2023

CAT Part IV: Occupational Therapy Interventions to Support Upper Extremity Spasticity in Older Adults Following a Stroke

Mary Redlin

Allie Reiffenberger

Shannon Ring

Aubrey Rude

CAT Part IV: Occupational Therapy Interventions to Support UpperExtremity Spasticity in Older Adults Following a Stroke

Mary Redlin, OTS, Allie Reiffenberger, OTS, Shannon Ring, OTS, & Aubrey Rude OTS

Department of Occupational Therapy, University of North Dakota, Grand Forks, North Dakota, United States

Please direct correspondence to Allie Reiffenberger at allie.reiffenberger@und.edu

***This resource was written by doctoral-level students in fulfillment of the requirements of the Occupational Therapy course "OT 403 - Clinical Research Methods in Occupational Therapy" at the University of North Dakota School of Medicine and Health Sciences, under the advisement of Professor/Course Director Anne Haskins, Ph.D., OTR/L, Assistant Professor Breann Lamborn, EdD, MPA, Professor Emeritus Gail Bass Ph.D., OTR/L, and Research and Education Librarian Devon Olson Lambert, MLIS.

Focused Question

What interventions improve hand functions in activities of daily living (ADLs) for elderly adults with chronic upper extremity spasticity following a stroke.

Case Scenario

This critically appraised topic focuses on interventions for improving hand functions in activities of daily living (ADLs) for elderly adults who have chronic upper extremity spasticity following a stroke. For the purpose of this critically appraised topic, the focus will be on the elderly population, defined as being age 55 and older; research indicates stroke is most prevalent in this population (Mayo Clinic, 2022). When considering a particular theory, the Ecology of Human Performance (EHP) is the most suitable model for our focus question (Dunn, 2017). The Ecology of Human Performance is focused on the person and environment to increase the performance range of tasks. The person is made up of the elderly population (55+) with a prior stroke. The environment includes those living at home and outpatient facilities without caregivers, and the task focus is on ADLs (Dunn, 2017). Of the various facets of stroke, the first to be addressed is upper extremity limb dysfunction following a stroke, followed by implications of this limb dysfunction on performance and occupational therapy's role in increasing occupational engagement in ADLs.

Upper Extremity Spasticity Following a Stroke

In 2013, the American Heart Association/American Stroke Association updated their endorsed definition of stroke to one that includes silent infarctions (inclusive of cerebral, spinal, and retinal) and silent hemorrhages (Sacco et al., 2013). 795,000 people in the United States each year experience a stroke, and two-thirds of these individuals will need rehabilitation (Almhdawi et al., 2016). This can impact almost every aspect of a person's life, including the ability to engage in activities of daily living (Kerr et. al., 2020). ADLs include tasks such as eating, dressing, bathing, grooming, and toileting. Common impairments following CVA include sensory, cognitive, vision, and motor functions. Of these, post-stroke spasticity (PSS) in the upper extremities, which is defined as "a motor disorder characterized by a velocity-dependent increase in tonic stretch reflexes ('muscle tone') with exaggerated tendon jerks, resulting from hyperexcitability of the stretch reflex," is the most common (Blanchette et al., 2017, p. 303). In other words, it is an increase in muscle stiffness that may interfere with movement and is often associated with pain. PSS is more common in the upper extremities than the lower extremities, and has a lengthier rehabilitation process in the upper extremities. The prevalence of PSS ranges from 30% to 92% in stroke survivors, and peaks one to three months after the CVA (Kuo & Hu, 2018). Regardless of the variability in prevalence estimates, stroke survivors will often experience PSS, and its effects on recovery from CVA is clear. When left untreated, spasticity will cause muscle shortening, leading to contractures, joint deformities, and pain (Wissel et al., 2015). Of those experiencing PSS, up to 78% report decreased independence in ADLs and self-care tasks, decreasing their quality of life (Barros Galvao et al., 2014).

Occupational Therapy and Improving Hand Function Following a Stroke

Occupational therapy (OT) holds a prominent role in improving function following a stroke. After a stroke, occupational therapists will work to facilitate and improve motor control and hand function in the CVA-affected upper limb; to maximize the person's ability to undertake his or her own personal self-care tasks and domestic tasks; to help the patient learn strategies to manage the cognitive, perceptual, and behavioral changes associated with stroke; and to prepare the home and work environment for the patient's return (Rowland et al., 2008). As occupational therapists begin to work with an individual following a stroke, they will initially interview the patient or their caretaker to establish their previous life roles and the tasks that went along with these roles (Rowland et al., 2008). Occupational therapists will also use observation as an assessment tool by observing the individual complete self-care tasks (ADLs), including dressing, showering, toileting, grooming, and eating. After the therapist observes the client completing these tasks, they are able to understand the level of assistance needed in each area along with working to target rehabilitation techniques to work towards goals. (Rowland et al., 2008). Rehabilitation following a stroke should begin as soon as the medical condition is stable (Rowland et al., 2008). When the individual is stable, occupational therapy interventions can be implemented. OT interventions may include methods aimed at maintaining or improving soft tissue properties of the upper limb (Rowland et al., 2008). Occupational therapy's goal in treatment is to promote an independent life following a stroke by providing various intervention techniques.

Purpose Statement

Currently, there is a need for further evidence supporting best practice interventions for improving hand function in elderly adults following a CVA that are experiencing upper extremity spasticity. This critically appraised topic aims to determine the best occupational therapy interventions for improving this population's upper extremity spasticity and hand function to increase independence in ADLs.

Methodology

The literature search took place from February 24, 2023, to February 28, 2023. In course of the literature searches, a combination of allied health, occupational therapy, and multidisciplinary databases were utilized, which included Cumulative Index to Nursing and Allied Health Literature (CINAHL), PubMed, ScienceDirect, DynaMed, American Journal of Occupational Therapy (AJOT), and Google Scholar. The search terms "occupational therapy", stroke, "hand function", "upper extremity spasticity", "older adults", geriatrics, elderly, CVA, hemiparesis, "upper extremity", "upper limb" and hands. For the purpose of creating a more refined search, Boolean search commands "AND" and "OR" were added to combine search terms and phrases. Exclusion criteria consisted of studies that were not written in English, studies that discussed lower extremities, and studies focusing on the pediatric population.

Types of Articles Reviewed

Initially, 41 articles were reviewed. From these, twenty-three were further reviewed, and six were added to further support findings. In total, these articles consisted of 14 level I studies (Ahn et al., 2017; Almhdawi, et al., 2016; Alashram et al., 2020; Barros Galvão et al., 2014; Choi & Kim, 2022; Ellis et al., 2021; Friedman et al., 2014; Kerr et al., 2020; Park & Kang, 2018; Song & Woo, 2019; Thieme et al. 2012; Tsao et al., 2017; Wissel et al., 2015; Villa-Berges et al., 2023), 4 level II studies (Lannin, N. A., & Herbert, R. D. 2003; Robinson-Bert, K., & Woods, A. B. 2022; Schneider et al., 2007; Yu, C.-H et al., 2021), 2 level IV studies (Adrienne, C., & Manigandan, C. 2011; Blanchette et al., 2017) and 3 level NA studies (Kuo et al., 2018; Rowland et al., 2007; Sacco et al., 2013). An additional resource added for this CAT was a textbook, *Perspectives on Human Occupation: Theories Underlying Practice* (Dunn, 2017).

Table 1
Articles Reviewed in the Synthesis

Author and publication date	**Level of Evidence/Study Type**	**Research Question/Aim**	**Population**
Adrienne, C., & Manigandan, C. (2011)	Level IV Survey	The study examined the nature and prevalence of the factors associated with therapists' hand-splinting practice and their perceived splinting efficacy	Sixty-two therapists participated in this national survey
Ahn, S.-nae, Yoo, E.-young, Jung, M.-ye, Park, H.-yean, Lee, J.-yeon, & Choi, Y.-im. (2017)	Level I, Randomized Control Trial	Discussed occupation-based intervention vs. action-focusing intervention (non-occupation based)	Forty-three participants experiencing their first stroke were enrolled in this study
Almhdawi, K. A., Mathiowetz, V. G., White, M., & delMas, R. C. (2016)	Level I, Randomized Control Trial	Focused on upper extremity rehabilitation in OT following a stroke and limited range of motion	Twenty poststroke patients, three months onset with limited shoulder and elbow abduction
Alashram, A. R., Annino, G., Aqtaishat, M., & Padua, E. (2020	Level I, Systematic Review	Combined physical practice and mental practice on the upper extremity function post-stroke	Stroke survivors (n=230) through nine studies
Barros Galvão, S. C., Borba Costa dos Santos, R., Borba dos Santos, P., Cabral, M. E., & Monte-Silva, K. (2014)	Level I, Randomized Control Trial	Assessed the efficacy of inhibitory repetitive transcranial magnetic stimulation (rTMS) for decreasing upper-limb muscle tone after chronic stroke	Patients with stroke (n=20) with poststroke upper limb spasticity
Blanchette, A. K., Demers, M., Woo, K., Shah, A., Solomon,	Level IV Questionnaire	The purpose of this study was to understand current trends in rehabilitation practice regarding spasticity	317 clinicians (204 physiotherapists and 113 occupational therapists) who assess and treat spasticity

J. M., Mullick, A. A., & Levin, M. F. (2017)		assessment and treatment	
Choi, S., & Kim, D. (2022)	Level I, Randomized Control Trial	Cognitive behavior therapy vs. conventional occupational therapy for bilateral upper arm training of daily activities	Twenty patients that experienced a stroke receiving inpatient treatment at a hospital or a rehab clinic in Cheongju-si
Ellis, N., Havala , C., Johnson, L., Lyon, B., & Stiens, M. (2021)	Level I, Systematic Review	For adults post-stroke, what was the effectiveness of occupational therapy for improving health-related quality of life?	Twenty-four studies included, participants reported history of strokes
Friedman, N., Chan, V., Reinkensmeyer, A. N., Beroukhim, A., Zambrano, G. J., Bachman, M., & Reinkensmeyer, D. J. (2014)	Level I, Randomized Control Trial	Focus was on improving hand function in patients with hemiparesis that is motivating and effective	Twelve chronic stroke survivors with hemiparesis
Kerr, L., Jewell, V. D., & Jensen, L. (2020)	Level I, Systematic Review	Examined the evidence for the effectiveness of stretching interventions, including splinting, on reducing upper extremity spasticity, increasing hand function, and improving functional tasks for adults with poststroke spasticity	Population was adults after stroke, eleven studies were selected and further analyzed
Kuo, C.-L., & Hu, G.-C. (2018)	Level NA	Spasticity after a stroke, looked at pathophysiology, and clinical manifestations, to select the best treatment approach	Review of fifty-one articles
Lannin, N. A., & Herbert, R. D. (2003)	Level II, Systematic Review	Assessed the effectiveness of hand splinting on the hemiplegic upper extremity following stroke	Nineteen studies in a systematic review on the effect of upper extremity splinting on motor control, functional abilities, contracture, spasticity, or pain in the hand or wrist
Park, J.-H., & Kang, D.-H. (2018)	Level I, Randomized Control Trial	Effects of task-oriented mental practice on upper limb function and coordination in chronic stroke patients	Thirty-four patients experienced a chronic stroke and without visual or hearing impairments
Robinson-Bert, K., & Woods, A. B. (2022)	Level II, Two-group pretest-posttest	Action observation/mental practice intervention compared to typical rehabilitation of upper extremity	Fifty-one people with a primary diagnosis of CVA who were able to speak, write and read in English

Rowland, T. J., Cookie, D. M., & Gustafsson, L. A. (2008)	Level NA	Provided an overview of occupational therapy practice in stroke patients	Review of seventy-two articles
Sacco, R.L., Kasner, S. E. , Broderick, J.P., Caplan, L.R., Connors, J.J., Culebras, A., et al. (2013)	Level NA	Provided an overview regarding the updated definition of a stroke along with its subtypes	Individuals who have experienced a cerebral hemorrhage, cerebral infarction stroke, subarachnoid hemorrhage, transient ischemic attack
Schneider, S., Schönle, P. W., Altenmüller, E., & Münte, T. F. (2007)	Level II, Pretest posttest	Evaluated a music-supported training program designed to induce an auditory–sensorimotor co-representation of movements	Forty inpatients of a neurological rehabilitation hospital participated, all suffering from a moderate impairment of motor function of upper extremities, as evidenced by clinical examination, following a stroke
Song, Lee, O.-N., & Woo, H.-S. (2019)	Level I, Randomized Control Trial	Investigated the effects of the CO-OP approach in comparison with task-specific upper extremity training (TUET) on performance related to daily and functional activities in individuals with chronic hemiparetic stroke	Forty-nine participants that suffered from a stroke at least six months before the trial and sufficient cognitive abilities
Thieme et al. (2012)	Level I, Randomized Control Trial	Evaluated the effects of individual or group mirror therapy on sensorimotor function, activities of daily living, quality of life and visuospatial neglect in patients with severe paresis after stroke	Sixty patients with a severe paresis of the arm within three months after a stroke
Tsao, L., Zubrenic, E., Pustina, K., Edelstein, J., Pritchard, K., Mark, B., & Q. Eileen, W. (2017)	Level I, Systematic Review	Review of the evidence surrounding the use of orthoses in stroke-related upper-extremity (UE) deficits	Seventeen articles met the inclusion criteria and were appraised using a data extraction form and the MacDermid (1996) quality appraisal scale
Wissel, J., Verrier, M., Simpson, D. M., Charles, D., Guinto, P., Papapetropoulos, S., & Sunnerhagen, K. S. (2015)	Level I, Systematic Review	Studies discussed predictors of early post-stroke spasticity development and factors predictive of motor/functional outcomes and recovery	A PubMed search of the following terms was conducted: predictors OR risk factors AND stroke AND spasticity. Studies discussing predictors of early PSS development and factors predictive of motor/functional outcomes and recovery were selected

			and reviewed in detail
Villa-Berges, E., Laborda Soriano, A. A., Lucha-López, O., Tricas-Moreno, J. M., Hernández-Secorún, M., Gómez-Martínez, M., & Hidalgo-García, C. (2023)	Level I, Systematic Review	Motor function of the upper limb in people that had suffered a stroke using motor imagery and mental practice alone or with other therapies	A systematic review of 11 randomized control trials
Yu, C.-H., Mathiowetz, V. G., Zieffler, A., & Tomlin, G. S. (2021)	Level II, Two-group repeated measures	Examines the efficacy of different occupational therapy task-oriented approaches as intervention	14 patients with a diagnosis of stroke and at least 10° of voluntary shoulder and elbow movement

Synthesis

The goal of this critically appraised topic paper was to gain an understanding of the existing interventions used to treat upper extremity spasticity following a stroke to help elderly adults re-engage in ADLs independently. The following interventions were the most prominent within research.

Splinting

One of the most common difficulties older adults face following a stroke is upper extremity spasticity impacting their mobility in their hand function. If untreated, this spasticity can lead to ineffective compensatory movement patterns, learned nonuse, and development of muscle contractures (Yu et al., 2021). To combat this, occupational therapy uses a treatment approach known as the occupational therapy task-oriented approach (OTTO). This method is compatible with clinical practice due to the clients' active engagement, less time spent in the clinic or hospital, and more widespread guidance (Yu et al., 2021). "One of the most commonly used therapeutic interventions for stroke rehabilitation is orthosis." (Tsao et al., 2017 p.1). Combined with OTTO, orthoses reduce poststroke spasticity and keep muscles and tissues functioning by immobilizing the patients' hands, wrists, or both. The orthoses can be adequate and are preferred by therapists if they are "custom-made, volar forearm-based wrist-hand splints" (Adrienne & Manigandan, 2011 p.141). These splints are used to achieve goals such as improving range of motion and stretching soft tissue contractures. Despite being one of the most common interventions, orthoses benefits are very specific to the case. They do not have universal guidelines for determining initiation, the duration, or the type of orthosis to provide the patient (Tsao et al., 2017). Our CAT is focused on improving functional mobility and orthoses are mainly focused on only improving mobility. The effectiveness of these splints is questionable and has very little research to back up orthosis efficacy (Lannin & Herbert, 2003). Within the literature, there is a limitation in the knowledge and evidence of if these patients are using the orthosis or splint at home leading to lack of proof of benefits.

Mental Practice

Cognitive behavior therapy (CBT) is the best known intervention for depression and anxiety; the main psychological problems of those experiencing a stroke (Choi & Kim, 2022). CBT is a form of therapy that helps to change negative thoughts and beliefs, specifically the stroke incidence, into positive thoughts, to help lead patients to set a personal goal to increase motivation (Choi & Kim, 2022). In a randomized control trial by Choi & Kim (2022), it was found that there is little evidence of CBT being used with stroke patients. The randomized control trial examined the difference between cognitive behavioral therapy versus conventional rehabilitation therapy, with both groups followed by bilateral upper limb training. In this randomized control trial by Choi & Kim (2022), CBT was effective in lowering the levels of depression and anxiety of stroke patients, and an increase in occupational performance as measured by the COPMA pretest-posttest done by Robinson-Bert & Woods (2022) identified mental practice as a promising intervention for patients with active participation to improve upper extremity recovery after a stroke. Mental practice/motor imagery is when a subject tries to imitate a movement using cognitive processes without actually doing the action. Through the review of the multiple randomized control trials, it was concluded that mental practice/ motor imagery is an effective technique for improving functionality of the affected upper limb in both subacute and chronic phases, and as complement to conventional treatment (Alashram et al., 2020; Kim et al., 2018; Park, 2021; Villa-Berges et al., 2023).

Mirror Therapy

In a randomized control trial by Thieme et al. (2012), research on the effects of mirror therapy in post-stroke patients was conducted at an inpatient rehabilitation center. Looking at interventions that focus on the holistic view of the individual, such as mirror therapy, can provide significant gains in activities of daily living and quality of life in post-stroke patients. Mirror therapy is a relatively new intervention introduced to stroke rehabilitation. In contrast to most interventions working with sensorimotor training strategies, mirror therapy focuses on visual input. While moving the unimpaired arm, an inverse reflection is created by a mirror that is positioned between the two arms. Reflection of the unimpaired arm creates a visual illusion of the enhanced movement capability of the impaired arm (p. 315). The authors of this study reported that approximately 80% of stroke survivors have an upper and/or lower limb paresis. Paresis of the arm explains up to 50% of the variance in functional limitation after stroke. Six months after stroke, between one-third and two-thirds of stroke patients will not regain functional arm use, and only 5–20% will achieve full recovery of arm function (p. 314). Knowing this information is vital when considering holistic interventions for the post-stroke population, emphasizing interventions to improve ADLs and various body functions rather than solely focusing on hand function (Thieme et al., 2012).

Music Glove

Following a stroke, people typically begin performing hand exercise rehabilitation at home as soon as two weeks poststroke. Without assistance and encouragement, motivation is lost, contributing to a decline in hand function. Unfortunately, there is a lack of at-home therapy options, and the small selection of home interventions available are either overpriced or unmotivating (Friedman et al., 2014). Music therapy has been proven to be beneficial in therapy,

as it is motivating, sensory-rich, and repetitive (Schneider et al., 2007). More specifically, the MusicGlove is a form of music therapy designed specifically to help people regain function following a stroke in the clinic or in the comfort of their home.

It is an instrumented glove that requires the user to practice functional gripping movements to play a customized version of an open-source music game called Frets on Fire inspired by the third most popular video game franchise to date, Guitar Hero. When the user touches the thumb lead on one of the five electrical leads on the fingertips or lateral aspect of the index finger, the device sends a signal to the computer through the USB port using a custom-made controller. The leads are positioned so as to require functional grips such as pincer grip or key pinch grip. In the computer game, colored notes scroll down the screen on five distinct frets. When the notes reach the bottom of the screen, the user must touch one of the respective leads on the glove with her thumb within a specified time window. Correct notes are logged and displayed in a summary at the end of the game, providing a quantitative assessment of hand motor performance, including which grip the user is best at completing and how accurately the user completes each target gripping movement in the desired time window (Friedman et al., p. 2).

In a study done at the University of California, the MusicGlove was found to significantly improve hand motor performance, as well as self-rated measures of motivation to engage in rehabilitative measures (Friedman et. al., 2014).

Occupation-Based Interventions

Following a stroke, many adults will report a decline in quality of life and occupational performance. Occupational therapy plays a major role in the rehabilitation process to combat these issues. Because of this, occupational therapists must apply an effective evidence-based approach (Ellis et al., 2021). The most utilized OT approach by practitioners is occupational or task-oriented interventions. These are individualized, client-centered, functional-based occupational therapy approaches targeted at improving motor learning and motor control to enable the client with opportunities to learn the most effective strategies to encourage occupational performance and engagement (Almhdawi et al., 2016). Examples of these interventions include Constraint-Induced Movement Therapy (CIMT), bilateral remediation training, and many more. Occupation-based interventions combined with other traditional methods can be useful in OT practice. When applying these combined methods to elderly clients facing upper extremity spasticity, improvements have been shown.

Summary

Overall, 23 articles were reviewed thoroughly. The articles included topics on orthosis and splinting, mental practice interventions, occupation-based interventions, the MusicGlove, mirror therapy, as well as stroke and stroke-induced upper extremity spasticity. The following main points were found.

- Following a stroke, upper extremity spasticity is the most common complication (Blanchette et al., 2017).
- Splinting is the most commonly used occupational therapy intervention to treat upper extremity spasticity (Tsao et al., 2017), but is under-researched, showing no proof of long-term benefits (Lannin & Herbert, 2003).

- There are other commonly used interventions to treat this spasticity, including cognitive behavior therapy (Choi & Kim, 2022), mirror therapy (Thieme et al., 2012), and the MusicGlove (Friedman et al., 2014, p.2).
- Occupation-based interventions such as Constraint-Induced Movement Therapy and bilateral remediation training combined with traditional interventions can improve upper extremity function (Almhdawi et al., 2016).

The goal of researching these topics was to review existing literature regarding best practice for improving upper extremity spasticity through occupational therapy. This review indicated that there is not enough evidence to determine which intervention is the best at improving hand function, but that each intervention brings its own list of strengths and weaknesses that when combined with the other existing interventions can be used for the best results.

Clinical Bottom Line

How beneficial are occupational therapy interventions to improve hand function in activities of daily living (ADLs) for elderly adults with chronic upper extremity spasticity following a stroke?

Splinting is currently one of the most prevalent intervention techniques used to improve hand function in ADLs for elderly adults following a stroke. The effectiveness of splints is questionable and has very little research to back up orthosis efficacy (Lannin & Herbert, 2003). Within the literature, there is a limitation in the knowledge and evidence of if these patients are using the orthosis or splint at home, leading to a lack of proof of benefits (Adrienne & Manigandan, 2011; Lannin & Herbert, 2003; Tsao et al., 2017; Yu et al., 2021).

To understand the factors that influence a person's performance, we viewed the person through the EHP model by identifying focus on the person and their environment to increase the performance range of tasks. In this case, the person comprises the elderly population (55+) with a prior stroke. With this population, a factor to be considered is the potential for ageism bias. A common bias associated with this age group is that these individuals are reaching the age where they do not need medical intervention. This bias is often seen among this population with the assumption to just move these clients into nursing homes. The environment includes those living at home and outpatient facilities without caregivers, and the task focuses on ADLs (Dunn, 2017). Of the research articles reviewed, the studies were strong, with a limitation being small sample sizes. After reviewing the research pertaining to the subject, additional intervention techniques, such as occupation-based and holistic-focused interventions can improve hand function in ADLs for elderly adults following a stroke (Alashram et al., 2020; Almhdawi et al., 2016; Choi & Kim, 2022; Ellis et al., 2021; Kim et al., 2018; Park, 2021; Villa-Berges et al., 2023). Some occupation-based interventions we researched consisted of mental practice, mirror therapy, and the MusicGlove. Instead of restricting hand function with a splint, these interventions can improve hand function while targeting the brain and the rest of the body.

Occupation-based interventions can support participation in ADLs by promoting a holistic approach for the person rather than restricting their function by splinting.The goal of

occupational therapy and these interventions is to allow these individuals to maintain as much independence as possible and to keep them participating in their desired occupations for as long as possible. The use of both occupation-based interventions with other complementary therapies have been shown to be most beneficial in treating upper extremity hand function of elderly adults in regaining and maintaining independence in activities of daily living following a stroke.

References

Adrienne, C., & Manigandan, C. (2011). Inpatient occupational therapists hand-splinting practice for clients with stroke: A cross-sectional survey from Ireland. *Journal of neurosciences in rural practice*, *2*(2), 141–149. https://doi.org/10.4103/0976-3147.83579

Ahn, S.-nae, Yoo, E.-young, Jung, M.-ye, Park, H.-yean, Lee, J.-yeon, & Choi, Y.-im. (2017). Comparison of cognitive orientation to daily occupational performance and conventional occupational therapy on occupational performance in individuals with stroke: A randomized controlled trial. *NeuroRehabilitation*, *40*(3), 285–292. https://doi.org/10.3233/nre-161416

Almhdawi, K. A., Mathiowetz, V. G., White, M., & DelMas, R. C. (2016). Efficacy of occupational therapy task-oriented approach in upper extremity post-stroke rehabilitation. *Occupational Therapy International*, *23*(4), 444–456. https://doi.org/10.1002/oti.1447

Alashram, A. R., Annino, G., Al-qtaishat, M., & Padua, E. (2020). Mental practice combined with physical practice to enhance upper extremity functional ability poststroke: A systematic review. *Journal of Stroke Medicine*, *3*(2), 51-61. DOI: 10.1093/ptj/81.8.1455

Barros Galvão, S. C., Borba Costa dos Santos, R., Borba dos Santos, P., Cabral, M. E., & Monte-Silva, K. (2014). Efficacy of coupling repetitive transcranial magnetic stimulation and physical therapy to reduce upper-limb spasticity in patients with stroke: A randomized controlled trial. *Archives of Physical Medicine and Rehabilitation*, *95*, 222–229. https://doi.org/10.1016/j.apmr.2013.10.023

Blanchette, A. K., Demers, M., Woo, K., Shah, A., Solomon, J. M., Mullick, A. A., & Levin, M. F. (2017). Current practices of physical and occupational therapists regarding spasticity assessment and treatment. *Physiotherapy Canada. Physiotherapie Canada*, *69*(4), 303–312. https://doi.org/10.3138/ptc.2016-54

Choi, S., & Kim, D. (2022). Effects of combining cognitive behavioral therapy with bilateral upper limb training in stroke patients: A randomized controlled trial. *Occupational Therapy International*, 1–9. https://doi.org.ezproxylr.med.und.edu/10.1155/2022/4688113

Dunn, W. (2017). The ecological model of occupation. In J. Hinojosa, P. Kramer, C. Royeen (Eds.), *Perspectives on human occupation* (2nd ed., pp. 207-235). F.A. Davis.

Ellis, N., Havala , C., Johnson, L., Lyon, B., & Stiens, M. (2021). Occupational therapy interventions for improving health-related quality of life in adults post-stroke: A rapid systematic review. *IUPUI ScholarWorks Repository.* https://hdl.handle.net/1805/25931

Friedman, N., Chan, V., Reinkensmeyer, A. N., Beroukhim, A., Zambrano, G. J., Bachman, M., & Reinkensmeyer, D. J. (2014). Retraining and assessing hand movement after stroke using the MusicGlove: Comparison with conventional hand therapy and isometric grip training. *Journal of NeuroEngineering and Rehabilitation*, *11*(1), 76. https://doi.org/10.1186/1743-0003-11-76

Kerr, L., Jewell, V. D., & Jensen, L. (2020). Stretching and splinting interventions for poststroke spasticity, hand function, and functional tasks: A systematic review. *The American Journal of Occupational Therapy*, *74*(5). https://doi.org/10.5014/ajot.2020.029454

Kuo, C.-L., & Hu, G.-C. (2018). Post-stroke spasticity: A review of epidemiology, pathophysiology, and treatments. *International Journal of Gerontology*, *12*(4), 280–284. https://doi.org/10.1016/j.ijge.2018.05.005

Kim, H., Yoo, E.-Y., Jung, M.-Y., Kim, J., Park, J.-H., & Kang, D.-H. (2018). The effects of mental practice combined with modified constraint-induced therapy on corticospinal excitability, movement quality, function, and activities of daily living in persons with stroke. *Disability & Rehabilitation, 40*(20), 2449–2457. https://doi.org/10.1080/09638288.2017.1337817

Lannin, N. A., & Herbert, R. D. (2003). Is hand splinting effective for adults following stroke? A systematic review and methodologic critique of published research. *Clinical Rehabilitation, 17*, 807–816. https://doi.org/10.1191/0269215503cr682oa1468255

Mayo Foundation for Medical Education and Research. (2022). *Stroke*. Mayo Clinic. https://www.mayoclinic.org/diseases-conditions/stroke/symptoms-causes/syc-20350113

Park, J. (2022). The effects of task-oriented mental practice on upper limb function and coordination in chronic stroke patients—Randomized controlled trial design. *British Journal of Occupational Therapy*, *85*(3), 164-171. doi:10.1177/03080226211057838

Robinson-Bert, K., & Woods, A. B. (2022). Effectiveness of synchronous action observation and mental practice on upper extremity motor recovery after stroke. *Occupational Therapy In Health Care*, 1–18. https://doi.org/10.1080/07380577.2022.2138675

Rowland, T. J., Cookie, D. M., & Gustafsson, L. A. (2008). Role of occupational therapy after a stroke. *Annals of Indian Academy of Neurology, 11*(1), https://doi.org/10.4103/0972-2327.41723

Sacco, R.L., Kasner, S. E. , Broderick, J.P., Caplan, L.R., Connors, J.J., Culebras, A., et al. (2013). An updated definition of stroke for the 21st century: a statement for healthcare professionals from the American Heart Association/American Stroke Association. *Stroke, 44*(7), 2064–2089. https://doi.org/10.1161/STR.0b013e318296aeca

Schneider, S., Schönle, P. W., Altenmüller, E., & Münte, T. F. (2007). Using musical instruments to improve motor skill recovery following a stroke. *Journal of Neurology, 254*(10), 1339–1346. https://doi.org/10.1007/s00415-006-0523-2

Song, C.- S., Lee, O.-N., & Woo, H.-S. (2019). Cognitive strategy on upper extremity function for stroke: A randomized controlled trial. *Restorative Neurology and Neuroscience, 37*(1), 61–70. https://doi.org/10.3233/RNN-180853

Thieme, H., Bayn, M., Wurg, M., Zange, C., Pohl, M., Behrens, J. (2013). Mirror therapy for patients with severe arm paresis after stroke – a randomized controlled trial. *Clinical Rehabilitation, 27*(4), 314-324. doi:10.1177/0269215512455651

Tsao, L., Zubrenic, E., Pustina, K., Edelstein, J., Pritchard, K., Mark, B., & Q. Eileen, W. (2017). Systematic review of orthoses for stroke-induced upper-extremity deficits. *American Journal of Occupational Therapy, 71*, 221. https://doi.org/10.5014/ajot.2017.71S1-PO4152

Wissel, J., Verrier, M., Simpson, D. M., Charles, D., Guinto, P., Papapetropoulos, S., & Sunnerhagen, K. S. (2015). Post-stroke spasticity: Predictors of early development and considerations for therapeutic intervention. *Physical Medicine and Rehabilitation Journal, 7*, 60–67. https://doi.org/10.1016/j.pmrj. 2014.08.946

Villa-Berges, E., Laborda Soriano, A. A., Lucha-López, O., Tricas-Moreno, J. M., Hernández-Secorún, M., Gómez-Martínez, M., & Hidalgo-García, C. (2023). Motor imagery and mental practice in the subacute and chronic phases in upper limb rehabilitation after

stroke: A systematic review. *Occupational Therapy International*. doi: 10.1155/2023/3752889

Yu, C.-H., Mathiowetz, V. G., Zieffler, A., & Tomlin, G. S. (2021). Efficacy of a forearm rotation orthosis for people with a hemiparetic arm. *American Journal of Occupational Therapy*, *75*(6), 1–11. https://doi-org.ezproxylr.med.und.edu/10.5014/ajot.2021.043455