International Journal of Advanced Nursing Education and Research
Vol.5, No.2 (2020), pp.19-28
http://dx.doi.org/10.21742/ijaner.2020.5.2.03

Descriptive Study on Rehabilitation Treatment Methods for Improving Upper Limb Function in Stroke Patients

Youn-Bum Sung [1], Dae-Hwan Lee[2] and Jung-Ho Lee[3*]

[1,2]Department of Physical Therapy, Daegu Univ., Jillyang-eup, Gyeongsan-si, Gyeongsangbuk-do, 38453, Republic of Korea
[3]Department of Physical Therapy, Kyungdong Univ., Bongpo-ri, Toseong-myeon, Goseong-gun, Gangwon-do, 219-705, Republic of Korea
[1]playeryoon@naver.com, [2]dhlee8510@naver.com, [3]ljhcivapt@naver.com

Abstract

Stroke is a central nervous system disease that causes partial loss of brain function due to the sudden hematopoietic or bleeding of the brain's blood supply to the brain tissue. Currently, therapeutic interventions for stroke patients include nerve system therapy, Bobath therapy, PNF, task-oriented training, CIMT, mirror therapy, and imagination training as various ways to improve upper limb function. In addition, research on robot therapy for continuous upper extremity training programs has been actively conducted, and recently, treatments using virtual reality systems have been introduced. However, despite the introduction of several treatments, most therapists tend to stick to only the methods they have primarily treated. A more qualitative treatment can be applied if the therapist can accurately recognize each treatment method and apply the appropriate treatment to various situations. Therefore, this study investigates treatments for improving the function of the upper extremities of stroke patients and seeks to explore the advantages and disadvantages of treatment methods and better use.

Keywords: *Stroke, Upper limb rehabilitation, Treatment methods*

1. Introduction

Stroke is a disease in the central nervous system in which sudden ischemia or hemorrhage in blood vessels inhibits the smooth blood supply to brain tissues, causing a partial loss of brain function and consequent functional disorders [1]. Stroke patients generally experience neurological disorders like motor, sensory, cognitive, language, and emotional [2]. Mainly, patients with stiffening, muscular weakness, excessive tension, and imbalances in their upper limbs can lose the ability to control their upper limb movement and thus perform only limited social activities and Activities of Daily Living (ADLs) [3][4]. These disorders cause stroke patients to experience lowered self-efficacy, psychological and emotional pains (such as depression), and lowered quality of life [5][6]. At least 70% of stroke patients develop upper limb paralysis, and at least 60% show declines in skill [6]. Stroke patients commonly recover from the disease three to six months after its onset. Rehabilitative treatments during this period can facilitate their functional restoration by aiding in neurological recovery [7]. Within

Article history:
Received (April 14, 2020), Review Result (May 18, 2020), Accepted (June 26, 2020)
*corresponding author

six months after stroke onset, patients can hardly exercise and thus require the assistance of therapists.

Approximately 85% of stroke patients exhibit cognitive, motor, sensory, and balance disorders, and over 69% of them develop dysfunctions in their affected upper limbs [8]. Notably, according to previous research, only about 20% of patients who showed severe motor disorders in their affected upper limbs in the early stages of stroke partially recover their upper limb function, and less than 5% of these patients fully recover their upper limb function. Moreover, around 25% of stroke patients complain of difficulties in the proper use of their upper limbs even five years after stroke onset, signifying small chances of recovering upper limb function after a stroke [9][10]. Upper limb disorders occurring after a stroke become a primary cause of the inhibition of movements such as eating, walking, handwriting, balancing, manipulation, delicate hand movements, personal hygiene management, and expression of opinions; thus, these disorders hinder stroke patients’ social independence and degrade their quality of life [11]. Stroke patients’ recovery of their upper limb function is essential for them to maintain the most basic human life. This function may be as crucial for performing ADLs as the lower limb's gait function [12].

The reason for focusing on upper limb rehabilitation out of the various issues that stroke patients can experience is that impairment of the middle cerebral artery, which is in charge of upper limb function, accounts for 75% of all stroke cases [13]. A stroke patient's weakness in the upper limb increases their reliance on others by lowering their independence in performing ADLs. Notably, a patient whose weakened upper limb and central hand are on the same side needs assistance in most ADLs, including eating, face washing, toilet use, dressing, and grooming. Therefore, not only stroke patients but also their caregivers, who should stay close to them, can experience declines in their quality of life. Stroke patients' upper limb rehabilitation should aim to reduce the spread of brain damage during the acute treatment period and mitigate the disorders resulting from aftereffects through problem-solving after the acute stage [13][14].

Stroke interventions employ various methods to improve upper limb function, including Bobath therapy, Proprioceptive Neuromuscular Facilitation (PNF), and task-oriented training. In addition, interventions and studies are underway for upper limb training programs, such as Constraint-Induced Movement Therapy (CIMT) and mirror therapy. In recent years, treatments using the robot and virtual reality systems have also been adopted [15].

However, despite the wide range of treatment and evaluation methods introduced to date, many therapists cling to the techniques they have mainly used. A more qualitative treatment can be applied if the therapist can accurately recognize each treatment method and apply the appropriate treatment to various situations. Therefore, this study intends to introduce the existing treatment and evaluation methods for improving stroke patients' upper limb function and find ways for therapists to better use them by adequately understanding each method's characteristics.

2. Methods

This study found and compiled papers on Bobath therapy, PNF therapy, Task-oriented movement therapy, CIMT, and Mirror therapy among stroke patients' upper limb rehabilitation methods posted on Pub-Med since 2000.

2.1. Bobath therapy

Bobath therapy aims to establish treatment programs that enable an individual to withstand the pressure from repeated active exercises, gravity, weight, or hands; achieve a balance between muscle groups; and reduce the effects of abnormal tension in exercise patterns and autonomous responses [16].

The principle of Bobath therapy is to inhibit abnormal types of sensory stimulations in the sensorimotor system's abnormal closed loops, arouse normal sensory stimulations as much as possible, and facilitate the maximum level of regular sensory inputs, thereby preventing the vicious cycle of abnormally closed loops. To activate this inhibition, reflex inhibitory postures were developed [16]. Bobath therapy addresses the problem where abnormal and widespread reflex patterns of exercises and postures occur from the brain stem, cerebellum, midbrain, basal ganglia, and cortex through their disassociation from inhibition. Therefore, this therapy is based on an approach to normal development, motion compensation, and habitual exercise patterns that can cause muscular imbalances or contractions. The underlying concepts of Bobath therapy are autonomous postural adaptation, sensory structures for inducing postural responses, muscle tone, fixation aimed at compensating for low muscle tone, development of motility, cognition of kinetic potentials, development of active muscles, and supply of muscle control [16]. Bobath therapy uses functional activities and teaches how to process muscle tensions. It values the quality of movements in every activity, encourages patients to perform on their own as much as possible, and emphasizes early treatment. It even teaches patients with cerebrovascular diseases to maintain proper postures in bed to recognize and use their affected sides. It also trains patients in skills to move quickly in bed as early as possible to help them avoid movement patterns that strengthen abnormal reflexes. Therapists should control patients' movements to generate standard patterns and teach them to sense such movements. Patients are also instructed to reduce the number of movements controlled by therapists and replace therapists' control with their own. Key points of control are used to promote regular movements. Initially, critical points of control are primarily in the body's proximal parts, such as the trunk and the pelvis. As their conditions improve, patients learn to use the distal parts of their bodies as the core of control. Therapists should control the intensity of therapy to promote patients' control of their movements [17].

2.2. Proprioceptive Neuromuscular Facilitation (PNF)

PNF treatment aims to increase the potential memory of movement patterns that are as normal as possible in the central nervous system. This is achieved by providing sufficient early aids (proprioceptive, foreign, and terminal-receptive signals) to arouse patients' needs and responses. Self-reliance means patients' deferred tasks for future use and already learned tasks [16].

PNF involves spiral and diagonal mass movement patterns [18]. These patterns combine exercises in the sagittal, coronal, and cross-sectional planes. Specifically, PNF combines flexion and extension in the sagittal plane, pronation and supination in the coronal plane, and rotation in the cross-sectional plane. This combination of functional movements increases muscle activities and spreads them toward the proximal and distal areas [19]. These characteristics can explain Beevor’s principle: 1) PNF uses group movement patterns that become the basis of all techniques. 2) Mass muscular movement patterns are the original trait of everyday movements. 3) The brain is unaware of any individual muscle action except the occurring movements. Mass movement patterns can be classified as the upper limb, lower limb, trunk, cephalic, and temporomandibular patterns. These patterns vary by the joint(axis) from which movements mainly occur. When each pattern is clinically used, the combination of rhythmic inception, rhythmic stability, repeated contraction, the timing of emphasis, reversed motions by the antagonist, slow reversal, reversal of the antagonist and the agonist, contraction-relaxation, maintenance-relaxation, and isotonic contraction can result in numerous variations of a single pattern [20].

The locations and positions of patients and therapists, verbal orders for auditory stimulations, use of patients' vision, extension and compression, timing, and movement patterns are applied in methods and procedures of applying the facilitation, proper resistance, use of diffusion and reinforcement, and barehand contact for cognitive and tactile simulations [19].

2.3. Task-oriented movement therapy

In the 1980s, based on motor learning theory, selective task-oriented training was developed as a treatment technique for stroke patients. This training assumes that providing functional tasks to patients and their active problem-solving is more effective for learning than the repeated training of a single movement [21]. Selective task-oriented training is characterized by its task-oriented approach to motor recovery. It is also based on dynamic system theory, which explains the performance of the tasks and motor recovery that occur in the dynamic interactions between individuals, environments, and functions that they perform [22].

Stroke patients' selective task-oriented training is goal-oriented; it helps them achieve their goals by performing movements within their daily environments through functional tasks. It is also an effective treatment technique through which stroke patients can expect functional recoveries [23]. Patients' full engagement in an activity or task from the beginning to the end can elicit more vital, more effective, and coordinated motor responses than partial engagement [24]. Previous research on task-oriented training shows that tasks and intervention strategies that provide meaningful activities related to daily living are more helpful than repeated or passive exercises for learning skills and improving functions [25]. A study on selective task-oriented training reports that task training focused on patients' preferred tasks or goals facilitates changes in ADLs and produces more effective outcomes from rehabilitation treatments [26].

2.4. Constraint-Induced Movement Therapy (CIMT)

CIMT is a behavioral neuroscience-based treatment method used to enhance a stroke patient's motor performance on the affected side in neurorehabilitation [27]. Stroke patients mostly experience difficulties using their affected upper limbs and thus learn patterns using their unaffected sides to compensate for such insufficient motions. Continued compensatory learning hinders their intrinsic recovery [28]. Taub et al. (1980) explained this phenomenon using the term "learned nonuse ."In their study, they blocked the vision of monkeys on one side and had them wear jackets designed to constrain their motions and suppress their compensatory patterns in the unaffected healthy upper limb; as a result, the monkeys used the affected side. Based on this principle, CIMT was introduced as a treatment that enables learning functional movement patterns by limiting the use of the unaffected side and inducing intensive movements on the affected side to control learned nonuse. In recent years, it has further evolved into the concept of task-oriented movement therapy [27].

CIMT is offered to stroke patients to enhance hemiplegic patients' upper limb function by overcoming the learned nonuse that occurs in the acute stage after stroke onset and inducing changes in the cerebral cortex [29].CIMT, which constrains the unaffected side, increases the use of the affected side through continuous and repeated practices of functional arm movements. Recent studies explain this therapy with changes in movement patterns through kinetic analyses and local terminal sprouting or functional synaptic reorganization achieved by stimulating the undamaged cortical circuit and the sensory cortex adjacent to the damaged area [30][31].

2.5. Mirror therapy

Contradicting the basic concept that sensorimotor training is practical for motor skills, mirror therapy is based on the facilitation of the mirror neuron system and induces improvements in the affected side's movements by providing visual information (the unaffected side's movements are reflected in the mirror as if they were the affected side's); mirror therapy focuses on the fact that visual stimulations are effective for improving motor skills [32]. This therapy was introduced by Ramachandran (1994) for phantom pain reduction in amputees. Its effects on reducing pain and stiffening have been reported [33]. Mirror therapy was also adopted by Altschuler, Wisdom, and Stone (1999) as a treatment to restore stroke patients' upper limb function [34]. Moreover, a systematic review by Pollock et al. (2014) defined mirror therapy in the rehabilitation of stroke patients as a visual stimuli-based technique that creates an illusion of movements on the affected side through the mirror reflection of the actual upper and lower limb movements on the unaffected side for the performance of tasks [35]. Mirror therapy positively affects stroke patients' upper limb function and ability to perform ADLs [36].

The neurological mechanism of mirror therapy is highly associated with the superior temporal sulcus, and the activation of the primary motor area is exhibited through magnetic resonance imaging [37].In addition, Thirumala et al. (2002) validated the effects of mirror therapy via mirror neurons by confirming increased stimulations in the primary motor cortex and both inferior parietal lobules during observation of upper limb and hand movements via the mirror [38]. According to a review of previous research on mirror therapy, recent practices of mirror therapy have shifted from the original movement-based treatment, which comprised forearm, wrist, and knuckle motions, toward task-oriented therapy; these recent practices also apply task-oriented training methods beyond the conventional, simple movement-based treatment [39].

3. Discussion

Stroke is one of the ten leading causes of death and one of the three major diseases in South Korea. The number of deaths from stroke is 23,415 per 100,000 people, accounting for 45.8%[40]. Stroke is a neurological condition generated by discontinuing blood supply due to the rupture of blood vessels or their blockage by blood clots. This disease impairs brain tissues by blocking the supply of oxygen and nutrients [41]. Its symptoms include motor, sensory, cognitive, emotional, and speech disorders [42]. About 16% to 30% of stroke patients show loss of mental functions, such as orientation, attention, memory, language skills, and visuospatial ability, within one year after stroke onset. These disorders cause difficulties in performing independent ADLs, including bathing, traveling, and bowel and bladder control [43][44]. Because most ADLs are linked to upper limb function, the recovery of upper limb function has a significant impact on stroke patients. Multiple studies assert that upper limb function is restored in the early stages of stroke. However, Taub et al. (1993) stated that some patients recovered their upper limb function until one year after stroke onset

[27]. They reported that, although quick recoveries are made in the early stages of rehabilitation, active functional recoveries require more time [21]. Therefore, therapeutic approaches to enhance upper limb function are essential [45].

This study found and compiled papers on Bobath therapy, PNF therapy, Task-oriented movement therapy, CIMT, and Mirror therapy among stroke patients' upper limb rehabilitation methods posted on Pub-Med since 2000.

The principle of Bobath therapy is to inhibit abnormal types of sensory stimulations in the sensorimotor system's abnormal closed loops, arouse normal sensory stimulations as much as possible, and facilitate the maximum level of regular sensory inputs, thereby preventing the vicious cycle of abnormally closed loops. PNF involves spiral and diagonal mass movement patterns. These patterns combine exercises in the sagittal, coronal, and cross-sectional planes. Specifically, PNF combines flexion and extension in the sagittal plane, pronation and supination in the coronal plane, and rotation in the cross-sectional plane. This combination of functional movements increases muscle activities and spreads them toward the proximal and distal areas. Task-oriented movement therapy assumes that providing functional tasks to patients and their active problem-solving is more effective for learning than the repeated training of a single movement. Selective task-oriented training is characterized by its task-oriented approach to motor recovery. It is also based on dynamic system theory, which explains the performance of the tasks and motor recovery that occur in the dynamic interactions between individuals, environments, and functions that they perform. CIMT is offered to stroke patients to enhance hemiplegic patients’ upper limb function by overcoming the learned nonuse that occurs in the acute stage after stroke onset and inducing changes in the cerebral cortex. CIMT, which constrains the unaffected side, increases the use of the affected side through continuous and repeated practices of functional arm movements. Recent studies explain this therapy with changes in movement patterns, explained through kinetic analyses, and local terminal sprouting or functional synaptic reorganization achieved by stimulating the undamaged cortical circuit and the sensory cortex adjacent to the damaged area. Lastly, contradicting the basic concept that sensorimotor training is practical for motor skills, mirror therapy is based on facilitating the mirror neuron system and induces improvements in the affected side’s movements by providing visual information. Mirror therapy focuses on the fact that visual stimulations are effective for improving motor skills.

4. Conclusion

The present study introduced various treatment methods, such as stroke interventions, to improve upper limb function. They included the Bobath therapy, PNF, task-oriented training, CIMT, and mirror therapy. It is difficult to state that specific evaluation or treatment methods are superior to others. Nevertheless, the flexible applications of the various treatment methods presented by this study to suit varied circumstances will induce effective treatments for the recovery of stroke patients' overall physical functions, ultimately enhancing their upper limb function.

Acknowledgments

This work was supported by the National Foundation of Korea (NRF) grant, which was funded by the Korean government (MSIT) (No-2019R1F1A1057731).

References

[1] G Prange, H. Jannink, and C. Groothuis-Oudshoorn, “Systematic review of the effect of robot-aided therapy on recovery of the hemiparetic arm after stroke,” Journal of Rehabilitation Research & Development, vol.43, no.2, pp.171-184, (2006) DOI:10.1682/JRRD.2005.04.0076

[2] C. Trombly, and M. Radomski, "Occupational therapy for physical dysfunction," Baltimore, Williams, and Wilkins, **(2008)**

[3] J. Gracies, J. Marosszeky, R. Renton, J. Sandanam, S. Gandevia, and D. Burke D., “Short-term effects of dynamic lycra splints on upper limb in hemiplegic patients," Archives of Physical Medicine and Rehabilitation, vol.81, no.12, pp.1547-1555, (2000) DOI:10.1053/apmr.2000.16346

[4] H. Dijkerman, M. Ietswaart, M. Johnston, and R. Macwalter, “Does motor imagery training improve hand function in chronic stroke patients? A pilot study” Clinical Rehabilitation, vol.18, no.5, pp.538-549, (2004) DOI:10.1191/0269215504cr769oa

[5] G. Robinson-Smith, M. Johnston, and J. Allen, "Self-care self-efficacy, quality of life, and depression after stroke" Archives of Physical Medicine and Rehabilitation, vol.81, no.4, pp.460-464, (2000) DOI:10.10 53/mr.2000.3863

[6] G. Kwakkel, B. Kollen, J. van der Grond, and A. Prevo, “Probability of regaining dexterity in the flaccid upper limb: Impact of severity of paresis and time since onset in acute stroke,” Stroke, vol.34, no.9, pp.2181-2186, **(2003)** DOI:10.1161/01.str.0000087172.16305.cd

[7] U. Rah, Y. Kim, S. Ohn, M. Chun, M. Kim, and M. Shin, "Clinical practice guideline for stroke rehabilitation in Korea 2012," Brain & Neuro Rehabilitation, vol.7, no.1, pp.1-75, (2014) DOI:10.12786/ bn.2014.7. Suppl1.S1

[8] C. Luke, K. Dodd, and K. Brock, “Outcomes of the Bobath concept on upper limb recovery following stroke,” Clinical Rehabilitation, vol.18, no.8, pp.888-98, (2004) DOI:10.1191/0269215504cr793oa

[9] J. Geddes, J. Fear, A. Tennant, and A Pickering, M. Hillman, M. Chamberlain, "Prevalence of self-reported stroke in a population in northern England," Journal of Epidemiol Community Health. vol.50, no.2, pp.140-143 DOI:10.1136/jech.50.2.140

[10] K. Hayward, R. Barker, and S. Brauer, “Interventions to promote upper limb recovery in stroke survivors with severe paresis: a systematic review,” Disability and Rehabilitation, vol.32, no.24, pp.1973-1986, (2010) DOI:10.3109/09638288.2010.481027

[11] S. Michaelsen, R. Dannenbaum, and M. Levin, "Task-specific training with trunk restraint on arm recovery in stroke," stroke. vol.37, no.1, pp.186-192, (2006) DOI: 10.1161/01.STR.0000196940.20446.c9

[12] B. Sheng, and M. Lin., “A longitudinal study of functional magnetic resonance imaging in upper-limb hemiplegia after stroke treated with constraint-induced movement therapy,” Brain injury. vol.23, no.1, pp.65-70, (2009) DOI:10.1080/02699050802635299

[13] H. Markus, A. Pereira, and C. Geoffery, Stroke Medicine. NY: Oxford University Press. **(2010)**

[14] P. Langhome, J. Bernhardt, and G. Kwakkel, “Post Stroke Rehabilitation,” The Lancet. vol.377, no.9778, pp.1693-1702, (2011) DOI:10.1016/S0140-6736(11)60325-5

[15] M. Bird, J. Cannell, E. Jovic, A. Rathjen, K. Lane, A. Tyson, M. Callisaya, S. Smith, and S. Less, "A Randomized Controlled Trial Investigating the Efficacy of Virtual Reality in Inpatient Stroke Rehabilitation," Archives of Physical Medicine and Rehabilitation, vol.98, no.10, pp.e27, (2017) DOI:10.1016 /j.apmr.2017.08.084

[16] J. Marilyn, and B. Lister, "Contemporary Management of Motor Control Problems: Proceedings of the II STEP Conference, Virginia, Bookcrafters Inc

[17] T. Platz, C. Eickhof, S. van Kaick, U. Engel, and C. Pinkowski, “Impairment-oriented training or Bobath therapy for severe arm paresis after stroke: a single-blind, multicentre randomized controlled trial,” Clinical Rehabilitation, vol.19, pp.714-724, (2005) DOI:10.1191/0269215505cr904oa

[18] M. Knott and D. Voss, "Proprioceptive Neuromuscular Facilitation: pattern and techniques, 2nd ed," Harper and Row, New York

[19] S. Adler, D. Beckers, and M. Buck, "PNF in practice," Springer-Verlag Berlin Heidelberg, New York

[20] S. Adler, D. Beckers, and M. Buck, "Patterns of Facilitation. In: PNF in Practice," Springer, Berlin, Heidelberg, pp.57-62, **(2000)**

[21] J. Carr, and R. Shepherd, "Stroke rehabilitation: guidelines for exercise and training to optimize motor skill," Butterworth-Hein emann Medical, **(2003)**

[22] A. Carrie, A. Linda, and G. David, "Enhanced task-oriented training in a person with dementia with Lewy bodies," The American of Occupational Therapy, vol.67, no.5, pp.556-563, **(2013)** DOI:10.5014/ajot.2 013.008227

[23] G. Thielman, C. Dean, and A. Gentile, "Rehabilitation of reaching after stroke: task-related training versus progressive resistive exercise," Archives of Physical Medicine and Rehabilitation, vol.85, no.10, pp.1613-1618, **(2004)** DOI:10.1016/j.apmr.2004.01.028

[24] H. Pendleton, W. Schultz-Krohn, and S. BCP, "Pedretti's Occupational Therapy: motor learning," Elsevier Health Sciences, **(2006)**

[25] C. Winstein, D. Rose, S. Tan, R. Lewthwaite, H. Chui, and S. Azen, "A randomized controlled comparison of upper-extremity rehabilitation strategies in acute stroke: a pilot study of immediate and long-term outcomes," Archives of Physical Medicine and Rehabilitation, vol.85, no.4, pp.620-628, (2004) DOI:10.1016/j.apmr. 2003.06.027

[26] A. Spooren, Y. Janssen-Potten, E. Kerckhofs, and H. Seelen, "Outcome of motor training programs on the arm and hand functioning in patients with cervical spinal cord injury according to different levels of the ICF: a systematic review," Journal of Rehabilitation Medicine, vol.41, no.7, pp.497-505, (2009) DOI:10.2340 /16501977-0387

[27] E. Taub, G. Uswatte, and R. Pidikiti, "Constraint-Induced Movement Therapy: a new family of techniques with broad application to physical rehabilitation—a clinical review," Journal of Rehabilitation Research and Development, vol.36, no.3, pp.237

[28] A. Dromerick, D. Edwards, and M. Hahn, "Does the application of constraint-induced movement therapy during acute rehabilitation reduce arm impairment after ischemic stroke?" Stroke, vol.31, no.12, pp.2984-2988, **(2000)** DOI: 10.1161/01.STR.31.12.2984

[29] S. Fritz, K. Light, S. Clifford, T. Patterson, A. Behrman, and S. Davis, "Descriptive characteristics as potential predictors of outcomes following constraint-induced movement therapy for people after stroke," Physical Therapy, vol.86, no.6, pp.825-832, (2006) DOI:10.1093/ptj/86.6.825

[30] G. Nelles, W. Jentzen, M. Jueptner, S. Müller, and H. Dienera, "Arm training-induced brain plasticity in stroke studied with serial positron emission tomography," Neuroimage, vol.13, no.6, pp.1146-1154, (2001) DOI:10.1006/nimg.2001.0757

[31] P. Rossini and F. Pauri, "Neuromagnetic integrated methods tracking human brain mechanisms of sensorimotor areas 'plastic' reorganization," Brain Research Reviews, vol.33, no.2-3, pp.131-154, (2000) DOI:10.1016/S0169-328X (00)00090-5

[32] H. Thieme, M. Bayn, M. Wurg, C. Zange, M. Pohl, and J. Behrens, "Mirror therapy for patients with severe arm paresis after stroke-randomized controlled trial," Clinical Rehabilitation, vol.27, no.4, pp.314-324, (2013) DOI:10.1016/j.jns.2013.07.2000

[33] V. Ramachandran, "Phantom limbs, neglect syndromes, repressed memories, and Freudian psychology," International Review of Neurobiology, vol.37, pp.291-333

[34] E. Altschuler, S. Wisdom, and L. Stone, "Rehabilitation of hemiparesis after stroke with a mirror," The Lancet, vol.353, pp.2035-2036

[35] A. Pollock, S. Farmer, M. Brady, P. Langhorne, G. Mead, J. Mehrholz, and F. van Wijck, "Interventions for improving upper limb function after stroke," Cochrane Database of Systematic Reviews. vol.46, no.3, pp.57-58, (2014), DOI:10.1161/STROKEAHA.114.008295

[36] M. Invernizzi, S. Negrini, S. Carda, L. Lanzotti, C. Cisari, and A. Baricich, "The value of adding mirror therapy for upper limb motor recovery of subacute stroke patients: A randomized controlled trial," European Journal of Physical Rehabilitation Medicine, vol.49, no.3, pp.311-317, **(2013)**

[37] K. Matthys, M. Smits, J. Van der Geest, A. Van der Lugt, R. Seurinck, H. Stam, and R. Selles, "Mirror-Induced Visual Illusion of Hand Movements: A Functional Magnetic Resonance Imaging Study," Archives of Physical Medicine and Rehabilitation, vol.90, no.4, pp.675-681, (2009) DOI:10.1016/j.apmr.2008.09.571

[38] P. Thirumala, D. Hier, and P. Patel, "Motor recovery after stroke: Lessons from functional brain imaging," Neurological Research, vol.24, no.5, pp.453-458, (2002) DOI:10.1179/016164102101200320

[39] K. Arya, and S. Pandian, "Effect of task-based mirror therapy on motor recovery of the upper extremity in chronic stroke patients: A pilot study," Topics in Stroke Rehabilitation, vol.20, no.1, pp.210-217, **(2013)** DOI:10.1310/tsr2003-210

[40] Statistics Korea, Cause of Death Statistics Results in 2016, **(2016)**

[41] World Health Organization, Global status report on noncommunicable diseases: Author, **(2014)**

[42] C. Trombly, and M. Radomski, "Occupational therapy for physical dysfunction, Baltimore: Williams & Wilkins, Philadelphia, **(2008)**

[43] P. Appelros, and A. Andersson, "Changes in Mini-Mental State Examination score after stroke: lacunar infarction predicts cognitive decline," European Journal of Neurology, vol.13, no.5, pp.491-495, (2006) DOI:10.1111/j.1468-1331.2006.01299.x

[44] R. Oros, C. Popescu, C. Iova, P. Mihancea, and S. Iova, "The impact of cognitive impairment after stroke on activities of daily living," Human & Veterinary Medicine, vol.8, no.1, pp.41-44, **(2016)**

[45] H. Feys, W. Weerdt, B. Selz, G. Steck, R. Spichiger, L. Vereeck, K. Putman, and G. Hoydonck, "Effect of a therapeutic intervention for the hemiplegic upper limb in the acute phase after stroke," Stroke, vol.29, no.4, pp.785-92, **(1998)** DOI:10.1161/01.STR.29.4.785

This page is empty by intention.