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Descriptive Study on the Influence of Intermediation Methods Using Robots on the Improvement of Upper Extremity in Stroke Patients

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

[1,2]Dept. Physical Therapy, Daegu Univ., Jillyang-eup, Gyeongsan-si, Gyeongsangbuk-do, 38453, Republic of Korea
[3]Dept. 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

Upper extremity dysfunction, which occurs after stroke, acts as a major cause of obstruction of motion, such as elaborate hand gestures, manipulation, eating, writing, personal hygiene control, expression of opinion, walking and balancing, etc., thus hindering the social independence of patients and causing poor quality of life. Restoration of upper limb function in stroke patients can be said to be important in maintaining the most basic human life. The walking function of the lower extremities is as important as the walking function of the lower extremities in carrying out daily life. In this study, when patient-centered robot assisted rehabilitation was applied to patients with subacute stroke through setting demands and goals for daily life, and motion analysis, it was positive not only to improve the patient's upper body function, but also to improve the performance of daily activities rather than robot-centered robot assisted rehabilitation with the focus of existing robot devices. In addition, patient-centered robot assisted rehabilitation and robot-centered robotic rehabilitation were more effective than traditional rehabilitation in the range of joint operation of the upper distal region, grip of the hand, and grip strength. On the other hand, patient-centered robot assisted rehabilitation and traditional rehabilitation showed more positive effects than robot-centered robot assisted rehabilitation. Based on these findings, it is meaningful that the research provided a basis for applying patient-centered robotic rehabilitation to improve upper limb function and performance of daily operations in subacute stroke patients.

Keywords: *Stroke, Upper limb rehabilitation, Robot assisted rehabilitation*

1. Introduction

According to the United Nation's standards, if more than 7% of a total population is 65 years or older, it is called an aging society, if it's more than 14%, it is called an aged society, and if it's more than 20%, it is called a super-aged society [1]. For South Korea, the population of 65 years or older accounts for more than 14.3% of the total population, which is about 7.4 million people. Thus, South Korea is an aged society. The number of disabilities in South Korea in 2017 was around 2.5 million, according to the disability statistics. Among them, a

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proportion of disabled elderly over 65 years was 46.6% in 2017, which increased by 3.3% from that in 2014 (43.3%) This data shows a steady increasing trend of disabled elderly.

One of the most common issues for many disabled elderly individuals around the world is stroke caused by cardiovascular disease. The number of patients with stroke reaches around 62 million around the world [2]. The number of hospitalized patients due to stroke from 2000 has increased annually, and the compound annual rate was 6.4% [3]. The survival rate after the onset of stroke was 80% in Korea, which is relatively higher than that of other major causes of death, but 64% of the survivors had disabilities, such as sensory motor loss in the upper and lower extremities. Among them, 15% to 30% had permanent disabilities [4][5].

In particular, a stroke involves various problems in sense, motor movements, cognition, perception, and language depending on the damage location in the brain, size, and rehabilitation period after onset. Hemiplegia symptoms are mostly followed [6]. Patients with disabilities due to stroke have problems such as balance ability, gait function, and fine motor control function due to hemiplegia. They have difficulties in normal posture control due to asymmetric posture and muscle strength shortage in the affected side caused by stiffness in the hemi-side and abnormal motor patterns and disability in coordination capability. In particular, their main complaint is a gait that requires harmonizing movements between the upper and lower extremities [7][8].

A stroke causes local and neurological damage in the brain, which occurs suddenly due to abnormal cerebral blood flow [9]. It is ranked as the second leading cause of death in the world. In Korea, it is the third leading cause of death following cancer and heart disease [10]. A stroke, which is also called cerebrovascular disease, is categorized into hemorrhagic stroke, in which blood from an artery begins bleeding into the brain due to the rupture of a blood vessel, causing part of the brain damage, and ischemic stroke caused by a blockage in an artery that supplies essential oxygen and blood to the brain due to blood clots or other causes. Around 80% of stroke patients belong to ischemic stroke, which was reported as the largest proportion of ischemic stroke occurring in the middle cerebral artery [11].

Contralateral hemiplegia and sensory loss in the face, arms, and legs are some of the general symptoms of the middle cerebral artery infarction. Up to 85% of stroke patients have motor function deficiency in the upper extremities, and 55% to 75% of them have the deficiency even after three to six months [12]. Since the upper extremities include functions that perform complex motions, such as gripping and controlling objects, the recovery of its functions is delayed longer than the lower extremities, which perform simpler motions [13][14]. The body functions that are lost due to stroke—acute and subacute phases—can be recovered mostly within three months, and additional recovery may occur within six months [11]. The level of recovery of deficient body functions in this process has been known to be affected by the increase in brain plasticity [15].

More than 70% of patients have paralysis in the function of the upper extremities, and more than 60% have degradation in hand dexterity [16]. The recovery from stroke occurs the most within three to six months after the occurrence of stroke, and the rehabilitation treatment in this period can facilitate functional recovery with the help of neurological recovery [17]. Since patients within six months after the occurrence of stroke cannot do exercises themselves, they need help from therapists.

2. Methods

2.1. Literature search

Computerized literature searches were conducted in Medline, EMBASE, Cochrane Controlled Trial Register, PubMed, and PEDRO since 2000. The keywords used were cerebrovascular accident, cerebrovascular disease, stroke, upper limbs and robots. A bibliographic list of descriptive reviews of the relevant publications was also evaluated: (1) the effects of robotic assisted therapy on patients diagnosed with cerebrovascular accidents, (2) the upper extremities were investigated, (3) the results were measured in terms of motor and/or functional recovery of the upper limb, and (4) the study was a randomized clinical trial. A study comparing discharge results with preinterference stability scores on people with chronic disabilities due to stroke and the effects of two different robot-assisted treatments were excluded.

2.2. Methodological quality

The methodological quality of the study was evaluated on the PEDro scale and scored by two independent reviewers. The interoperability reliability of individual items was tested with Cohen's Kappa statistics. When no agreement was reached between the two reviewers, the third reviewer made the final decision. The reviewer was blinded to in authors, institutions, or journals. PEDro scores of four or more points were classified as "high quality," and studies of three or less points were classified as "low quality".

2.3. Quantitative analysis

Abstract data (average age, the number of patients in experiment and control groups, the average change score for motor recovery and function level measurements, and the standard deviation of experiment and control groups in criteria) were entered into Excel for Windows. For all the resulting variables, the threshold for rejecting the H 0 hypothesis was set to $P < 0.05$ (2-tailed)

2.4. Definitions

Cerebral vascular thinking has been defined as "a sudden non-convulsive loss of nerve function due to ischemic or hemorrhagic intravascular events". Robotics was defined as "applying electronic and computerized control systems to mechanical devices designed to perform human functions". Previously restricted to industry, but today certain human functions can also be controlled by bionic devices such as automatic insulin pumps and other prostheses.

3. Results

3.1. Disorders of stroke

Around 85% of stroke patients have problems with cognition, motor ability, sensory, and balance, and more than 69% of them have functional disabilities in the upper extremities of the affected side [18]. In particular, only 20% of patients with severe motor disability in the upper extremities on the affected side at the early days of stroke occurrence had partial recovery in upper extremity functions, and only 5% or smaller had complete recovery of upper extremity functions. Around 25% complained of difficulty in the use of their upper extremities after five years from the occurrence of stroke [19][20].

In summary, the recovery of upper extremity functions is highly negative after the occurrence of stroke. The disabilities in upper extremity functions can play a major role in disturbing movements, such as sophisticated hand motion, operating, eating, writing, personal hygiene, expression of intension, walking, and balancing, which inhibit the social independence of patients and incurs degradation in their quality of life [21]. The recovery of upper extremity functions of stroke patients is vital in order for them to live their most basic lives as humans. However, it should be noted that lower extremity functions are just as important as upper extremity functions in performing daily functions [22].

3.2. The goals of stroke rehabilitation

The reason for focusing on the rehabilitation of upper extremity functions among many various problems in patients is due to the damage to the middle cerebral artery, which is responsible for upper extremity functions and accounts for 75% of all strokes [23]. The weakness of the upper extremities can disturb the independence of patients in performing daily activities, thereby increasing their dependence on others. In particular, if a patients' weak upper extremity is on the same side as their dominant hand, the patient will need help in most daily activities, such as eating, washing, toileting, dressing, and appearance management, which can degrade a patient's quality of life, as well as family members who are close to the patient. Thus, the goal should be to set not only a reduction in the expansion of brain damage during the subacute treatment phase, but also to decrease the patients' disabilities due to the after effect through the problem-solving process after the subacute phase [23][24].

4. Discussion

Robot-assisted rehabilitation has been developed to improve the activities of daily living in patients with upper extremity disabilities for the past 20 years [25]. From the 1990s, various rehabilitation robot devices have been developed and introduced around the USA and Europe, and studies on the effects have been reported [26]. Since robot-assisted rehabilitation is more advantageous in repetitive and high-strength training than conventional rehabilitation treatment, many proofs are increasing that they are effective in improving the upper extremity functions of patients (muscle strength, joint range of motion, and coordination ability) However, answers to more meaningful questions are needed to draw the effects through robot-assisted rehabilitation to the maximum [27].

For example, the systematic literature review on the effects of upper extremity rehabilitation treatment using a robot was published in 2008, and it reported that upper extremity muscle strength and motor functions were improved, but activities of daily living were not enhanced [28]. A Cochrane Review (with 666 stroke patients and 19 studies conducted up to July 2011) was published in 2012 and reported that upper extremity training using a robot showed improvements in upper extremity functions and activities of daily living of stroke patients more than other treatments, including traditional rehabilitation treatments, but did not significantly improve the muscle strength in upper extremities. Nonetheless, the review indicated that careful interpretation was required because the robot type and characteristics applied in their studies were different, and the training period and intensity varied.

A Cochrane Review including studies up to March 2015 analyzed the effects of robot-assisted upper extremity training according to the onset period of the subjects. Eight studies were analyzed with 320 patients in their subacute period who had a stroke no more than three months from the onset; their results showed improvements in activities of daily living, but 10 studies with 397 patients who had a stroke more than three months ago did not show improvements in daily living activities. The results did not find any significant difference between the two groups [27][28][29]. The robot-assisted rehabilitation in a number of previous studies exhibited clear improvement evidence, such as improvements in the proximal segments of the upper extremities and hands, improvements in hand muscle strength, an increase in the joint range of motion of the upper extremities, and improvement in upper extremity functions [28].

In contrast, improvements in the activities of daily living have rarely been reported, and studies that report positive effects were cautious about the interpretation of the positive effects, or exhibited the lowest level in the Quality of Evidence 4-level scale that represented a clear level of effect measurements [30]. As described above, robot-assisted rehabilitation has been limited to correlate recovered upper extremity functions of patients with activities of daily living [29].

One of the reasons for this limitation was the lack of the map that could convert improved movements into activities of daily living because the motor movements that are required in daily activities were not performed in the treatment process using a robot. In addition, studies on robot-assisted rehabilitation performed in Korea and overseas were focused on simple repetitive training on muscle strength or joint range of motion. However, these were deficient around the damaged area, and the motions or preferences required in activities of daily living were considered by applying the robot-assisted rehabilitation, which was dependent on the robot's system itself.

The critical patient-oriented approach of physical therapy for improvements of activities of daily living and upper extremity functions for stroke patients has been applied more universally and practically than before in rehabilitation treatment environments. This intervention method plays an important role in establishing the proper therapeutic strategy and goal by making patients actively participate in all procedures of treatment [31].

It is also a positive and decisive method used to recover the independence of patients and improve their quality of life, allowing them to participate in tasks and meaningful activities again [32]. Many researchers have proved that the patient-oriented approach is effective not only in subjective satisfaction but also in the recovery of body functions. For therapists, it is very important to use assessment tools by which changes in the quantity and quality of task performance skills can be known in order to treat patients and prove the effect based on the above viewpoint [33].

5. Conclusion

Patient-oriented robot-assisted rehabilitation was applied through the requirements of daily activities, goal setup, and analysis on movements of stroke patients in their subacute phase, and the results showed that not only the upper extremity functions of patients improved, but their ability to take part in activities in daily living improved more than when using the previous robot-oriented robot-assisted rehabilitation.

In addition, patient-oriented and robot-oriented robot-assisted rehabilitation strategies were more effective in the joint range of motion of the distal segment of the upper extremities, as well as the power of hand grip and pinch, as opposed to traditional rehabilitation treatments. In contrast, both patient-oriented robot-assisted rehabilitation and traditional rehabilitation treatments were positively effective in improving patients' activities of daily living compared to robot-oriented robot-assisted rehabilitation.

Based on these study results, this study contributes to providing a basis that can apply the patient-oriented and robot-assisted rehabilitation to improve upper extremity functions and activities of daily living of stroke patients in their subacute phase.

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References

[1] National Statistical Office, "2018 Elderly Statistics," **(2018)**

[2] C. P. Ferri, C. Schoenborn, L. Kalra, D. Acosta, M. Guerra, Y. Huang, K. S. Jacob, J. J. L. Rodriguez, A Salas, A. Luisa Sosa, J. D. Williams, Z. Liu, T. Moriyama, A. Valhuerdi, and M. J. Prince, "Prevalence of stroke and related burden among older people living in Latin America, India and China,," Journal of Neurology, Neurosurgery and Psychiatry, vol.82, no.10, pp.1074-1082, **(2011)**

[3] Kwon Y.D., Chang H.J., Choi Y.J., and Yoon S.S., "Nationwide trends in stroke hospitalization over the past decade," Journal of Korea Medical Association, vol.55, no.1, pp.1014-1025, **(2012)**

[4] M. D. Patel K. Tilling E. Lawrence A. G. Rudd C. D. A. Wolfe C. McKevitt, "Relationships between long-term stroke disability," handicap and health-related quality of life, Age and Ageing, vol.35, no.3, pp.273–279, **(2011)**

[5] Ve´ronique L. Roger, Heart disease and stroke statistics-2011 update a report from the American heart association, **(2011)**

[6] Roger E. Kelley and Aimee P. Borazanci, "Stroke rehabilitation," Neurological Research, vol.31, pp.832-840, **(2009)**

[7] Janet H. Carr, Roberta B. Shepherd, Lena Nordholm, and Denise Lynne, "Investigation of a new motor assessment scale for stroke patients," Physical Therapy, vol.65, no.2, pp.175-180, **(1985)**

[8] Berta Bobath, "Adult hemiplegia evaluation and treatment," **(1990)**

[9] R. Lozano, "Global and regional mortality from 235 causes of death for 20 age groups in 1990 and 2010: a systematic analysis for the Global Burden of Disease Study 2010," Lancet Lond. Engl., vol.380, no.9859, pp.2095-2128, **(2012)**

[10] "Annual Report on the Causes of Death Statistics. Daejeon: Statistics Korea," Korean Statistical Information Service (KOSIS), **(2016)**

[11] S. B. O'Sullivan, T. J. Schmitz, and G. Fulk, Physical Rehabilitation. F.A. Davis, **(2013)**

[12] E. Chinnavan, Y. Priya, R. Ragupathy, and T. C. Wah, "Effectiveness of mirror therapy on upper limb motor functions among hemiplegic patients," Bangladesh Journal of Medical Science, vol.19, no.2, pp.208-213, **(2020)** DOI: 10.3329/bjms.v19i2.44997

[13] T. S. Olsen, "Arm and leg paresis as outcome predictors in stroke rehabilitation," Stroke, vol.21, no.2, pp.247-251, **(1990)**

[14] P. Raghavan, "Upper Limb Motor Impairment Post Stroke," Phys. Med. Rehabil. Clin. N. Am., vol.26, no.4, pp.599-610, **(2015)**

[15] R. J. Nudo, B. M. Wise, F. SiFuentes, and G. W. Milliken, "Neural substrates for the effects of rehabilitative training on motor recovery after ischemic infarct," Science, vol.272, no.5269, p.1791, **(1996)**

[16] Kwakkel G., Kollen B. J., van der Grond J., and Prevo A. J., "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

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

[18] Luke C, Dodd KJ, and Brock K. "Outcomes of the Bobath concept on upper limb recovery following stroke," Clin Rehabil. vol.18, no.8, pp.888-898, **(2004)**

[19] Thanchanok P, Noppol P, and Pagamas P, "The effect of the Bobath therapy programme on upper limb and hand function in chronic stroke individuals with moderate to severe deficits," International Journal of Therapy and Rehabilitationvol.26, no.10, pp.1-12, **(2019)** DOI: 10.12968/ijtr.2018.0124

[20] Hayward K, Barker R, and Brauer S. "Interventions to promote upper limb recovery in stroke survivors with severe paresis: a systematic review," Disabil Rehabil, vol.32, no.24, pp.1973-1986, **(2010)**

[21] Michaelsen SM, Dannenbaum R, Levin MF. "Task-specific training with trunk restraint on arm recovery in stroke," Stroke. vol.37, no.1, pp.186-192, **(2006)**

[22] Sheng B and Lin M. "A longitudinal study of functional magnetic resonance imaging in upper-limb hemiplegia after stroke treated with constraint-induced movement therapy," Brain inj, vol.23, no.1, pp.65-70, **(2009)**

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

[24] Firoozeh F, Noorizadeh S, Dadgoo M, Islam D, and Habibi A, "A comparison among Task Oriented Training with and without Bobath program on upper limb in stroke patients," Func Disabil J. vol.2, no.1, pp.83-90, **(2019)** DOI: http://fdj.iums.ac.ir/article-1-88-en.html

[25] Mehrholz J., Pohl M., Platz T., Kugler J., and Elsner B. "Electromechanical and robot-assisted arm training for improving activities of daily living, arm function, and arm muscle strength after stroke," status and date: New search for studies and content updated (conclusions changed), published in(11), **(2015)**

[26] Basteris A., Nijenhuis S. M. Stienen A. H., Buurke J. H., Prange G. B., and Amirabdollahian F. "Training modalities in robot-mediated upper limb rehabilitation in stroke: a framework for classification based on a systematic review," Journal of NeuroEngineering and Rehabilitation, vol.11, no.1, **(2014)**

[27] Hsieh Y.-w., Wu C.-y., Liao W.-w., Lin K.-c., Wu K.-y., and Lee C.-y., "Effects of treatment intensity in upper limb robot-assisted therapy for chronic stroke a pilot randomized controlled trial," Neurorehabilitation and neural repair, vol.25, no.6, pp.503-511, **(2011)**

[28] Mehrholz J., Platz T., Kugler J., and Pohl M. "Electromechanical and robot‐assisted arm training for improving arm function and activities of daily living after stroke," The Cochrane Library, **(2008)**

[29] Wu C.-y., Yang C.-l., Chuang L.-l., Lin K.-c., Chen H.-c., and Huang W.-c. "Effect of therapist-based versus robot-assisted bilateral arm training on motor control, functional performance, and quality of life after chronic stroke: a clinical trial," Physical therapy, vol.92, no.8, pp.1006-1016, **(2012)**

[30] Wisneski K. J. and Johnson M. J. "Quantifying kinematics of purposeful movements to real, imagined, or absent functional objects: Implications for modelling trajectories for robot-assisted ADL tasks," Journal of NeuroEngineering and Rehabilitation, vol.4, no.1, **(2007)**

[31] Mottura S., Fontana L., Arlati S., Redaelli C., Zangiacomi A., and Sacco M. "Focus on patient in virtual reality-assisted rehabilitation. virtual reality enhanced robotic systems for disability rehabilitation," vol.85, **(2016)** DOI:10.4018/978-1-4666-9740-9.ch006

[32] Vockins H. "Occupational therapy intervention with patients with breast cancer: a survey," European journal of cancer care, vol.13, no.1, pp.45-52, **(2004)**

[33] McColl M. A., Law M., Baptiste S., Pollock N., Carswell A., and Polatajko H. J. "Targeted applications of the Canadian occupational performance measure," Canadian Journal of Occupational Therapy, vol.72, no.5, pp.298-300, **(2005)** DOI:10.1111/j.1365-2354.2004.00443.x|

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