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Mirror Therapy using Cylindrical Grip Muscle Strength and Extremity Range of Motion

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Stroke is the third leading cause of death in the world, after heart disease and cancer. The main disability in productive age is caused by stroke. This study aimed to analyse the effect of the mirror therapy combination of cylindrical grip muscle strength, upper limb range of motion and post-stroke client self-care, at the two hospitals in Banjarmasin. A quantitative research design was used, with a quasi-experimental research design. The sample comprised 66 respondents. Interventions involved giving mirror therapy combined cylindrical grip three times a week for four weeks. Researchers used a handgrip dynamometer to measure limb strength over post-stroke clients. A goniometer tool assessed a joint range of motion and questionnaire as to the modification of the level of independence of patients, in fulfilling post-stroke client self-care. Analysis of the data in this study used normality tests with Kolmogorov Smirnov. Analysis of each group pre-test and post-test used the Wilcoxon signed-rank test, while the post-test value of each group using MANOVA. The results showed that Muscle Strength (p=0.000) and Range of Motion (p=0.000) have a significant effect with Mirror Therapy of Cylindrical Grip Combination. The effect of mirror therapy combined cylindrical grip muscle strength and upper limb range of motion. It can be applied to nurses and physiotherapists to carry out complementary therapy. It can also be used as a support for pharmacological therapy to increase muscle strength and upper limb range of motion.

Key words: *Mirror therapy, cylindrical grip, muscle strength, range of motion, hemiparesis.*

Introduction

Stroke is the third leading cause of death in the world after heart disease and cancer. The main disability in productive age is caused by stroke (Koyama, Koumo, Uchiyama, & Domen, 2018). Upper limb hemiparesis is the most common example of disability post-ischemic post-stroke with a percentage of 73%, compared to haemorrhagic, which is only 13%. As much as 80-85% of these ischemic strokes occur in the supratentorial (STS) which affects the vertebrobasilar region, involving the cerebellum and brain stem, which causes many hemipareses in the upper limb. Whereas, if a stroke occurs in the infratentorial (STS), the clinical symptoms are vertigo, dysarthria, dysphagia and ataxia. (Park, Chang, Kim, & Kim, 2015). In individuals with hemiparesis, spasticity, muscle weakness, and permanent disruption in the coordination of movements in both fine and gross motor skills cause limitations in self-care (Park et al., 2015). Ischemic post-stroke hemiparesis occurs not because of musculoskeletal abnormalities, but is caused by damage to the central nervous system that controls the neuromusculoskeletal system and normal postural reflex mechanisms (Chan & Au-Yeung, 2018).

Various attempts were made to increase muscle strength and self-care in clients, such as posture reflex exercises, weight-bearing, balance and coordination. The weakness of the previous intervention was that it did not use media or tools, and only focused on weak parts of the body, rather than involving healthy parts of the body. This is what causes the duration of rehabilitation. A combination of muscle strength and range of motion exercises using a tool or media as active brain stimulation and self-care has never been implemented. Various factors that affect the recovery of post-stroke client muscle strength include gender, age, stroke, lesions in the affected part of the brain, type and duration of exercise used and client compliance in therapy (Purslow, 2017). Hemiparesis affects muscle strength, range of motion and self-care of stroke clients. This is generally caused by corticospinal pathway lesions, which run down from cortical neurons in the frontal lobe to the motor neurons of the spinal cord, and are responsible for the movement of muscles of the body and limbs (Vergara, Sancho-Bru, Gracia-Ibáñez, & Pérez-González, 2014).

Mirror Therapy was originally developed to reduce limb pain in amputation clients. The reflection of an intact arm in the mirror gives the client the sensation of having two arms capable of moving, which causes a decrease in pain. In 1999, Altschuler et al. introduced Mirror Therapy for the recovery of hemiparesis after stroke. Mirror Therapy will provide visual stimulation to the brain (cerebral motor nerves, i.e. ipsilateral or contralateral for hemiparesis movement) through observation of body movements that will tend to be mimicked as in the mirror by disturbing body parts (Chan & Au-Yeung, 2018). Mirror Therapy is recommended as a simple and inexpensive alternative therapy for treating gross motor function (Samuelkamaleshkumar et al., 2014).

Another simple method is the cylindrical grip. The cylindrical grip is a functional exercise of the hands by holding a cylindrical shaped object such as a roll of tissue or a glass bottle on the palm to move the fingers gripping perfectly (Irfan, 2010). The cylindrical grip was first developed by Huxley and Julian (1966) as a motor stimulation exercise in children who experience delays in growth and development. Providing cylindrical grip exercises can help develop ways to balance fine motor paralysis of the fingers (Irfan, 2010). These two interventions each influence increasing muscle strength. Mirror Therapy can increase muscle strength, by activating sensory and cylindrical grip, increasing the strength of fine motor muscles in the fingers that are widely used in daily activities and self-care of clients. The cylindrical grip itself can be combined in the phase variation and shaping the Mirror Therapy using a cylinder-shaped object. The purpose of this study was to analyse the effect of mirror therapy combination of cylindrical grip muscle strength, upper limb range of motion and post-stroke client self-care at the two Hospital in Banjarmasin.

Literature Review

Stroke is a disease or functional brain disorder in the form of nerve paralysis, due to obstruction of blood flow to the brain. In simple terms, acute stroke is defined as brain disease due to interruption of blood supply to the brain because of blockages (ischemic stroke) or bleeding (hemorrhagic stroke). People who suffer a stroke usually experience many functional disorders, such as motor, psychological or behavioural disorders, where the most typical symptoms are hemiparesis, weakness in the limbs, loss of facial sensation, difficulty speaking and loss of vision in the side (ICONS Patient, 2013; National Stroke Network, 2014).

Risk factors for stroke include those that cannot be changed such as age, gender, race, or family history. That can be changed by factors such as hypertension, obesity, diabetes, smoking, alcohol. The World Stroke Organisation notes that almost 85% of people who have risk factors can avoid a stroke, if they are aware of and overcome these risk factors early on. World health agencies predict that deaths from stroke will increase along with deaths from heart disease and cancer, from approximately six million in 2010 to eight million in 2030. Stroke that is late getting treatment will result in extensive paralysis and cognitive impairment. Thus, handling it as quickly as possible reduces the number of physical disabilities due to stroke (Fugl-Meyer, Jaasko, Leyman, Olsson, & Steglind, 1975; National Stroke Network, 2014). Stroke complications that often occur are pressure sores caused by prolonged sleep, due to paralysis, resulting in sores on blisters when lying down; pneumonia occurs because patients usually cannot cough or swallow properly, causing fluid to collect in the lungs and subsequently infect, and additionally muscle and joint stiffness caused by prolonged lying down will cause stiffness in muscles or joints (J., M., & W., 2015; Ossi, 2013).

Stroke that is late getting treatment will result in extensive paralysis and cognitive impairment. Thus, handling it as quickly as possible reduces the number of physical disabilities due to stroke (Barman & Mahapatra, 2017; Pérez-Rojas & del Pilar Torres-Arreola, 2012). AHA / ASA guidelines for the management of stroke patients, 2013, states that stroke management must be carried out as soon as possible. The golden time for stroke patients, especially ischemic stroke, is three hours after the onset of the attack. Restoring limb strength is still a major problem faced by stroke patients who experience hemiparesis. About 80% of patients experience acute hemiparesis in the extremities and only about one third experience fully functional recovery. To minimise disability in people suffering from stroke, joint motion therapy, extensive joint motion therapy, superficial (infra-red) heat therapy, active, passive joint motion exercises, facility training or muscle reduction and exercise can be done as other movements (Barman & Mahapatra, 2017; ICONS Patient, 2013).

Motion ability is gathering information or data about the appearance of movements relevant to decision making and programs; both are conducted by the teacher and therapist to determine the ability to move the test method used to determine the strength of muscles, for the area of joint motion, and to find out which pattern of motion is true in carrying out activities of daily living (Ossi, 2013). One of the new therapies performed to restore muscle strength in stroke patients is mirror therapy. Mirror therapy is a form of rehabilitation that relies on motor images, where the mirror will provide visual stimulation to the body experiencing interference, by a healthy body part. It is based on research in stroke rehabilitation. The results obtained p value of 0,000; it can be concluded that Mirror Therapy in stroke rehabilitation is effective for stroke patients (Guo et al., 2016; Kim & Lee, 2015).

Methodology

This study used a quantitative research design with a quasi-experimental research design (pre-post-test with control group design) (Nursalam, 2017). Sampling was done by purposive sampling technique. A total of 66 respondents (33/33) was collected during November 2019 - January 2020. Interventions will be given mirror therapy combined with cylindrical grip, three times a week for four weeks. The purpose of this study was to analyse the effect of the mirror therapy combination of cylindrical grip muscle strength, upper limb range of motion and post-stroke client self-care, at two hospitals in Banjarmasin. The inclusion criteria in this study were (1) having upper limb hemiparesis at least three months since the first attack, (2) undergoing medical rehabilitation for at least one week, (3) compos mentis, (4) age 45-74 years, (5) normal vital signs. Exclusion criteria in this study were (1) cognitive impairment (delirium, dementia and amnestic disorders), (2) hearing loss, (3) visual field disorders, (4) injury or acute complications of joints. Researchers used handgrip dynamometers to measure limb strength over post-stroke clients. Goniometer tools assessed joint range of motion and a questionnaire modification of the level of independence of patients, in fulfilling post-stroke

client self-care with validity test r = 0.514. Reliability was tested used Cronbach's alpha with α > 0.819. Analysis of the data in this study used normality tests with Kolmogorov Smirnov. Analysis of each group pre-test and post-test using the Wilcoxon signed-rank test, while the post-test value of each group used MANOVA. This research has also previously passed an ethical test by the Health Research Ethics Commission of the Faculty of Nursing, Universitas Airlangga, with an ethical certificate number 1786-KEPK.

Results and Findings

Table 1: Demographic characteristic of study participants

Characteristics	Treatment		Control		Total		Homogeneity
	f(x)	%	f(x)	%	f(x)	%	
Gender							
Male	16	48.5	16	48.5	32	48.5	1.000
Female	17	51.5	17	51.5	34	51.5	
Age (years)							
45-59	23	69.7	14	42.4	37	48.5	0.061
60-74	10	30.3	19	57.6	29	51.5	
75-90	0	0	0	0	0	0	
Hemiparesis							
Right	18	54.5	19	57.6	37	56.1	0.636
Left	15	45.5	14	42.4	29	43.9	
Education Level							
Bachelor	11	33.3	16	48.5	27	40.9	0.223
High School	11	33.3	11	33.3	22	33.3	
Middle School	5	15.2	3	9.1	8	12.1	
Elementary School	5	15.2	3	9.1	8	12.1	
Not school	1	3	0	0	1	1.5	
Profession							
Work	10	30.3	13	39.4	23	34.8	0.140
Unemployed	23	69.7	20	60.6	43	65.2	
Marital status							
Married	33	100	33	100	66	100	-
Single	0	0	0	0	0	0	

Table 1 shows that in the intervention and control group, 32 people (48.5%) in this study were male and 34 were female (51.1%) and had an age range distribution of 45-59 years by 37 people (48.5 %) and 60-74 years by 29 people (51.5%). The number of post-stroke patients who have the right hemiparesis location is more than 37 people (56.1%). The

education level of 27 people (40.9%) is a Bachelor, with 45 respondents (65.2%) unemployed. A total of 66 respondents (100%) were married. The results of the analysis of the equality of post-stroke patients based on gender, age, hemiparesis, education and work status can be seen in the homogeneity value ≥ α (0.05). This means there is no significant difference, or the data group characteristics of respondents are homogeneous. Characteristics of respondents based on marital status cannot be analysed equally because the data is of constant value and has no variance.

Table 2: Mirror Therapy of Cylindrical Grip Combination on Upper Extremity Muscle Strength in the Intervention and Control Groups

Variable	Group	Pre-Test (Mean ± SD)	Min-Max	Post-Test (Mean ± SD)	Min-Max	Delta (Δ)	*p-Value*
Muscle Strength	Treatment	20.79 ±7.164	12-37	25.88±7.204	15-40	5.09	0.000
	Control	21.89 ± 7.111	15-40	20.99 ± 6.768	15-40	-0.9	0.021

After being tested for normality and the results obtained are not normally distributed, then in Table 2, the intervention group obtained the mean strength of the pre-test muscle strength 20.79 ± 7.164. Whereas, after a mirror therapy of cylindrical grip combination for four weeks, the mean value of post-test muscle strength was 25.88 ± 7.204 in the intervention group, and the delta value was 5.09. Wilcoxon test results in the intervention group showed a significant difference between muscle strength, before and after mirror therapy, using a cylindrical grip combined with a value of 0.001 ($p < 0.05$). In the control group, the mean muscle strength, pre-test, was 21.89 ± 7.111. Whereas, after a mirror therapy of cylindrical grip combination for four weeks, the mean value of post-test muscle strength was 20.99 ± 6.768 in the control group. The delta value of -0.9 was obtained. Wilcoxon test results in the intervention group showed a significant difference between muscle strength before and after mirror therapy using a cylindrical grip combined with a value of 0.021 ($p < 0.05$). The negative delta value in the control group explains that the post-test value is smaller than the pre-test value.

Table 3: Mirror Therapy of Cylindrical Grip Combination on Upper Extremity Range of Motion

Variable	Group	Pre-Test (Mean ± SD)	Min-Max	Post-Test (Mean ± SD)	Min-Max	Delta (Δ)	*p-Value*
Range of Motion	Treatment	30.04 ± 1.310	29-32	84.33± .910	80-85	54.29	0.000
	Control	32.74 ± 0.868	31-33	61.46 ± 22.746	40-85	28.72	0.000

In Table 3, the intervention group obtained the mean value of the pre-test range of motion 30.04 ± 1.310. Whereas, after a mirror therapy of cylindrical grip combination for four weeks, the mean value of the range of motion post-test was 84.33± .910 in the intervention group. The delta value was 54.29. Wilcoxon test results in the intervention group showed that there were significant differences between the range of motion before and after mirror therapy combined cylindrical grip, with a value of 0,000 (p <0.05).

Table 3: MANOVA

Variables	N	Box Test				*p-value*	
		Box M	F	df 1	df 2	*Lavene*	*Pillay's trace*
Muscle Strength	66	0.000	17.817	3	737280.0	0.251	0.000
Range of Motion						0.000	

Table 3 shows that testing the variance-covariance similarity individually for each variable shows a Box test value of 0.000, which means the variance-covariance in all variables is not the same for each group. Therefore, in decision making the results of statistical tests can be seen in the Pillai's trace. Manova test results obtained significance value p-value <0.00 (α 0.05). That indicates differences in the average value of muscle strength and upper limb range of motion in the intervention group and the control group. This shows an effect of mirror therapy in a combination of cylindrical grip muscle strength and range of motion, of the upper limb of post-stroke patients.

The Effects Mirror Therapy of Cylindrical Grip Combination on Muscle Strength

The results showed that the administration of mirror therapy with a cylindrical grip combination increased the strength of the upper limb muscles in post-stroke patients, with hemiparesis in the intervention group. The combination of mirror therapy and cylindrical grip will produce a feedback mechanism. Fine sensory stimulation and pressure will be processed in the sensory cortex, which is then implanted and distributed in the motor cortex (Xu et al., 2018). The surplus that forms in the second motor neuron in the cranial nerve nucleus and anterior horn of the spinal cord runs through the anterior root, nerve plexus (in the cervical and lumbosacral region), and peripheral nerves on its way to the skeletal muscles (Rodrigues, Farias, Gomes, & Michaelsen, 2016). The surplus is delivered to the muscle cells through the motor endplate of the neuromuscular link, and then there will be muscle movement in the upper extremity. This mechanism is called feed-forward control in response to pressure stimuli and the touch of cylindrical objects in the hands (Irawandi, 2018; Irawati, Sekarsari, & Marsita, 2017; Yang et al., 2018).

The results of this study are also in line with several related studies that combine mirror therapy with various therapeutic exercises for muscle stimulation in stroke clients. They

include (Ji, Cha, Kim, & Lee, 2014) mirror therapy with electrical stimulation which shows improvements in upper limb motor skills in clients' stroke, with the first day of the fourth stroke carried out for three weeks. Research by (Lin et al., 2014) found that the combination of mirror therapy with somatosensory stimulation had a positive effect on the motor healing process of post-stroke clients including muscle strength, manual dexterity (grasping task), increasing the ability to move for three weeks.

Some other factors that can influence this research are the timing of the intervention and the measurement of muscle strength. Increased muscle strength is more dominant in the morning than in the afternoon (P. Broderick, F. Horgan, C. Blake, M. Ehrensberger, D. Simpson, 2018). This is because oxygen pressure in the morning is higher than in the afternoon; high oxygen pressure will affect the ability of haemoglobin to bind oxygen to be increased (Purslow, 2017). Lack of oxygen will reduce the body's energy reserves so that the body feels easily tired. The chemical reaction between sugar and oxygen will produce Adenosine Tri Phosphate (ATP), which is called the cell's pure energy. ATP transfers the energy needed by cells to perform various activities and maintain the effectiveness of all bodily functions (Vinstrup et al., 2018). If oxygen is available in sufficient quantities, the mitochondria will produce ATP (Kusnanto, Haryanto, Sukartini, Ulfiana, & Putra, 2018). Without oxygen, mitochondria cannot make ATP. Although in conditions of a lack of oxygen, ATP will be produced through the process of glycolysis in the cytosol, the ATP produced is not as much as in the mitochondria, lack of ATP will disrupt the electrical signals from the brain to the muscles so that makes the muscles become tired easily (Fitria, Rahmawati, Suamiati, & Helmiati, 2017; Lee & Gyu, 2019).

Explanations and related research findings above relate to the effect of mirror therapy combined with cylindrical grip in the two groups, namely intervention and control. The researcher believes that this condition is a result of the intervention, rather than because of the influence of other factors. If seen from the characteristics of respondents in both groups, the two groups already have the same characteristics (homogeneous), meaning that the confounding variable that is suspected of affecting the result of this therapy can be controlled.

The Effects Mirror Therapy of Cylindrical Grip Combination on Range of Motion

In the dependent variable, the upper extremity range of motion has another variable, including the range of motion in the elbow joint and the fingers. The elbow joint stretch includes elbow flexion and elbow extension. The range of joint motion in the fingers includes flexion, extension, abduction and adduction fingers. The last is the range of joint motion in the thumb which includes thumb flexion, extension, abduction and adduction; all range of motion has occurred in terms of joint stiffness, decreased muscle contraction, pain during

movement, such that as a whole it will result in the inability to move or be active (Rosipal et al., 2018).

The range of motion of the elbow joints includes elbow flexion and elbow extension, then the range of motion of the joints in the fingers includes flexion, extension, abduction and adduction fingers and finally the range of joint motion in the thumb. That motion includes thumb flexion, mother finger extension, thumb abduction and adduction. These were then calculated to get an average value and a statistical test with the results of P-value = 0.00. This means that, as to the range of joint motion and control groups in each joint, there is a difference between the pre- and post-intervention mirror therapy combined cylindrical grip, with a hospital control group given three times a week during a four week monitoring period.

From the results of the data obtained in the study after the mirror therapy intervention, the cylindrical grip range as to joint motion in the patient, has increased in terms of the angular range of motion (G. & S., 2018). The range of flexion and extension joints has increased or increased, to be close to the normal range of flexion and extension range (Louw et al., 2017). This is in line with research conducted by (Fitria et al., 2017) which shows that there is an increase in flexion and extension range of motion after power grip training. Power grip exercises normalise the range of joint motion. Power grip training will cause the surface of the cartilage between the two bones to rub against one another. Cartilage contains a lot of glycaemic protein which attaches to hyaluronic acid and is hydrophilic. Emphasis on cartilage due to movement will force water out of the cartilage matrix into the synovial fluid. Joint activity will maintain synovial fluid, a lubricant to the joint, so that the joint can move optimally. Shortened muscle tissue will slowly elongate when a power grip exercise is performed and the muscle tissue will begin to adapt to restore muscle length to normal (Irawati et al., 2017; Wang et al., 2018).

The abduction fingers have a low delta value in each group after given a mirror therapy cylindrical grip intervention. That is due to several factors such as etiological history, hypertension and pain in the joints of the small joints patient. These conditions can cause contractures, affecting the range of motion in the patient's joints. Contractures are defined as loss or decrease in the range of motion of the joint, both passively and actively because of joint limitations, fibrosis of the muscle and skin tissues (Fitria et al., 2017).

Conclusions

The results of this study prove the effect of a mirror therapy combined cylindrical grip muscle strength and upper limb range of motion. Therefore, it can be applied to nurses and physiotherapists to carry out complementary therapy. It can also be used as a support for pharmacological therapy, to increase muscle strength and the upper limb range of motion.

Post-stroke rehabilitation needs to be done together with an instructor and a training schedule, to achieve maximum results using established procedures.

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