Achieving ADL Independence Post-Stroke Through Occupational Therapy Interventions

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Key Words

- Occupational Therapy
- Stroke
- Activities of Daily Living
- Independence
- Older Adult
- Intervention
- Standard of Care

This rapid systematic review evaluates the current literature on occupational therapy interventions aimed at improving ADL independence in post-stroke individuals. 28 studies were evaluated and 6 categories (task-oriented training, virtual reality and video games, technology, constraint-induced movement therapy, electrical stimulation, and other) of interventions were identified. The 28 articles used in this rapid systematic review were retrieved from PubMed and CINAHL using Covidence. Literature included are publications from the past 10 years, studies with participants 60+ years of age that have experienced a stroke, and studies with interventions focused on ADL independence. Level IV and V studies were excluded. TOT, CIMT/mCIMT, technology, E-stim, VR and virtual reality, sensory interventions, ankle-foot orthoses, and strategy training are evidence-based stroke interventions that have been showing improvement in ADL participation when compared to the standard of care. Findings reveal overall moderately strong evidence for the impact of the identified occupational therapy interventions on ADL performance for adults 60+ post-stroke. The current review supports six categories of interventions that improve ADL independence, which informs occupational therapy practice for older adult stroke patients.

Focused Clinical Question

Considering 15 million people across the world suffer strokes every year, nearly 80% suffer from upper extremity motor impairment which causes limited independence in ADLs (Maryam D). The following rapid systematic review considers the clinical question: What occupational therapy intervention approaches for ADLs for adults >60 years old post-stroke are effective in achieving ADL independence compared to standard of care?

Introduction

The National Institutes of Health (NIH) defines stroke, or cerebrovascular accident (CVA), as "when blood flow to the brain is blocked or there is sudden bleeding in the brain" (NIH, 2023). When a stroke has occurred, a person may present with unilateral paralysis to the face or body segments, headache, aphasia, and declined comprehension abilities. For older adults who have experienced a stroke, the recovery process can be both long and daunting. OT interventions that target clients' rehabilitation process positively influence activities of daily living (ADLs) including, but not limited to, dressing, toileting, bathing, self-care, functional mobility, and self-feeding. With improvements in coordination, balance, and functional range of motion, impacted individuals can participate in meaningful occupations and learn to adapt to their post-stroke capacities more efficiently.

Basic standard of care refers to the minimum level of healthcare required by law to safely and adequately treat patients. The specific therapeutic interventions directed at ADL performance studied were the following: task-oriented training (TOT), adaptive technology, constraint-induced movement therapy (CIMT), and electrical stimulation (E-Stim) for post-stroke patients. There is limited research focusing on which ADL interventions geriatric populations (65+) best benefit from following a stroke. The objective of this rapid systematic review is to synthesize evidence-based studies regarding specific occupational interventions to determine the influence on ADL performance in older adults post-stroke.

Methods

This rapid systematic review identifies occupational therapy interventions for older adult stroke patients that increase their independence with ADLs. Six doctoral occupational therapy students identified 613 relevant articles from PubMed and 360 articles from CINAHL for a total of 973 articles during an evidence search. While searching, a filter to limit the articles to the ones published within the last 10 years was applied. All articles included were published between 2014 and 2024. Levels of evidence were defined according to guidelines published by the Oxford Centre for Evidence-Based Medicine (OCEBM) for this study (2019). Levels I, II, and III were included, while levels IV and V were excluded. All articles were imported to Covidence, a data extraction and analysis program, to identify the studies that answered our primary research question. Figure 1 depicts the PRISMA table that shows the process of the articles being chosen and reasons for exclusion. After title and abstract screening and full-text screening, 28 articles were chosen to be used in this review.

The following search terms were utilized for article searches in CINAHL:

> *(MH “occupational therapy” AND MH “stroke” AND “activities of daily living”) OR (ot or occupational therapy or occupational therapy intervention or occupational therapist) AND (stroke or cerebrovascular accident or cva) AND (activities of daily living or adl or occupational performance or everyday functioning or daily functioning or daily routine or daily activities)*

The following search terms were utilized for article searches in PubMed:

> *((("Stroke"[Mesh]) OR "CVA" OR "cerebrovascular accident" OR "stroke") AND (("Activities of Daily Living"[Mesh]) OR "ADL" OR "daily routine" OR "daily functioning" OR "activities of daily living") AND (("Occupational Therapy"[Mesh]) OR "OT" OR "occupational therapist" OR "occupational therapy intervention" OR "occupational therapy"))*

To be included in this review, all articles were required to meet the following criteria:

- Published within the last 10 years
- Participants aged 60+
- Participants who suffered a stroke
- Evidence levels I, II, and III according to OCEBM (2019)
- Outcome measures ADL independence

Articles were excluded from this review for the following reasons:

- Published more than 10 years ago
- Participants aged <60
- Participants who did not suffer a stroke
- Articles published in a non english language
- Irrelevant study designs including systematic reviews, meta-analysis, descriptive/qualitative studies, case, reports, cochran reviews, etc.

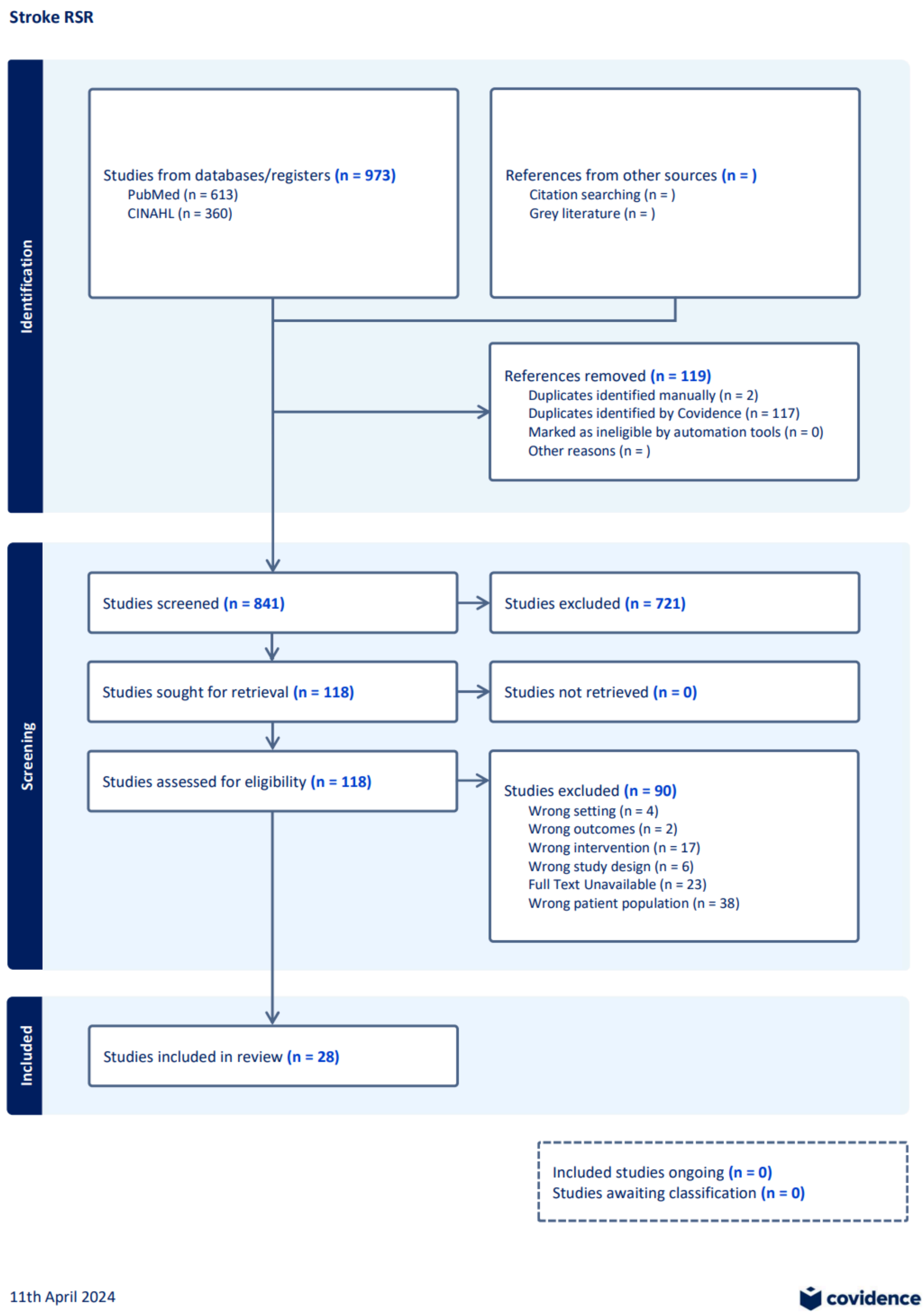

Figure 1. Covidence PRISMA diagram.

Results

Task-Oriented Training

Task-oriented training (TOT) is a functional intervention approach focused on neuroplasticity and motor control through repetitive, activity-based, and client-centered performance tasks (Moon, 2018). It involves intensive task-oriented practice, grading the task difficulty, and variable environmental parameters to determine optimal occupational performance for the patient. TOT provides an opportunity to create motor learning strategies best suited to client motivation levels and enhances neuromuscular connections for successful movement patterns (Chanuk, 2015). Seven studies were found on TOT intervention. All seven articles found significant findings that contributed to ADL independence. Out of these studies, five were Level 1 and two were Level 3. Five of these focused on TOT and two focused on dual-task training.

Chanuk et al. (2015) found that a 4-week TOT program showed improvements in hand function and ability to complete activities of daily living for stroke recovery when begun within six months of the CVA. This study focused on tasks related to eating, dressing, personal hygiene, and standing up/sitting down. Almhdawi et al. (2016) found that a task-oriented (TO) approach is an innovative, client-centered, effective UE post-stroke rehabilitation intervention that showed significant and clinically meaningful functional improvements. However, the TO approach did not show significant improvements in the WMFT quality scale, UE AROM, and strength measures. Moon et al. (2018) found that their task-oriented circuit training (TOCT) program using rehabilitation tools had more significant impacts on improvements in functional UE use when compared to the NDT group, although improvements seen in this group were less significant. Each group had 30 min of treatment 5-6 times a week for 4 weeks and used 3 assessments pre and post to determine changes in outcomes. Woodbury et al. (2016) found matching individual ability to task difficulty is effective in improving UE motor ability. By continually matching task difficulty to patient ability, the sessions maintained optimal challenge and ensured repetition of novel movements. Participants gained UE motor function, shoulder-elbow coordination, and less trunk displacement. However, comparing person-ability and item-difficulty measures showed no statistically significant differences. Fleming et al. (2014) predicted the amount of arm use after receiving 12 sessions of either active or sham somatosensory stimulation followed by 30 minutes of TST. They found that an increase in self-reported use of one's paretic arm depends on the change in functional ability the stroke survivors experienced. Using the UE in ADLs requires a high functional ability of that arm.

An et al. (2021) found that dual-task training when combined with attention and executive function during daily living activities was found to be meaningful, as it encouraged active participation and motivation. This study compared a control group that received 20 minutes of single-task training and 10 minutes of conventional OT, while the experimental group received 20 minutes of dual-task training and 10 minutes of conventional OT. The dual tasks combined attention or executive function with ADLs. Park et al. (2019) found that dual-task training is effective in improving UE function and performance in ADLs. They found statistically significant improvements in both upper limb function and the ability to perform ADLs.

Virtual Reality and Video Games

Video games and Virtual Reality (VR) are newer interventions for individuals who are recovering from a stroke. Interventions such as video games and immersive VR have been showing promising improvements in post-stroke UE functions. Commercial video game programs with motion sensors like Wii Sports are being used as accessible VR options to simulate functional ADLs and to improve balance and coordination. The use of VR for rehabilitation post-stroke is providing an innovative and accessible way to integrate ADL practice into post-stroke care.

Three out of four studies covering VR and video game interventions included in this RSR found significant improvements in ADL participation and upper extremity (UE) functioning. Of the four studies 2 were level 1 - (Samar et. al., 2016) (Rodriguez et. al., 2021), 1 study was level 2 - (Choi et. al., 2014), and one study was level 3 - (Jung et. al., 2017). Rodriguez et. al. found that the basic standard of care and rehabilitation strategies combined with VR seems to improve motor function in the UE and autonomy of ADL participation (2021). In the same study, they observed decreased muscle tone in both the control group and the experimental groups with the biggest change being observed in the experimental group. A study completed by Choi et. al. also found VR to be a good alternative to task-oriented training when focusing on UE functioning. They stated " VR movement therapy had significant effects on ADL and arm function" (Choi et. al., 2014). VR's impact on UE functioning and ADL participation was also studied by Jung et. al. This study found that "there were significant differences in the pre-test outcomes of arm and pre-and post-test outcomes of hand in the FMA between the two groups" (Jung et. al., 2017). All three of these studies found significant results in UE functioning and ADL participation after participating in VR interventions.

A similar study conducted by Samar et. al. looked at UE functioning and ADL participation in relation to VR interventions and video game interventions. This study was not significant or generalizable due to its low number of participants. They hypothesize that further research findings will show that "the combination of video games with traditional therapy in occupational therapy can facilitate the motor recovery and transfer of daily-use of the weaker UE of individuals recovering from stroke" (Samar et. al., 2016). As VR is emerging and being integrated into stroke recovery, further research is required to develop a long-term understanding of its impact on ALD and UE functioning.

Technology

New computerized technologies such as The TENZRTM and the Neuro Tracker wearable wrist sensor have been undergoing more and more research. The Neuro Tracker is a wearable wrist sensor device that tracks functional reach and grasp activities using multiple sensors detecting finger movement, wrist movement, and grip force (Yang et. al., 2021). This wrist sensor can be worn at all hours of the day and during all ADLs that do not involve water. The wrist sensors are used in conjunction with computer software to collect data. The software can use a machine learning process in order to collect movement data and create an algorithm designed to be able to detect ADLs that the participant does throughout the day (Chen et. al., 2021). This software can give context on how the participant uses their movements functionally rather than measuring only the amount of movements. Two level III studies were found for wrist sensors and machine learning algorithms.

Chen et. al. conducted a study that required participants to wear a wrist sensor to complete ADL tasks during the first visit and atomic activities on the second visit. They state that the XGBoost and SVM algorithms were most successful in detecting ADLs while the top 3 activities most accurately detected are sweeping, eating with hands, and vacuuming. Yang et. al. required participants to wear wrist sensors at home and within the community to track bilateral upper extremity use. A correlation was found between decreased upper extremity motor function and increased asymmetry index. This indicates that individuals with severe unilateral upper extremity impairments tend to use their unaffected hand at a much higher frequency than their affected hand.

Robot-assisted therapy uses upper limb devices to facilitate repetitive muscle stimulation of varied intensities combined with specific task training to promote upper limb function or recovery. Robot-assisted therapy devices provide 3 planes of assistive movement and movement feedback during situational activities (Tang et. al., 2023). Two level I studies were found for robot-assistive technology. Iwamoto et. al and Tang et. al both found that robot-assistive technology in conjunction with occupational therapy improves ADL performance. However, Tang et. al. suggest that robot-assistive technology alone is not a superior treatment for improving motor function.

Constraint-Induced Movement Therapy

Constraint-induced movement therapy (CIMT) is an evidence-based approach that focuses on restoring movement and function of upper limbs in therapy post-stroke (Galvão et al., 2021). The CIMT technique involves using a mit, sling, or splint to limit the use of the unaffected upper extremity while encouraging the affected side to participate in activities. A modified version of CIMT (mCIMT) was created to lower traditional limitations (i.e., time and available resources) of regular CIMT protocols (Ju & Yoon, 2018). The purpose of the CIMT technique is to improve the use of the paralyzed or paretic arm by practicing repetitive planned task-oriented movements for multiple hours a day. Four studies about CIMT's impact on ADL independence for individuals post-stroke were reviewed. Three out of the four studies revealed significant changes in ADL independence. Out of these studies, one was Level I (Garrido et al., 2023), one was Level II (Ju & Yoon, 2018), and two were Level III (McCluskey et al., 2020; Galvão et al., 2021).

Garrido et al. conducted a randomized, double-blind clinical trial to evaluate the effects of CIMT with and without bihemispheric transcranial direct current stimulation (tDCS) (2023). Both the intervention and control groups received mCIMT for 7 days for 20 minutes each time, but only the intervention group received active bihemispheric tDCS in addition to mCIMT (Garrido et al., 2023). Findings indicate that the combination of mCIMT and bihemispheric tDCS improves a stroke patient's functional recovery and increases their independence in ADLs (Garrido et al., 2023).

Ju & Yoon conducted a nonrandomized case-control study where 28 participants were divided into mirror therapy (MT) and mCIMT groups (2018).

Each group received their respective interventions, ADL training, and exercise for 20 minutes each five times a week for three weeks. While both mCIMT and MT showed upper extremity functional improvements, only mCIMT showed increased upper extremity function correlated to ADL performance in hygiene, feeding, and dressing (Ju & Yoon, 2018).

McCluskey et al., conducted a pre-post implementation study in which participants adhered to a strict 10-day CIMT program that involved extensive training of the affected upper extremity, daily repetitions of exercises, activities to be completed at home, and use of the mitt for 90% of their day (2020). Results show statistically significant improvements in outcomes for the participants' scores of the Motor Activity Log (MAL), Box and Blocks Test (BBT), Canadian Occupational Performance Measure (COPM), and Motor Assessment Scale-Upper Limb (MAS-UL) (McCluskey et al., 2020). However, Galvão et al., conducted a similar pre-post implementation study and found different results. In Galvão et al.'s study, participants completed CIMT activities at home, used the glove for 90% of their day, and received group CIMT therapy once a week for five months (2021). Results reveal insignificant changes between the pre-treatment and post-treatment scores for the MAL, Wolf Motor Function Test (WMFT), and COPM (Galvão et al., 2021).

Electrical Stimulation

Electrical stimulation (E-stim) is a mechanism that sends electrical stimulation through the skin to muscles by applying short, programmed bursts of electric current to specific nerves and muscles. E-stim is used to stimulate injured muscles or mimic nerves to make muscles contract. As muscles contract, blood flows through more, and helps injured muscles repair and are strengthened as they contract. E-stim also helps re-teach muscles how to respond to the injured nervous system components that are a common result of stroke. A total of 6 experimental studies, five level I and one level III, regarding electrical stimulation and its application for ADL rehabilitation post-stroke were analyzed to assess electrical stimulation effects when used during occupational therapeutic rehabilitation.

The level III study done by Cuesta-Gomez and colleagues examined changes in the functional reaching abilities of the affected UE when functional electrical stimulation (FES) is applied, resulting in significant increases in shoulder flexion and elbow extension when compared to the placebo control group (2019). When FES was applied to the paretic lower limb for first-time stroke patients, functional muscle tone was maintained and spasticity was delayed, leading to enhanced balance during ADL activities and overall motor function of the LE (You et al., 2014).

Bihemispheric transcranial direct current stimulation (tDCS), a noninvasive technique that excites the cortical motor system, was utilized in three of the level 1 experimental studies (Alisar et al., Maeda et al., and Liao et al.) to analyze its impact on voluntary motor abilities of a paretic limb post-stroke. Alisar and colleagues found when tDCS is combined with OT treatment, there is an increase in neuronal activity within the cerebral cortex and enhanced plasticity of synapses, resulting in significant improvements in functional motor control (2020). Maeda et al. examined the impact of peripheral nerve stimulation (to median and ulnar nerves) during OT treatment, following exposure to repetitive transcranial stimulation, to discover a significant increase in Fugl-Meyer, MAL, and WMFT scores, specifically hand function levels (2020). When tDCS was integrated into treatments in sequence before mirror therapy intervention, there was an increase of efficiency in motor control in the hand for ADLs, and reduced movement time in the paretic hand, positively impacting occupational performance (Liao et al., 2020).

The final study, completed by Moon et al., examined transcutaneous electrical nerve stimulation (TENS) paired with TOT to address UE spasticity and function for ADLs. The TENS group received the stimulation 30 min before OT and then was followed by TOT to maximize muscle activation, resulting in significant findings of decreased spasticity, increased UE function, and overall improvement in ADLs (2021).

Sensory Interventions

Sensory stimuli, both exteroceptive and proprioceptive, have been found to be an effective technique to be used alongside traditional occupational therapy interventions to improve upper extremity motor function and ADL participation for years after experiencing a stroke, according to a level II single-blind clinical trial by Derakhshanfar (2021). Significant changes in motor function, ADLs, and muscle tone were not found until after the third and sixth week of intervention. No significant changes were documented prior. This study focused their sensory stimulations around the Rood approach, which includes brushing, icing, and stretch pressure as exteroceptive stimuli, as well as weight bearing in different body positions to enhance proprioceptive stimuli. Further studies using this protocol need to be conducted to determine if sensory stimuli improvements are generalizable to this geriatric population (Derakhshanfar, 2021).

Strategy Training

Strategy training is an intervention that teaches patients to self-identify problem areas within their daily activities, develop goals and create a plan to address the problem(s), and promote independence by strengthening their ability to perform those meaningful tasks. A level II study by Skidmore et al. found that patients' level of awareness post-stroke may not impact their response(s) to a strategy training approach. However, the study suggests that this style of training may improve independence more efficiently for post-stroke patients with poor self-awareness. The study concluded that the results were not significant due to the small sample size; further research is suggested to determine if strategy training is an effective intervention for ADL improvements in older adults (2018).

Ankle-Foot Orthoses

A doctor could prescribe an ankle-foot orthosis for a post-stroke patient if they have difficulty clearing their foot from the ground during gait or ambulating successfully in their environment. Occupational therapy's role in this intervention is to provide patient education on the purpose of using an AFO and to practice completing ADLs the patient regularly performs while wearing the AFO. A level III single group case/control study by Don Kim et al. found that wearing an AFO can reduce asymmetry during weight bearing and ultimately decrease the patient's fall risk. They concluded that for patients experiencing hemiplegia, wearing an AFO supports easier weight shifting in differing directions (2015). The limitations of this study were not significant enough to impact the result, however, the small sample size prevents the results from being generalizable to the studied population.

Discussion

In response to the initial clinical research question investigating what OT interventions are effective for post-stroke individuals 60+ to achieve ADL independence when compared to standard of care, five major themes and three miscellaneous intervention strategies were identified. The studies included present moderately strong evidence for the OT interventions used to increase ADL performance in post-stroke older adults overall. TOT, virtual reality and video game interventions, technology, and electrical stimulation indicate a strong level of evidence. CIMT indicates a moderate level of evidence. Interventions such as strategy training and sensory stimuli exposure may benefit individuals based on their personal recovery experience, however, these have not been proven as evidence-based interventions that meet standards for clinical utilization within the general post-stroke population. Sensory interventions, AFOs, and strategy training all indicate a low level of evidence. Based on these findings, the most beneficial interventions for this population are TOT, electrical stimulation, and modified CIMT, however, in terms of accessibility, mCIMT is most practical.

Future research should include studies focused strictly on the geriatric stroke population (65+) to determine the best interventions for older adults. The protocols from studies included in this rapid systematic review need to be replicated to determine if more results are significant.

Limitations

The included 28 studies each had various limitations such as small sample size, lack of a control group, lack of blinding, co-treatments, and interventions administered by health professionals other than an OT. Many of the included studies were completed internationally which limits generalizability within US clinical settings and Western cultures. Further research should be completed to determine the relevance and correlations between stroke populations across the world. Within the included studies, there are limited data on patient follow-up post return to home to examine retained gains following the interventions provided in the hospitals or rehab settings.

This rapid systematic review was tailored strictly to include only quantitative studies for data collection and analysis; therefore it is limited in its qualitative data representation and correlations between both types of data. Additionally, the ideal age for older adults (65+) had to be lowered to a mean age of 60+, due to limited research done solely on 65+ patients. Many studies lacked specification about what exact age each result pertained to, therefore the 60+ mean age was assumed to be relevant to the study findings.

Conclusion & Implications for Practice

All aforementioned interventions for stroke rehabilitation are more beneficial when paired with traditional occupational therapy compared to receiving the basic standard of care. TOT was determined to be the most versatile throughout different settings due to its clinical accessibility, as it requires no specific equipment to implement. Modified CIMT maintains the foundations of traditional CIMT while using a less intense and less time-consuming intervention regimen; therefore, it was concluded that mCIMT is more practical and accessible for OTs and their patients compared to the traditional CIMT protocol. Wrist sensors have clinical utility to successfully track the incorporation of the affected UE during OT sessions, as well as monitor the progress of the affected arm during reaching and grasping tasks performed in the home and community. Furthermore, electrical stimulation can be implemented in various forms (FES, TENS, tDCS) to target specific client needs and can be used both independently for muscle activation or paired with TOT and mirror therapy to facilitate enhanced ADL performance. In conclusion, compared to the basic standard of care, the most evidence-based interventions to improve ADL independence for 60+ post-stroke patients are as follows: TOT, CIMT/mCIMT, technology, E-stim, VR and virtual reality, sensory interventions, ankle-foot orthoses, and strategy training.

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Table 1. Evidence Table.

Intervention 1: Task-Oriented Training					
Title	**Author/Year**	**Level of Evidence, Study Design, Participants, Inclusion Criteria**	**Intervention & Control Groups**	**Outcome Measures**	**Results**
Self-perceived utilization of the paretic arm in chronic stroke requires high upper limb functional ability	Fleming, M. K., Newham, D. J., Roberts-Lewis, S. F., & Sorinola, I. O. (2014)	Level 1, Randomized Control Trial N = 33 **Inclusion Criteria:** ">18 years, single stroke of ≥3 months duration, unilateral upper limb weakness, completed upper limb rehabilitation, and the presence of motor-evoked potentials in response to transcranial magnetic stimulation with the muscles either at rest or preactivated (to ensure potential for functional improvement)."	**Intervention Group:** Active somatosensory stimulation followed by 30 minutes of TST, 3x/week for 4 weeks. 30-minute sessions were divided into 5 minute sections: stretching and warm-up, grasp, grip, pinch, gross movements, and patient choice. **Control Group:** Sham somatosensory stimulation followed by the same TST intervention.	Motor Activity Log Fugl Meyer Assessment Action Research Arm Test	Good functional arm use in the paretic limb is necessary for increased use of that arm. Self reported use of paretic arm after TST depends on the change in functional ability the stroke survivor's experienced.
Impact of task-oriented training on hand function and activities of daily living after stroke	Chanuk Yoo, JuHyung Park (2015)	Level 1 N = 32 **Inclusion:** "(1) patients diagnosed with cerebral hemorrhage or cerebral infarction less than 6 months prior to the training (2) test results of manual	**Intervention Group:** "The task-oriented training included eating (using a cup and spoon), dressing (wearing and taking off a shirt, using a belt and zipper), personal hygiene (using a towel, combing, tooth brushing), and standing up and sitting down (standing up from and sitting down	Modified Barthel Index Jamar Hydraulic Hand Dynamometer & Pinch Gauge Box & Block Test	"Hand function and ADLs were improved after the training. According to these results, 4-week task-oriented training leads to a significant improvement of stroke patients' hand function and ability to perform activities of daily living."

		muscle tests of the affected hand were higher than ‘fair’ with spontaneous movement (3) recognition ability was sufficient to make routine communications and follow directions (4) patients could move independently with or without a wheelchair for more than 30 min”	on a chair).” 30 min/day for 4 weeks **No Control Group.**		
The effects of task-oriented circuit training using rehabilitation tools on the upper-extremity functions and daily activities of patients with acute stroke	Moon, J.-H., Park, K.-Y., Kim, H.-J., & Na, C.-H. (2018)	Level 1, randomized control trial N= 18 **Inclusion**: “(1) acute stroke patients who developed their condition within the past 30 days and were confirmed to have hemiparesis due to cerebral infarction; (2) those who scored 24 points or above in the Mini-Mental State Examination Korean version, and could understand instructions; (3) those who did not have serious joint contracture, or musculoskeletal pain or fracture; (4) those whose Brunnstrom recovery stage in the proximal and distal regions of the affected upper extremities was 3 or below;	**Intervention Group:** Task-Oriented Circuit Training, TOCT included 6 different tasks in which subjects performed for 5 minutes in each task in a circular manner. Each task was based on 4 levels of difficulty and the therapist provided a task fit for the subject’s ability level. 5-6 days/week for 4 weeks for 30 min **Control Group:** neurodevelopmental treatment (NDT); The control group underwent NDT to improve the functions of the trunk and upper extremities. In this study, the NDT group performed its training without using tools under the guidance of therapists. The intervention consisted of a preliminary exercise for 10 minutes and an NDTbased manual exercise for 20 minutes. 5-6 days/week for 4 weeks for 30	Fugl-Meyer (FMA) Motor Activity Log (MLA) Stroke Impact Scale (SIS)	Each group exhibited statistically significant improvements in FMA, MAL, and SIS scores for all except “using the spoon & chopsticks” in the control group ($p < 0.05$). The TOCT group achieved statistically significant improvement in the MAL, arm and grip strengths on the affected side, and “using the spoon & chopsticks” in the SIS, when compared to the control group

		and (5) those who had sufficient endurance to engage in 30 minute training sessions.”	min		
Effects of activities of daily living-based dual-task training on upper extremity function, cognitive function, and quality of life in stroke patients	An, H. S., & Kim, D. J. (2021)	Level 1, Randomized Control Trial N= 30 **Inclusion:** **“**Those with disease onset within the past 6 months, those who scored at least 20 points on the Korean version of the Mini-Mental State Examination (K-MMSE) and were able to follow the researcher’s instructions, those in Brunnstrom Recovery Stage (BRS) 3 or higher, and those who had no issues in communication or problems with vision or hearing and could follow instructions.”	**Intervention Group:** performed 20 minutes of dual-task training and received 10 minutes of conventional occupational therapy. The dual tasks combined attention or executive function with daily life activities 5 days a week for 5 weeks.” **Control Group:** “20 minutes of singletask training and received 10 minutes of conventional occupational therapy. single tasks consisted of sensory stimulation training on the paralyzed side, upper extremity muscle strength training, cognitive and perceptual training, and fine hand movement using tools. Completed 5 days a week for 5 weeks.”	Korean version of the Mini Mental exam (K-MMSE) Manual Function test Digital Span test Executive Function Performance Test Korean version	In stroke patients, dual-task training that combined attention and executive function with daily living activities was found to be meaningful, as it encouraged active participation and motivation
Matching Task Difficulty to Patient Ability During Task Practice Improves Upper Extremity Motor Skill After Stroke: A Proof-of-Concept Study.	Woodbury ML, Anderson K, Finetto C, Fortune A, Dellenbach B, Grattan E, Hutchison S. (2016).	Level 3, one group nonrandomized feasibility study, single group design N = 10 **Inclusion:** “experienced stroke more than 3 months prior,	**Intervention Group:** “Targets were repetitively practiced within the context of client-selected functional tasks not in isolation. We developed a detailed study-specific treatment activity menu that linked each of the 30 FMA-UE voluntary movement items to functional	Wolf Motor Function Test	“All participants were able to complete 200 movement repetitions per session in an average of 1.5 to 2 hours without adverse events, pain, or fatigue. By continually matching task difficulty to patient ability, the sessions

		exhibited voluntary paretic shoulder flexion greater than 30 degrees with simultaneous elbow extension greater than 20 degrees to enable engagement in treatment-related reaching tasks, demonstrated passive range of motion throughout the paretic UE within 20 degrees of normal values, 21 to 90 years of age”	tasks that primarily require the item’s arm movement.” **No Control Group.**		maintained optimal challenge and ensured repetition of novel movements. Participants’ gained UE motor function (WMFT) and shoulder - elbow coordination (IOC) while also demonstrating less TD.”
Efficacy of occupational therapy task‑oriented approach in Upper Extremity post‑stroke rehabilitation	Al Mahdawi, K. A., Mathiowetz, V. G., White, M., & delMas, R. C. (2016)	Level 1, Randomized, Single-Blinded, Cross-Over Trial N = 20 **Inclusion Criteria:** “needed to demonstrate active anti-gravity movements of at least 10° of shoulder abduction and flexion as well as 10° of elbow flexion-extension in the more-affected UE.”	**Intervention Group: Immediate intervention** Received 6 weeks of TO intervention, followed by 6 weeks no intervention. TO intervention included two 1.5 hour sessions/week for 6 weeks, focused on individualized intervention goals, both in clinic (70% of time) and at home (30% of time). TO also included homework functional and impairment exercises (1-1.5 hours/day). **Control Group: Delayed intervention** 6 weeks of no intervention control, followed by TO intervention for 3 hours/week for 6 weeks. TO intervention was the same.	Canadian Occupational Performance Measure Motor Activity Log Wolf Motor Function Test Dynamometry AROM	A TO approach is an innovative, client-centered, effective UE post-stroke rehabilitation intervention. With 3-hour sessions for 6-week, study participants showed significant and clinically meaningful functional improvements. However, the TO approach did not show significant improvements on the WMFT quality scale, UE AROM, and strength measures.

Dual task training effects on upper extremity functions and performance of daily activities of chronic stroke patients	Park, J. (2019)	Level 3, Single Group Pretest Posttest Design N = 21 **Inclusion Criteria:** “diagnosis of hemiplegia induced by a stroke which has occurred at least 6 months from the initial onset, and had a score of at least 20 on the Mini Mental State Examination-Korean [indicating the capability to follow the instructions of the researcher, capability of independent walking for 5 minutes at a comfortable pace, and the absence of neurological or orthopedic diseases other than stroke.”	**Intervention Group:** Dual task training performed for 30 minutes, 5 days/week, for 4 weeks. The applied individual program for upper limbs included moving beans with a spoon, classifying wooden blocks by color, and opening bottle caps. **No Control Group.**	Box and Block Test Korean Modified Barthel index	Dual task training effectively improved UE function and performance of ADLs. Because studies have shown that the more the training/rehabilitation environment is similar to a person’s home environment, the better the therapeutic interventions will be transferred home to patient’s real lives.
Intervention 2: Virtual Reality & Video Games					
Effectiveness of commercial gaming-based virtual reality movement therapy on functional recovery of upper extremity in subacute stroke patients	Choi, J. H., Han, E. Y., Kim, B. R., Kim, S. M., Im, S. H., Lee, S. Y., & Hyun, C. W. (2014)	Level 2, randomized single blind study N= 20 **Inclusion:** “-clinical diagnosis of subacute stroke confirmed by neuroimaging (computed tomography or magnetic resonance imaging), -hemiparesis of the upper extremity (upper limb score	**Intervention Group:** Participants received commercial gaming based VR movement therapy using the Wii (Nintendo) for 30 minutes a day. delivered five times a week for 4 weeks and received conventional rehabilitation therapy except for OT. Wii games: The swordplay, table tennis, and canoe games were used in the current study, as these involve motor function and are of interest to older patients. The	Manual function test (MFT), box and block test (BBT), grip strength Fugl-Meyer Korean Modified Barthel Index (K-MBI) Korean Mini	“Commercial gaming-based VR movement therapy would be an effective alternative to high-intensity, task-oriented, repetitive training after a stroke. After the 4-week intervention, both groups showed improvement in the score of FMA-UL. Also, both groups showed significant improvements in K-MBI, MFT, and BBT scores; These results

		of the Fugl-Meyer Assessment <50 -MMT grade no more than 2/5 in hemiparetic shoulder -Ability to follow more than one step directions	swordplay game involved performing flexion, extension, internal and external rotation of the shoulder, and flexion and extension of the elbow. The table tennis and canoe games also required upper extremity motions including internal and external rotation of the shoulder, flexion and extension of the elbow, and pronation and supination of the forearm. All the participants were instructed to play the games with their hemiparetic upper extremity. 5x/ week for 4 weeks , 30 min **Control Group:** Participants in the control group received conventional OT for 30 minutes a day delivered five times a week for 4 weeks received conventional rehabilitation therapy Conventional OT was goal-oriented and highly repetitive training assisted by occupational therapists. It was composed of stretching and strengthening exercises using full range of motion of the upper extremity, which was a task-oriented therapy for the ADL, fine motor training, and sensory motor recovery. The occupational therapist chose the appropriate tasks for the	Mental Examination (K-MMSE)	indicated that our VR movement therapy had significant effects on ADL and arm function, but not on hand grip strength. A recent systematic review confirmed the effect of VR therapy on upper limb recovery and ADL function after a stroke and highlighted the potential value of commercial VR gaming as a tool for stroke rehabilitation. Our conclusion was consistent with this view.”

			individual patient and developed them in stages. 5x/ week for 4 weeks , 30 min		
Weaker Upper Extremity of Individuals with Subacute Stroke: A Pilot Randomized Controlled Trial.	Samar Hmaied Assadi, Irina Zwecker Lazar, Debbie Rand (2016).	Level 1, RCTs N = 21 **Inclusion:** "(1) Stroke occurred within previous 10 weeks (2) Participant can sit without support for at least 10 seconds, demonstrating mild to moderate UE weakness (scores ranging from 28-90 points on the Motricity Index)" and gave consent	**Intervention Group:** "VG consoles (games) were used to encourage UE movements while the participant was seated. The console was chosen based on the participant's UE motor ability. The Wii and PS3 MOVE both require the use and operation of a hand-held remote while the EyeToy does not. Using different VG consoles for different sessions permitted for more interest." **Control Group:** "One of three occupational therapists, who were not aware of the study objectives and worked in the rehabilitation ward, treated the participants' UE using eclectic traditional approaches (such as neurodevelopmental, motor learning or task-specific). Tasks were therapeutic (such as rolling a ball, transferring cubes) and functional (setting the table, sorting cards) and included therapeutic aids as well as functional objects. Prior to the study the three occupational therapists met with the researchers to ensure consistent	Fugl-Meyer Jamar Dynamometer Action Research Arm Test (ARAT) ActicalTM accelerometers (Mini Mitter Co.)	"This pilot study demonstrated that VG can be used as a tool for treating the UE at the subacute stage post-stroke, leading to improvement of the motor ability, functional ability and grip strength of the UE. Possibly, the combination of VG with traditional therapy in occupational therapy can facilitate the motor recovery and transfer of daily-use of the weaker UE of individuals recovering from stroke." "No statistical differences in demographic or stroke information were found (see Table 1). Two participants in the traditional intervention had sustained a recurrent stroke yet had higher MI scores, indicating less UE impairment."

			treatment for the participants across therapists.” 3 1-hour sessions/week		
Effects of Specific Virtual Reality-Based Therapy for the Rehabilitation of the Upper Limb Motor Function Post-Ictus:	Rodríguez-Hernández, M., Polonio-López, B., Corregidor-Sánchez, A. I., Martín-Conty, J. L., Mohedano-Moriano, A., & Criado-Álvarez, J. J. (2021).	Level 1, RCT, 2 groups N= 46 **Inclusion Criteria**: “Age: 18 to 85 years; (2) maximum evolution time of six months; (3) upper limb motor involvement (Fugl-Meyer Assessment and Modified Ashworth Scale); (4) dependence in ADLs (Stroke Impact Scale, version 3.0); (5) life expectancy greater than six months (absence of life-threatening diagnosis, such as end-stage cancer); and (6) absence of other serious and disabling pathology”	**Intervention Group:** “Combined conventional upper and lower limb strength and motor training (50 min physiotherapy and 50 min occupational therapy) with SVR technology devices (50 min) for 15 sessions over 3 weeks.” **Control Group:** “Received only conventional training in physiotherapy (75 min) and occupational therapy (75 min). For 15 sessions over 3 weeks”	Fugl Meyer Modified Ashworth	The conventional rehabilitation approach combined with SVR appears to be more effective than conventional physiotherapy and occupational therapy alone in improving upper limb motor function and execution and autonomy in ADL in stroke survivors. Virtual reality as a complement to conventional rehabilitation treatment is associated with a decrease in muscle tone and greater overall recovery after stroke diagnosis
Effects of virtual reality intervention on upper limb motor function and activity of daily living in patients with lesions in different regions of the brain.	Jung, S.-M., & Choi, W.-H.. (2017)	Level 3, Pre - Post Test N= 14 **Inclusion Criteria**: “The inclusion criteria were as follows: (1) adults with hemiplegia with onset for the past 6 months, (2) no	Participants were divided into 2 groups (Basal Ganglia (BGG) and Middle Cerebral Artery (MCAG)) based on where their stroke occurred in the brain, but both groups received the same intervention. **Intervention Group:** “Motion-controlled VR games,	Fugl-Meyer Assessment (FMA) Korean Modified Barthel Index (K-MBI)	The findings show “significant differences in the pre- and post-tests outcomes of the Arm and Coordination and Speed (CS) in the FMA and K-MBI in the MCAG”. Also, “significant differences were also seen in

		limited range of motion in the upper extremities, and (3) no visual deficit".	like the Nintendo Wii and Sports, were used in this study" as the intervention to stimulate functional activities and improve balance and affected side function. The VR game was played for 30 minutes at a time for a total of 20 sessions. **No Control Group.**		all sub-tests of FMA and K-MBI in the BGG". "In this manner, VR improved the upper limb function of patients in the BGG better than those in the MCAG. This result indicates that patients in the BGG have neuroplasticity in the brain, which is consistent with the results of the study conducted by Jang and colleagues".
Intervention 3: Technology					
Measuring Activities of Daily Living in Stroke Patients with Motion Machine Learning Algorithms: A Pilot Study.	Pin-Wei Chen, Nathan A. Baune, Igor Zwir, Jiayu Wang, Victoria Swamidass, and Alex W.K. Wong. (2021)	Level 3, Pilot study One group, nonrandomized N=11 **Inclusion**: "(1) age 18+; (2) English-speaking; and (3) mild stroke as defined by baseline National Institutes of Health Stroke Scale (NIHSS) score from 0 to 5. We chose to study patients with mild stroke because motor function and ability to accomplish basic ADLs are only minimally affected, increasing the chance that the protocol will be fully completed in an appropriate time and allowing us to adhere to the project	**Intervention Group:** One group of 11 subjects participated in 2 experiment visits. The first visit required the subjects to complete ADL tasks while wearing a wrist sensor (apple watch series 3). The examiner used a standardized script and minimal guidance to inform participants about the task they needed to complete. A machine learning (ML) software collected data during this session and labeled ADLs predicted. During the second visit, participants completed atomic activities for a total of 4 minutes while wearing the wrist sensor to train the ML algorithms to detect certain tasks. Atomic activity data was collected after ADL tasks to	Machine Learning algorithms (accurate detection, prediction, and labeling of ADLs) No OT specific outcome measures were used.	Wearable wrist sensors and ML software are useful at ADL detection in individuals post-stroke. (Specifically with XGBoost and SVM algorithms) "We found the top three activities that can be accurately classified are sweeping (0.95), eating with hands (0.88), and vacuuming (0.84), whereas other activities that had the lowest accuracy are serving on a plate (0.25) and pan stirring (0.32)."

		budget."	reduce the amount of influence the atomic activities would have on how the participants completed the ADLs. This also allowed the ADL completion to be more "natural" or closer to their normal ADL behavior. **No Control Group.**		
Bilateral Upper Limb Robot-assisted rehabilitation improves upper limb motor function in stroke patients: A study based on quantitative EEG - European Journal of Medical Research	Tang, C., Zhou, T., Zhang, Y., Yuan, R., Zhao, X., Yin, R., Song, P., Liu, B., Song, R., Chen, W., & Wang, H. (2023)	Level 1, Randomized Control Trial N= 24 **Inclusion:** "Diagnosis of stroke was confirmed by computed tomography (CT) and/or magnetic resonance imaging (MRI); (ii) aged 18–80 years old, clear consciousness, able to complete the corresponding assessment (Mini-Mental State Examination (MMSE) ≥ 20 points); (iii) first onset, course of 2 weeks to 3 months; (iv) the modified Ashworth spasticity assessment of the upper limb major muscle tension was less than or equal to grade 2; (v) Brunnstrom assessment of hemiplegic upper limb was in stage II–IV"	**Intervention Group:** "For the bilateral upper limb robot-assisted therapy, the patient is seated in the treatment chair between two upper limb rehabilitation robots. The robots are then adjusted so that the blue line on the robot arm is aligned with the patient's acromion. The upper limbs are secured to the end-effectors of the intelligent force feedback rehabilitation robot with glove straps to prevent slippage during treatment, and to secure the trunk. The training program was switched to bilateral arm training mode. The assistance force was adjusted to resist the gravity of arms. Then, the range of motion is calibrated according to the patient's active mobility or the therapist's prescription, and games with simultaneous bilateral movements are selected **Control Group:** Control group received a 60 min routine rehabilitation treatment,	Fugl Meyer Upper Extremity Barthel Index	"Findings suggest that the use of BRT in addition to conventional treatment improves ADL performance in stroke patients, but is not superior for improving motor function in patients. Quantitative EEG tests showed that BRT increased the connectivity of bilateral cerebral hemispheres, especially M1 and the contralateral SMA."

			including physical therapy (neuromuscular electrical stimulation, rolling, transferring, sitting, standing and walking) and occupational therapy (dressing, eating, grooming). Based on the routine treatment.”		
Real-World Functional Grasping Activity in Individuals With Stroke and Healthy Controls Using a Novel Wearable Wrist Sensor.	Yang, C., Liu, J., Simpson, LA., Menon, C., Eng, JJ. (2021)	Level 3, Quasi-experimental; controlled, but randomized N= 28 **Inclusion:** Intervention: “(1) were >18 years old; (2) had a stroke more than 3 months ago; (3) were right-hand dominant by self-report, (4) had difficulty using the affected UE; (5) had some voluntary movement in the affected UE, including the ability to lift the affected arm to chest level and hold for 5 seconds, some ability to extend the affected wrist, and some ability to grasp and release an object such as a cup handle; (6) were living in the community; (7) were able to understand and follow instructions” Control: “(1) were >18 years old; (2) were right-hand dominant by self-report; (3)	**Intervention Group:** 14 participants that met all inclusion criteria specific to stroke. They were instructed to wear one wrist sensor on each wrist for 3 days during all waking hours to track their hand use. Participants were instructed to remove the wrist sensors at night before bed to charge them and put them on again in the morning. Because the wrist sensor devices aren’t waterproof, the participants could also remove them to complete activities involving water. Participants were told to record all removals and time on an activity log. **Control Group:** 14 participants that met inclusion criteria specific to the control group. They were given all of the same instructions as the intervention group.	Fugl-Meyer Upper Extremity Assessment (FM-UE)21 was administered to characterize UE impairment. Rating of Everyday Arm-use in the Community and Home (REACH) Scale22 was used to characterize how the affected UE was being used in their daily lives. Control group did not complete assessments.	“The stroke group demonstrated less functional hand activities of the affected hand compared to that of the nondominant hand in the control group. This was represented by fewer daily hand counts, fewer hourly hand counts, and a larger asymmetry index (Table 2). No significant difference was observed in functional hand activities of the non affected hand of stroke participants compared to that of the dominant hand of the control group.” “A significantly strong and negative Spearman’s rank-order correlation was found between FM-UE and the asymmetry index ($\rho = -.70$, $P = .005$) (Figure 3), indicating that stroke participants with more severe UE motor impairment (lower FM-UE

		had no neurological conditions besides a stroke; (4) had no musculoskeletal disorders affecting the UE.”			score) had less functional hand activities of the affected hand (larger asymmetry index).”
Combination of Exoskeletal Upper Limb Robot and Occupational Therapy Improve Activities of Daily Living Function in Acute Stroke Patients.	Iwamoto, Yuji; Imura, Takeshi; Suzukawa, Takahiro; Fukuyama, Hiroki; Ishii, Takayuki; Taki, Shingo; Imada, Naoki; Shibukawa, Masaaki; Inagawa, Tetsuji; Araki, Hayato; Araki, Osamu. (2019)	Level 1, RCT N=30 (only 12 included in study) **Inclusion:** “(1) first-time stroke, (2) Brunnstrom recovery stage (Br-stage) II to IV, and (3) study participant within 2 weeks after stroke onset”	**Intervention Group:** 12 participants completed 2 blocks of the combination therapy, which includes occupational therapy and using a single joint Hybrid Assistive Limb (HAL-SJ). Therapy sessions were 40 minutes per day and at least 200 movements (elbow flexion and extension) were completed. **Control Group:** 12 participants completed 2 blocks of conventional occupational therapy without using the HAL-SJ. These sessions varied depending on the patient's symptoms. However, many included “passive or active mobilization, task-specific training, and ADL training”	12-grade hemiplegia recovery grade (upper limb) Brunnstrom Recovery Stage (Br-stage) Barthel Index (BI) Motricity Index (MI) Grip strength Modified Ashworth Scale (MAS) Sensory function Functional Independence Measure (FIM) Mini Mental State Evaluation (MMSE)	“The score change for the recovery grade (1-12) of hemiplegia was significantly higher during A than during B in both group A and group B, suggesting that combination HAL-SJ and occupational therapy has the positive effect of recovering upper limb function in stroke patients.” … “Both groups significantly improved during A in not only upper limb motor function but also ADL parameters such as FIM-motor, FIM-total, and BI-total. Subscore independent analysis revealed that the score changes of FIMupper body dressing and BI-dressing were significantly higher during A than during B in both groups.”

Intervention 4: Constraint Induced Movement Therapy					
Increasing the delivery of upper limb constraint-induced movement therapy post-stroke: A feasibility implementation study.	McCluskey A, Massie L, Gibson G, Pinkerton L, Vandenberg A. (2020)	Level 3, Pre – Post Implementation Study N= 16 **Inclusion:** "Occupational therapists recruited and consented participants who had attended outpatient occupational therapy in the previous year for upper limb retraining. These stroke participants were known to therapists, had active wrist and finger extension in their affected arm, and were likely candidates for CIMT."	**Intervention Group:** Prior to CIMT, participant goals were established using the COPM. CIMT intervention was given for 4 hours for 10 weekdays. "Components included (a) intensive training of the more-affected arm for 10 weekdays, with 1:1 supervision and shaping of targeted motor behaviors, and recording of daily repetitions; (b) a transfer package of behavioral techniques to transfer gains made outside supervised CIMT sessions, including a signed behavioral contract, 10 daily homework assignments, a homework diary, administration of 10 questions from the MAL each morning; and (c) use of a mitt restraint for 90% of waking hours worn on the less affected arm." **No Control Group.**	Motor Assessment Scale-Upper Limb (MAS-UL) Nine Hole Peg Test (NHPT) Motor Activity Log (MAL) Box and Block Test (BBT)	There were statistically significant improvements in pre and post outcomes for MAL, BBT, COPM, and MAS-UL. Findings reveal "mean differences between [1 week before CIMT] and [after 10 days of CIMT] were statistically significant for all measures except NHPT, also between [1 week before CIMT] and [4 weeks after CIMT]. The amount of change was clinically important at [after 10 days of CIMT] and [4 weeks after] for BBT and COPM. At [12 months after], most changes were maintained or there was a small non-significant reduction in scores."
Group-based constraint-induced movement therapy in the rehabilitation of chronic poststroke patients	Galvão, F. R., Silvestre, M. C., Gomes, C. L., Pereira, N. K., Nóbrega, V. T., Lima, W. S., ... & Cacho, R. O. (2021).	Level 3 (one group, nonrandomized) Retrospective single treatment group N = 6 **Inclusion:** "clinical diagnosis of ischemic or hemorrhagic	**Intervention Group:** "Participants were randomly divided into 3 stations, each with different shaping tasks, in line with CIMT methodology. Participants signed a behavioral contract whereby they agreed to perform some activities at home and use the glove for	Wolf Motor Function Test = Primary Outcome Motor Activity Log Canadian Occupational	"In the present study, no significant difference was found in the MAL, WMFT and COPM clinical scales between the pretreatment, posttreatment, and follow-up periods, or for the daily MAL, except the daily MAL-AOU and mean values for

		stroke, time since stroke has been more than 6 months, age over 18 years, unilateral sequelae according to the functional criteria of the original protocol, as follows: active movement of at least 45° of shoulder flexion and abduction, 20° of elbow extension, 10° of wrist extension, 10° of thumb abduction/extension and at least 10° of extension in 2 other fingers, based on goniometric assessment”	90% of waking hours. On completion of the protocol, participants were submitted to group care once a week for 1 hour a day, over 5 months, consisting of conventional exercises that targeted mobility and balance.” **No Control Group.**	Performance Measure (COPM)	repeated shaping tasks. This suggests that the 90-minute protocol may not be sufficient to rehabilitate these patients due to the short clinical treatment time, or that they had already achieved maximum functionality.”
Early transcranial direct current stimulation with modified constraint-induced movement therapy for motor and functional upper limb recovery in hospitalized patients with stroke	Garrido M, M., Álvarez E, E., Acevedo P, F., Moyano V, Á., Castillo N, N., & Cavada Ch, G. (2023)	Level 1; A randomized, multicentre, double-blind, clinical trial N= 70 **Inclusion:** “Hospitalized adults aged 18 years and older (average age of participants 60+), with an unihemispheric stroke, 2e14 days since the time of stroke, ischemic or hemorrhagic stroke, with UL hemiparesis (at least 20 of active wrist extension and 10 of finger extension), and who signed an informed consent form were included.”	**Intervention:** “Active bihemispheric tDCS combined with mCIMT for 7 days in 20 min sessions.” **Control:** “Sham bihemispheric tDCS combined with mCIMT for 7 days in 20 min sessions.”	Functional Independence Measure Grip FMA UE Wolf Functional Motor test	“Combining mCIMT with bihemispheric tDCS in patients hospitalized with acute-subacute stroke allows us to maximize the motor and functional recovery of the paretic upper limb in the early stages and independence in ADL, maintaining the effects over time.”

The effects of modified constraint-induced movement therapy and mirror therapy on upper extremity function and its influence on activities of daily living	Ju, Y., & Yoon, I.-J. (2018)	Level 2, two groups, nonrandomized N = 28 **Inclusion Criteria:** "1) Diagnosed as stroke by the doctor of rehabilitation specialist 2) Onset within 3 months 3) Able to follow 3 steps of command 4) Able to grip the objects with paralyzed arm 5) Unable to oppose thumb and other fingers with paralyzed arm 6) Wrist extension >20°, MCP (Metacarpophalangeal) joints >10°"	**Intervention Group: Mirror Therapy** MT for 20 minutes, ADL training for 20 minutes, and self-exercise with therapeutic equipment for 20 minutes. Mirror was placed in midline of the patient and the paretic arm hidden behind the mirror. The mirror therapy program consisted of shoulder, elbow, forearm, wrist, finger movement and hand exercise with therapeutic putty and hand size ball. **Control Group: mCIMT** mCIMT for 20 minutes, ADL training for 20 minutes, and self-exercise with therapeutic equipment for 20 minutes. Movements on shoulder, elbow, forearm, fingers joint on the affected side guided by the therapist were performed. Repetitive training was focused on muscle strengthening, gross motor exercise, and fine motor exercise. Activities with thera-band, grip power, therapeutic putty were applied for muscle strengthening. Moving the arch-ring, throwing and catching the ball, and cup shifting were provided in gross motor exercise and peg-boards and block construction were used for fine motor exercise. The speed, difficulty, frequency, weight of	Manual Function Test Korean Modified Barthel Index	While both mCIMT and MT showed UE functional improvements, but only mCIMT showed increased UE function correlated to ADL performance in hygiene, feeding, and dressing. MT group showed improvements in UE function, but did not show any influences on ADL performance. The biggest difference between the two is that the MT group did not move their affected arm, while the mCIMT group did.

			task were adjusted according to individually pronounced deficits and functions.		
Intervention 5: Electrical Stimulation					
Effects of peripheral nerve stimulation on paralysed upper limb functional recovery in chronic stroke patients undergoing low-frequency repetitive transcranial magnetic stimulation and occupational therapy	Maeda, M., Mutai, H., Toya, Y., Maekawa, Y., Hitai, T., & Katai, S. (2020)	Level 1, Randomized Control Trial N= 22 **Inclusion:** Stroke patients with upper limb hemiparesis Able to voluntarily extend at least three fingers including the thumb in the hemiparetic upper limb Able to raise the hemiparetic upper limb to at least the chest level, and more than six months since stroke onset.	**Intervention Group:** Peripheral nerve stimulation was administered to the median and ulnar nerves during OT. These stroke patients were treated with upper limb hemiparesis and were treated with non invasive magnetic stimulation therapy to the ulnar and median nerves and OT from October 2017 to November 2018 (n = 12). **Control Group:** Chronic stroke patients with upper limb hemiparesis who were treated with non invasive magnetic stimulation therapy to the ulnar and median nerves and OT from August 2013 to September 2017 (n = 104)	Fugl Meyer Motor Activity Log Wolf Motor Function Test	The Wolf Motor Function Test, Fugl-Meyer Assessment, and Motor Activity Log showed significant improvement after the intervention in the treatment group. The Fugl-Meyer Assessment hand score improved in the intervention group compared to minimal change in the control group.
Functional electrical stimulation early after stroke improves lower limb motor function and ability in activities of daily living	You, G., Liang, H., & Yan, T. (2014).	Level 1, Randomized, SIngle-Blinded, Controlled Trial N= 37 **Inclusion Criteria:** “(1) the first diagnosis was first-time primary cerebral infarction or hemorrhage that was confirmed by either	**Intervention Group:** The intervention group received FES to induce foot dorsiflexion and eversion for 30 minutes, 5 days per week for 3 weeks, along with the SR, 30 minutes of PT, 30 minutes of OT. All patients received a SR (standard rehabilitation) program including 60 minutes of physiotherapy based on neurodevelopmental	Composite Spasticity Scale Fugl Meyer Assessment Balance Modified Barthel Index	Compared to standard rehab alone, FES for 30 minute sessions, 5 days/week for 3 weeks on paretic lower limb combined with standard rehab is more efficient in delaying onset of spasticity, limiting increases in muscle tone, improving balance and paretic lower limb motor function post-stroke, and

		computed tomography (CT) or magnetic resonance imaging (MRI); (2) they were aged between 45 and 80 years old; (3) time since the incident was less than 3 months; (4) strength of muscles induced ankle dorsal flexion was less than grade 3 (out of 5) in a manual muscle test; (5) without serious cognitive impairment as confirmed by a score of at least 7 (out of 10) on the abbreviated mental test (Hodkinson, 1972); and (6) willing to sign the informed consent form."	facilitation approach and OT focused on ADLs. **Control Group:** The control group received the SR program only for 30 minutes, 5 days per week for 3 weeks, which included 60 minutes of physiotherapy based on neurodevelopmental facilitation approach and OT focused on ADLs.		thus making more effective improvement in patient's ability in ADLs.
Influence of electrotherapy with task-oriented training on spasticity, hand function, upper limb function, and activities of daily living in patients with Subacute Stroke	Moon, J.-H., Cho, H.-Y., & Hahm, S.-C. (2021)	Level 1; double blind randomized control N= 43 **Inclusion**: "-first stroke diagnosed by a neurologist - middle cerebral artery lesions -stroke onset between 1 and 3 months; -fair upper limb manual muscle test findings.	**Intervention group:** High-frequency (100 Hz) TENS with below-motor threshold intensity applied for 30 min/day, five times a week, for 4 weeks. also received task-oriented training after TENS. TENS was applied for 30 min before occupational therapy. Electrical stimulation (100 Hz, 200 µs) below the motor threshold was applied to the triceps muscle and wrist extensor muscle belly using a 2-channel TENS unit. Stimulation was applied to the level at which	Jebsen-Taylor Hand Function Test (JTHFT) Modified Ashworth Scale (MAS) Manual Function Test (MFT) Modified Barthel Index (MBI)	The TENS group showed a significant improvement in MAS scores before and after intervention ($p = 0.003$), but the placebo-TENS group did not show a significant improvement in MAS scores. The TENS group showed a significant improvement in JTHFT scores before and after intervention ($p < 0.001$), as did the placebo-TENS group ($p < 0.001$). The TENS group showed a significant improvement in MFT scores

			muscle contraction was observed. 5x/week for 4 weeks , 30 min/day **Control group:** placebo-TENS was applied for 30 min/day, five times a week, for 4 weeks and received task-oriented training after TENS. electrodes were attached to the same locations, and a transient current was delivered for 30 s, then ramped down to zero over 15 s. Task-oriented training using stacking cones, rings, putty, ROM arcs, pegboards, coins, and towels was conducted. The task-oriented training was repeated for three categories: gross movement, grip, and pinch. The subjects were trained for 10 min per category and allowed to rest if they experienced fatigue. The training intensity of the tasks gradually increased after setting goals according to each subject's athletic performance.		before and after intervention ($p < 0.001$). MFT scores showed a significant correlation ($r = 0.341$, $p = 0.025$) with the scores for activities of daily living "Spasticity was significantly decreased in the TENS group. Spasticity in the placebo-TENS group did not significantly improve after the intervention."
Timing-dependent effects of transcranial direct current stimulation with mirror therapy on daily function and motor control in chronic stroke	Liao, W., Chiang, W., Lin, K., Wu, C., Liu, C., Hsieh, Y., Lin, Y., & Chen, C. (2020).	Level 1; Double-blinded randomized control N= 28 Inclusion: "-a first ever unilateral stroke	**5 day/week for 90 min for 4 weeks** **Group 1: sequential combination of tDCS and MT -** stimulation alone for 20 min, then sham (fake) stim and MT for 20 min, then only MT for 20 min, then functional task for 30 min **Group 2- concurrent comb. Of**	Nottingham Extended ADLs (NEADL) Fugl-Meyer Unilateral Reaching Task	There were significant differences in daily function between the three groups. The SEQ group had greater improvement in daily function than the CON and SHAM groups. Kinematic analyses showed that movement time of the paretic hand significantly

		-Age above 18 years old, -stroke onset more than 6 months, -Fugl-Meyer assessment (FMA) scores between 20 and 56, indicating moderate to mild impairments [28], -no severe muscle spasticity at the paretic arm at all joints (the Modified Ashworth Scale scores < 3 - adequate cognitive function to follow instructions (the Mini Mental State Examination ≥24)"	**tDCS with MT** This group received 20 min of sham tDCS, then 20 min of combined real stim and MT, then 20 min of MT alone, then functional task – different than group one bc tDCS and MT were used together as opposed to sequentially. Group 3 **- sham tDCS with MT (control group)** 20 min tDCS (sham) then 20 min tDCS sham and MT then 20 min MT alone then functional task **only true MT intervention with simulated tDCS so used as control group		reduced in the SEQ group after interventions. All three groups had significant improvement in motor function from pre-intervention to post-intervention. For the kinematic outcomes, significant improvement was demonstrated in the index movement time of the SEQ group from pre-intervention to post-intervention
Effects of bihemispheric transcranial direct current stimulation on upper extremity function in stroke patients: A randomized double-blind sham-controlled study.	Alisar, D. C., Ozen, S., & Sozay, S. (2020)	Level 1, Prospective Randomized Double Blind Sham Controlled Study N= 32 **Inclusion**: "Inclusion criteria were (1) age 18-75 years (2) first time stroke sufferer (3) stroke of vascular aetiology as determined by computerised tomography or magnetic resonance imaging (4) at least 3 months since stroke onset (5) mini mental state examination score 23 6) stable medical condition".	Participants in both groups received UE rehab for 5 days/week for 3 weeks for 60-120 minutes/session. The sessions consisted of "neurofaciliation techniques, range of motion, progressive resistance and strengthening exercises, and 30 minutes of occupational therapy". **Intervention Group**: Transcranial Direct Current Stimulation (tDCS) was implemented using a "double channeled direct current simulator" via electrodes. The International EEG 10/20 system very specifically guided electrode	Fugl-Meyer Upper Extremity (FMUE) Scale Functional Independence Measure (FIM) Brunnstrom Stages of Stroke Recovery (BSSR)	Data analysis reveals that the "FIM values were significantly greater in the tDCS group in comparison to the sham group both before (65.44 § 28.43 versus 51.19 § 27.53, P = .05) and after (88.19 § 24.61 versus 58.37 § 27.24, P = .002) treatment". The level of significance largely increased from pre to post. Furthermore, "analysis of within group outcome measures revealed a statistically significant improvement in FMUE

			placement on the heads of each participant in this group. Electrodes were placed on the ipsilesional and contralesional hemisphere, making it bihemispheric tDCS. The current was 2mA and lasted for 30 minutes during the occupational therapy session. **Control Group**: Electrodes were placed on each participant's each using the same method as the tDCS group. However, the current emitted caused only a "tingling" sensation for 30 seconds before it was switched off. The electrodes remained on the person for the duration of the 30 minute occupational therapy session without stimulation.		scale, BSSR, and FIM values after treatment in the tDCS group (P = .001)". There were no significant changes in assessment scores for the sham group. Findings also revealed "significantly greater improvement in function as shown by the FIM in the group receiving bihemispheric tDCS in combination with OT and PT when compared to the sham tDCS group." "Chronic stroke patients undergoing tDCS had a significantly higher post treatment FIM score when compared to chronic stroke patients receiving sham tDCS and subacute stroke patients receiving tDCS/ sham tDCS".
Functional electrical stimulation improves reaching movement in the shoulder and elbow muscles of stroke patients: A three-dimensional motion analysis.	Cuesta-Gómez, Alicia; Carratalá-Tejada, María; Molina-Rueda, Francisco; Miangolarra-Pag e, Juan Carlos (2019).	Level 3, Cross-sectional study N=20 **Inclusion:** Ages 30-70 years old, diagnosis of chronic stroke (>6 months), "UL motor impairment with a Fugl-Meyer score ≥ 16; a modified Ashworth scale score ≤ 2 in the deltoid,	**Intervention Group: FES** Participants were connected to the electrical stimulation unit via electrodes at the anterior deltoid, the triceps brachii, and the wrist and fingers extensor muscles. The participants sat with ankle, knee, hip, and elbow joints at 90 degrees. They were instructed to reach for the glass strategically placed at their farthest reachable distance while using functional electrical stimulation (FES). "The	The Vicon Nexus software v1.8.5® Vicon Upper limb® biomechanical model.	During the FES trials, participants had significantly increased shoulder flexion, elbow extension, and ROM in both shoulder and elbow joints.

		triceps brachii, biceps brachii and in the wrist and finger flexor and extensor muscles of the upper limb", ability to understand instructions and complete tasks, a score ≥ 20 in the Mini-mental Test, assist at home using device	frequency, pulse width and duration of the FES onset ramp were set at 25 Hz, 200 s and 0.5 s respectively, for the duration of the session." **Control Group: Placebo** The control group experienced the same instructions. However, the electrical stimulation used during these trials were not intense enough to produce or facilitate movement. All participated in an at home training program to get acclimated to the sensation of the electrical stimulation. This program consisted of 2 40 min sessions a day for 7 days and did not require them to do exercise in combination with the electrical stimulation.		
			Intervention 6: Miscellaneous		
Sensory interventions on motor function, activities of daily living, and spasticity of the upper limb in people with stroke: A randomized clinical trial	Maryam Derakhshanfar, Parvin Raji, Hossein Bagheri, Mahmood Jalili, Hosein Tarhsaz	Level 2, Single-blind clinical trial N= 30 **Inclusion:** "one stroke, chronic phase of the disease (more than 6 months from the time of their stroke), the ability to detect the 4.31 monofilament in their fingers (diminished	**Intervention Group:** "The intervention group, in addition to the usual occupational therapy services, received randomly exteroceptive and proprioceptive stimulations. The program of sensory stimulation used in this study was based on the principles of Rood approach. The participants received 6 minutes	Fugl-Meyer Barthel Index Modified Ashworth Scale	"Results show no significant difference between the two groups before starting intervention for the three main variables; motor function, ADL and muscle tone, respectively, but after the third week and sixth week of intervention, significant changes were found.The results of this study indicated an improvement in

		protective sensation), stage 4 or higher according to the Brunnstrom's stages of stroke recovery described as spasticity is decreased and controlled, normal movements are observed in a limited range of joint movement, the ability to understand our instructions"	of brushing, 5 minutes of icing, and 5 minutes of stretch pressure as exteroceptive sense, and 5 minutes of weight bearing in side-sitting and 5 minutes in quadruped position on the affected hand as proprioceptive sense." (N=30) **Control Group:** "Conventional occupational therapy included exercises for improvement of upper extremity range of motion and fine movement and also strengthening upper extremity muscles." (N=30)		motor function of upper limb (P < .001), the activity of daily living (P < .000), and spasticity (P < .002). This treatment seems to work well because the effect sizes all outcome measures are above 0.8. Of these, the greatest effect size is related to motor function, and the least belonged to spasticity."
Effect of ankle-foot orthosis on weight bearing of chronic stroke patients performing various functional standing tasks.	Don Kim, K., Lee, H. J., Lee, M. H., & Hwangbo, G.. (2015).	Level 3, Case/Control Study N= 16 **Inclusion**: "The study subjects were chosen based on the following criteria: over six months since stroke onset; the patient had been prescribed an AFO by a rehabilitation medicine specialist; the patient had an MMSE-K score of 24 or over; the patient was able to stand up from a chair independently and had a Modified Ashworth Scale rating of 0 to while 1 using the AFO".	All 16 participants were part of both the intervention and control group. They participated in 1 session of each. **Intervention Group:** "The five functional standing tasks were: standing on both feet (task 1, rising from a chair; task 2, quiet standing) one foot (task 3, lateral weight shift; task 4, forward weight shift, and task 5, backward weight-shift)". Each of those tasks were completed 5 times with AFO donned. The tasks were completed barefoot on force plates and were performed randomly to eliminate learning effects. **Control Group:** The same 5 functional tasks were performed	Force Plates	Participants demonstrated "increased weight-bearing ability on the affected side while wearing the AFO in all tasks." Significant differences (p<0.05) were found in increased weight-bearing ability on the affected side when rising from a chair, quiet standing, and lateral weight shift. Additionally, "patients wearing an AFO on the affected side increased their weight bearing load from 78.67% to 100.83% while performing the task of rising from a chair." The weight bearing ratio also increased "on the affected side from

			without the AFO. Each of those tasks were completed 5 times with AFO doffed. The tasks were completed barefoot on force plates and were performed randomly to eliminate learning effects.		79.91% to 92.15% when the hemiplegic patients performed the quiet standing task, suggesting that an AFO improves static balancing ability.”
Self-Awareness and Recovery of Independence With Strategy Training.	Elizabeth R. Skidmore, Melissa Swafford, Shannon B. Juengst, Lauren Terhorst (2018)	Level 2, Secondary Analysis Case/Control Study N=30 **Inclusion**: “Participants had a recent stroke; were admitted to inpatient rehabilitation; had cognitive impairments, evident by a score of ^{3}3 on the Quick Executive Interview; did not have moderate or severe aphasia, evident by a score ^{3}2 on the Boston Diagnostic Aphasia Examination; did not meet criteria for dementia, untreated mood disorder, psychotic disorder, or current drug or alcohol abuse; and had an expected inpatient rehabilitation length of stay of at least 5 days.”	Both groups began with setting goals using the COPM. **Intervention Group:** “In the strategy training group, participants addressed their self-selected goals by identifying problems or barriers to meeting their goals and applying a global strategy (i.e., Goal–Plan–Do–Check) to address these problems.” Therapists utilized guided discovery to support this group. This group was further divided into groups of those with good (5 participants) and poor (10 participants) awareness. **Control Group:** “In the attention control group, participants engaged in a facilitated discussion with the therapists, who used scripted, open-ended questions to stimulate personal reflection on the participants’ rehabilitation experience.” This group was further divided into groups of those with good (6 participants) and poor (9 participants) awareness.	Self-Awareness of Deficits Interview (SADI) Canadian Occupational Performance Measure (COPM) Functional Independence Measure (FIM)	Data shows that “strategy training was associated with greater improvements in independence over time than attention control.” Interaction between time, awareness, and intervention was not significant in improving FIM results. The FIM scores did improve throughout the study, but they were not significant improvements, and there was not a significant difference in results between the case and control groups.