ramos, B. R., et al. (2023) (30) | N.D. |  | Self-organization |  | To explore the effect of a new game-based ocular virtual reality training on the cerebral activity in sensorimotor regions and accuracy in eye and hand movements in three different profiles of stroke survivors. | - FMA-UE;  - mean absolute error during the continuous tracking of a target task mentioned above;  - fMRI scanning during continuous tracking of a target tasks through eye-tranking and a hand-controlled joystick. | Dot clipart green, Dot green Transparent FREE for download on ... |
| Gilmore, P.E., & Spaulding, S.J. (2007) (31) | N.D. |  | Self-organization |  | To determine the effectiveness of combining a program of VOT and OT in learning the skill of donning socks and shoes poststroke | -KB-ADL socks and shoes subtests.  - COPM | Dot clipart green, Dot green Transparent FREE for download on ... |
| Hegazy E. M. et al. (2022) (32) | N.D. |  | Self-organization |  | To compare the effect of a virtual reality training program and a task-oriented training program on the paretic upper limb function after stroke. | -UEFI  -grip strength test (using a dynamometer) | Dot clipart green, Dot green Transparent FREE for download on ... |
| Huang, C.Y., et al. (2022) (33) | N.D. |  | Self-organization |  | To identify the effects of immersive VR training on inflammation, oxidative stress, neuroplasticity and UL motor function in stroke patients. | -FMA-UE  -AROM (shoulder flexion, elbow extension, wrist extension, forearm supination and pronation)  -SSQ  -RPE molecular biomarkers (BDNF) | Dot clipart green, Dot green Transparent FREE for download on ... |
| Jonsdottir, J., et al. (2010) (34) | N.D. |  | Robotics |  | To examine the efficiency of EMG BFB training combined with theories of motor learning in improving performance and learning of gait parameters after stroke. | -Gait analysis | Dot clipart green, Dot green Transparent FREE for download on ... |
| Jonsdottir, J., et a.l. (2007) (35) | N.D. |  | Robotics |  | To evaluate the efficacy of task-oriented EMG-BFB in increasing push off power of the plantar flexors muscle on the affected side and to increase gait velocity in a population with hemiparetic stroke. | -Ankle power peak (W/kg)  -Velocity  - Stride length  -Knee flexion peak (degrees) | Dot clipart green, Dot green Transparent FREE for download on ... |
| Junata, M., et al. (2021) (36) | N.D. |  | Self-organization |  | To evaluate the effectiveness of the interactive RMT and CBT on chronic stroke survivors overall balance recovery reaction. | -BBS  -TUG  -FMA-UE  -Barthel index  -EMG activation | Dot clipart green, Dot green Transparent FREE for download on ... |
| Kamatchi K. et al. (2023) (37) | N.D. |  | Robotics |  | To assess the effectiveness of virtual reality in the rehabilitation of persons with stroke to improve the upper extremity function. | - FMA-UE  - sEMG signal amplitude | Dot clipart green, Dot green Transparent FREE for download on ... |
| Kim H., et al. (2023) (38) | N.D. |  | Robotics |  | To i evaluate the effectiveness of the of mirror therapy with video augmented wearable refection device on reach-to-grasp motor control and upper extremity motor function. | -Trunk kinematics  -FMA-UE  -MFT  -BBT | Dot clipart green, Dot green Transparent FREE for download on ... |
| Kim, G.J., & Chen, P. (2020) (39) | N.D. |  | Robotics |  | To examine the effects of instruction adherence on UL motor outcomes after highly structured intervention. | -MCQ -FMA-UE -WMFT  -FAS | Dot clipart green, Dot green Transparent FREE for download on ... |
| Krishnamoorthy, V., et al. (2008) (40) | N.D. |  | Robotics |  | To describe the findings of training with a specially designed gravity-balanced orthosis, treadmill walking, FES, and principles of motor learning. | -TUG  -FMA-LE  -BBS  -Gait analysis | Dot clipart green, Dot green Transparent FREE for download on ... |
| Longatelli, V., et al. (2021) (41) | N.D. |  | Neuroanatomy |  | To investigate the gait rehabilitation process and evaluates motor re-learning in patients with subacute post-stroke by analysing and comparing LL muscular activation patterns. | - Gait functionality by means of clinical scales combined to obtain a Capacity Score (5-item modified Barthel index, MI, TMWT, 6MWT, FAC, TCT).  - Gait neuromuscular lower limbs pattern using surface EMG signals | Dot clipart green, Dot green Transparent FREE for download on ... |
| Luque-Moreno, C., et al. (2019) (42) | N.D. |  | Self-organization |  | To determine whether a program that includes the combination of TR and RFVE decreases the level of spasticity of the PF muscles and improved gait function | - MAS  - FAC  - FIM | Dot clipart green, Dot green Transparent FREE for download on ... |
| Maenza, C., et al. (2021) (43) | N.D. |  | Robotics |  | To assess whether a rehabilitation approach focused on remediation of ipsilesional arm motor deficits in stroke survivors with moderate to severe contralesional arm paresis and with significant ipsilesional arm coordination deficits, improves functional performance and independence. | - JTHFT  - FIM  - Grip Strength hand dynamometer  - FMA-UE | Dot clipart green, Dot green Transparent FREE for download on ... |
| Maggio, M.G., et al. (2021) (44) | N.D. |  | Neuroanatomy |  | To evaluate the usefulness of a RAGT equipped with augmented visuomotor feedback in improving LL sensorimotor function, gait performance and body representation.  To understand the putative neurophysiological correlates (EEG analysis) of the correlation between BR recovery and motor performance improvement. | - BES  - BUT  - FMA-LE  - FAB  - MoCA  - BDI  - SF12  - EEG | Dot clipart green, Dot green Transparent FREE for download on ... |
| Mazzoleni, S., et al. (2019) (45) | N.D. |  | Robotics |  | To investigate the effectiveness of combining tDCS and wrist robot-assisted rehabilitation in subacute stroke patients in comparison with the wrist robotic training only | - FMA-UE  - MAS (wrist muscles)  - MI  - BBT  - Kinematic parameters of wrist movements: abduction, adduction, extension, flexion | Dot clipart green, Dot green Transparent FREE for download on ... |
| Castro-Medina, K.G. (2023) (46) | N.D. |  | Robotics |  | To determine the effect of visual feedback on gait speed after stroke in adults with subacute and chronic stages. | - TMWT | Dot clipart green, Dot green Transparent FREE for download on ... |
| Paolucci, T., et al. (2021) (47) | N.D. |  | Robotics |  | To determine the effects of an integrated rehabilitation protocol, including botulinum toxin and conventional rehabilitation exercise plus end-effector robotic training for UL functional recovery compared to training with the robot alone in post-chronic stroke | - FMA-UE  - MI  - MAS  - Numeric rating scale.  – BBT  - Frenchay Arm Test  - Barthel Index | Dot clipart green, Dot green Transparent FREE for download on ... |
| Park, M., et al. (2019) (48) | N.D. |  | Robotics |  | To assess the clinical effectiveness of the VR-based rehabilitation device (Rapael Smart Board™) for the UL rehabilitation in chronic stroke patients.  To investigate the correlations between kinematic data from the Rapael Smart Board™ and clinical outcome. | - FMA-UE  - WMFT  - AROM (proximal upper extremities)  - Barthel index  - SIS | Dot clipart green, Dot green Transparent FREE for download on ... |
| Piron, L., et al. (2010) (49) | N.D. |  | Self-organization |  | To determine if a rehabilitation technique that aimed to augment the possibility of motor learning using VR (RFVE) could improve motor outcome scores significantly more than conventional treatment.  To compare the effects of a VR based technique with a control intervention of progressive therapy for the affected UL. | - FMA-UE  - ROM (Shoulder, Elbow, Wrist)  - AROM  - PROM  - MAS  -CAHAI  - CHART  - EMG analysis | Dot clipart green, Dot green Transparent FREE for download on ... |
| Powers, J., et al. (2022) (50) | N.D. |  | Robotics |  | To investigate the effects of augmented feedback during overground gait training, on TGA | - NIHSS  - MCA  - TGA  - gait speed | Dot clipart green, Dot green Transparent FREE for download on ... |
| Pundik, S., et al. (2022) (51) | N.D. |  | Neuroanatomy |  | To evaluate MyoPro as a tool for motor learning-based therapy for individuals with chronic UL impairment. | - FMA-UE; Shoulder, Elbow, Wrist  - PROM/AROM  - MAS  - CAHAI  - CHART  - OPUSsat | Dot clipart green, Dot green Transparent FREE for download on ... |
| Sainburg, R.L., et al. (2016) (52) | N.D. |  | Robotics |  | To test intense non-paretic arm training in improving motor coordination and functional performance in the trained arm, but also in improving functional independence and paretic arm function. | - FIM  - FMA-UE  - JTHFT | Dot clipart green, Dot green Transparent FREE for download on ... |
| Salameh, A., et al. (2022) (53) | N.D. |  | Self-organization |  | To develop and test a combination protocol of simultaneous brain stimulation and focused stance phase training for people with chronic stroke. | - TMWT  - TUG  - Functional Gait Assessment | Dot clipart green, Dot green Transparent FREE for download on ... |
| Saleh, S., et al. (2017) (54) | N.D. |  | Self-organization |  | To compare the effect of robot-assisted VR repetitive task practice-based interventions on neural pattern reorganization. | - fMRI  - JTHFT | Dot clipart green, Dot green Transparent FREE for download on ... |
| Schreiber, J., et al. (2001) (55) | N.D. |  | Neuroanatomy |  | To determine the relationship between type of task and type of environment on retention and transfer of motor skills when applied to stroke survivors, as measured by time to complete the task and the number of errors. | - Number of errors in keyboard typing. | Dot clipart green, Dot green Transparent FREE for download on ... |
| Smedes F., & da Silva, L.G. (2019) (56) | N.D. |  | Neuroanatomy |  | To illustrate the clinical reasoning and the feasibility of applying PNF-concept as an alternative approach in patients who are not accepted or not suitable for CIMT. | - AROM/PROM wrist extension  - grip strength (handheld dynamometer)  - MAS  - FAT  - NHPT | Covid-19: la divisione in zone e le FAQ di interesse per i negozi di ... |
| Tretriluxana, J., et al. (2013) (57) | N.D. |  | Self-organization |  | To investigate the feasibility of Accelerated Skill Acquisition Program delivered during the 1- to 3-month outpatient interval in stroke survivors and included an assessment of Reach-to-Grasp coordination. | - Reach-to-Grasp  - WMFT  - SIS | Covid-19: la divisione in zone e le FAQ di interesse per i negozi di ... |
| Tsaih, P.L., et al. (2018) (58) | N.D. |  | Robotics |  | To determine the effects of constant force or variable force practice with task related EMGBFB-assisted exercise training on the TA muscle strength, balance, and LL motor function in people with chronic stroke. | - TA strength  - dynamic posturography  - walking speed  - TUG  - 6MWT | Dot clipart green, Dot green Transparent FREE for download on ... |
| Turolla, A., et al. (2013) (59) | N.D. |  | Robotics |  | To evaluate the efficacy of the proposed technological solution for the rehabilitation of hand and fingers motor function in poststroke patients | - FMA-UE  - NHPT  - speed  - smoothness (Jerk)  - fMRI | Dot clipart green, Dot green Transparent FREE for download on ... |
| Van Vugt, F.T., et al. (2016) (60) | N.D. |  | Robotics |  | To test the hypothesis whether rehabilitation benefits in music-supported therapy are due to auditory feedback-based motor learning. | - Barthel index  - NHPT  - Finger tapping measurements  - Auditory and auditory-motor tests | Dot clipart green, Dot green Transparent FREE for download on ... |
| Winstein, C., et al. (2019) (61) | N.D. |  | Self-organization |  | To explore the dose response and test the dosage of task-specific practice needed to achieve meaningful improvement in arm and hand use in chronic stroke survivors. | - MAL  - WMFT | Dot clipart green, Dot green Transparent FREE for download on ... |
| Zollo, L., et al. (2011) (62) | N.D. |  | Robotics |  | To provide quantitative measure of biomechanical and motion planning features of arm motor control following upper-limb robot-aided motor therapy. | - FMA-UE  - Motor Power | Dot clipart green, Dot green Transparent FREE for download on ... |

**Abbreviation list:** UL= Upper Limb; FMA-UE= Fugl-Meyer Assessment–Upper Extremity; VR= Virtual Reality; ROM= range of motion; MSM= Muscle Shortening Maneuver; TSRT=Tonic Stretch Reflex Threshold; EMG= electromyography; GMFM= Gross Motor Function Measure; PEDI= Pediatric Evaluation of Disability Inventory; CFP= Challenge Point Framework; KR= knowledge of results; KP= knowledge of performance; ABC=Activities-speciﬁc Balance Conﬁdence Scale; BBT= Box and Blocks Test; NHPT= Nine Hole Pegboard Test ; NIHSS= NIH Stroke Scale; ARAT= Action research arm test; SF-SIS= stroke impact scale; PAT= Prisma Adaptation Treatment; CBS= Catherine Bergego Scale; N.D.= Not Defined; fMRI= functional Magnetic Resonance Imaging; VOT= videotape feedback occupational therapy; OT= occupational therapy; KB-ADL=Klein Bell Activities of Daily Living Scale; COPM=Canadian Occupational Performance Measure; UEFI= Upper Extremity Functional Index test; AROM= range of active motion; SSQ= Simulator Sickness Questionnaire; RPE= Borg Scale of Perceived Exertion; BDNF= Brain-derived neurotrophic factor; BFB= biofeedback; RMT= Rapid Movement Training; CBT= Conventional Balance Training; BBS= Berg Balance Scale; TUG= Timed Up-and-Go test; MCQ= Manipulation Check Questionnaire; WMFT= Wolf Motor Function Test; FAS=Functional Ability Scale; FES= Functional Electrical Stimulation; MI= Motricity Index; TMWT= ten meters walking test; 6MWT= six minutes walking test; FAC= Functional Ambulatory Category; TCT= Trunk Control Test; TR= traditional rehabilitation; RFVE= reinforced feedback virtual environment; PF= plantar flex; MAS= Modified Ashworth Scale; FIM= Functional Independence Measure; JTHFT= Jebsen Taylor Hand Function Test; RAGT= robot-aided gait training; LL= Lower Limb; EEG= electroencephalogram; BR= body representation; BES=Body Esteem Scale; BUT= Body Uneasiness Test; FMA-LE= Fugl-Meyer Assessment–Lower Extremity; FAB= frontal assessment battery; MoCA= Montreal Cognitive Assessment; BDI= Beck depression inventory; SF12= Short Form-12 health status questionnaire; tDCS= Transcranial direct current stimulation; SIS= Stroke Impact Scale; PROM= Passive ROM; CAHAI= Chedoke Arm and Hand Activity Inventory; CHART= Craig Handicap Assessment and Rehabilitation Technique; MCA= Chedoke McMaster Stroke Assessment; TGA= Temporal Gait Asymmetry; OPUSsat= Orthotic and Prosthetic User’s Survey Satisfaction module; PNF= proprioceptive Neuromuscular Facilitation; CIMT= Constraint Induced Movement Therapy; FAT= Frenchay Arm Test; TA= Tibial Anterior; BART= Bilateral Arm Reaching test.

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