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Assessment of the Effectiveness of Facial Expression Exercises Stimulation Using Mirror Media in Increasing Facial Muscle Strength in Hemiparetic Stroke Patients

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Abstract

BACKGROUND: Stroke can cause facial muscle weakness that can affect mobility, limitations in daily activities, and quality of life. One alternative solution that is non-invasive to restore facial muscle paralysis in post-stroke patients is facial expression exercises using mirror media.

AIM: This study aimed to assess the effectiveness of facial muscle expression exercises stimulation using mirror media and without a mirror as media in increasing facial muscle strength in hemiparetic stroke patients.

METHODS: This study used an experimental quantitative design, in which two groups of subjects who met the inclusion criteria were randomly assigned. The number of subjects who participated in this research was 60 samples divided into the intervention group (n = 30) with a mirror for facial muscle expression exercises and the control group (n = 30) without a mirror for five weeks. The research data were collected using the Fisch Facial Grading System sheet. The statistical analysis procedure of the data consisted of One-Way ANOVA, paired-samples T-test, and N-Gain score test with 95% significance.

RESULTS: The difference in facial muscle strength increase was significantly greater in the intervention group (mean difference 19.4; p = 0.000). The intervention group was more effective in increasing facial muscle strength than the control group (N-Gain score 56.31%).

CONCLUSION: The facial muscle expression exercise procedure using a mirror was more effective in increasing muscle strength than the group without a mirror.

Introduction

Stroke is a serious public health problem with the risk of sudden disability, increasing the burden of health financing, and significant mortality. The risk of stroke increases with age. Ischemic stroke is more common, but hemorrhagic stroke causes more disability and death. The incidence and mortality of stroke differ between countries, geographic regions, and ethnic groups. Over the past 30 years, in high-income countries, improvements in prevention, acute treatment, and neurorehabilitation have led to a substantial reduction in the burden of stroke [1]. The global prevalence of stroke in 2019 was 101.5 million people, ischemic stroke 77.2 million, intracerebral hemorrhage 20.7 million, and subarachnoid hemorrhage 8.4 million. Globally in 2019, a total of 3.3 million people died from ischemic stroke, 2.9 million died from intracerebral hemorrhage, and 0.4 million died from subarachnoid hemorrhage. Overall, stroke prevalence rates by age were highest in Oceania, Southeast Asia, North Africa and the Middle East, and East Asia. The mortality of intracerebral hemorrhage is highest in Oceania, Central Asia, Southeast Asia, and parts of sub-Saharan Africa. The highest mortality is due to subarachnoid hemorrhage in parts of Asia [2]. In Indonesia, it is reported that the prevalence of stroke nationally is 2.1 million. Provinces with the highest prevalence of stroke in Indonesia are East Kalimantan (14.7%) and Yogyakarta (14.6%), and the incidence of stroke is more in the 55−64 years age group, both women and men [3].

Stroke can cause motor function deficits such as facial muscle weakness that can affect one's mobility, limitations in daily activities, and quality of life. Thus, it requires rehabilitation. Motor function deficits due to stroke affect the mobility of patients, their limitations in activities of daily living, their participation in society and their overall low quality of life [4]. Stroke causes cranial nerve disorders and central nervous system pathways that result in sensory deficits, motor impairment, muscular atrophy, cognitive deficits, and psychosocial impairment [5]. Stroke causes facial paresis, which is manifested by changes in facial movements [6].

Potential problems due to facial muscle weakness are facial drooping; absence of forehead, nasolabial, or periorbital folds; lagophthalmos (incomplete eyelid closure); open mouth posture; drooling; and inability to make facial expressions, frown, whistle, and/or difficulty with the articulation of labial consonants [7]. The weakness of post-stroke patients is not only in the limbs but also in facial muscle. Both urgently require effective facial muscle expression exercises. Here, nurses play essential roles in restoring optimal functional abilities, as a study conducted by Giacalone *et al*. [8] states the facial exercises can restore them.

One non-invasive alternative solution to recover facial muscle paralysis in post-stroke patients is biofeedback exercises using mirror media. This method aims to increase facial muscle strength and feedback (biofeedback). In other words, patients can see the results of their therapy so that they are motivated to be more actively exercising. Mirror therapy is a relatively new therapeutic intervention that focuses on moving an undisturbed limb [9]. It is a non-invasive, economical, and directly related to the motor system by training or stimulating the contralateral sensory-motor cortex that has a lesion using mirror media. This exercise relies on the interaction of visual-motor perception to increase the movement of limbs that have impaired muscle weakness on one side of the body that has hemiparesis [10].

In this study, we hypothesized that congruent visual feedback and motor images of moving non-paretic facial muscles, such as those provided by mirrors, would help restore the integrity of cortical processing and thereby restore function in hemiparetic facial muscles. We designed a randomized trial to evaluate the effect of facial expression exercises using mirror media as motor images on the recovery of facial muscle weakness in post-stroke patients. This study aims to assess the effectiveness of facial muscle expression exercises using mirror media and facial muscle expression exercises without mirror media in increasing facial muscle strength in hemiparetic stroke patients.

Methods

Research design

This study used an experimental quantitative design, in which two groups of subjects who met the inclusion criteria were randomly assigned. The number of subjects who participated in this research was 60 samples. In addition to standard treatment, the first group (intervention group/IG) received facial expression exercises using a mirror for 5 weeks. In addition to standard treatment, the second group (control group/CG) received facial expression exercises without a mirror. This study used a pre-test and a post-test. A pre-test was conducted to measure subjects' initial facial muscle strength level in both groups. After the subjects received facial expression exercises according to the procedure, they were given a test to assess the level of strength of their facial muscles.

Protection of human subjects

Respondents were provided with information that all observations were kept confidential and only used for scientific purposes to fulfill ethical considerations. Participation was voluntary, and there were no penalties for not participating. Protection of human subjects included IRB approval from the Health Research Ethics Committee of the General Hospital Dr. Moewardi, Medical Faculty of Sebelas Maret, Surakarta, No. 1.486/VII/HERC/2019. Written consent forms were obtained from all respondents (N = 60). A detailed description of the methodology of expectation, anonymity, and confidentiality was discussed in the written agreement.

Subject recruitment

Subjects were recruited among hemiparetic stroke patients who had received treatment at the General Hospital of Dr. Moewardi Surakarta, Indonesia. A group of 60 subjects who met the inclusion criteria were randomized into two groups. Inclusion criteria included hemiparetic stroke patients who experienced facial muscle weakness, both bedridden and able to ambulate after receiving standard care and treatment on the 3rd day and were conscious. Using a computer-generated program, subjects were randomly divided into two groups. The IG group (n = 30) participated in a facial expression exercise intervention using a mirror. The CG group (n = 30) participated in a facial expression exercise without a mirror. Subjects participated in a facial expression training session for five weeks. Next, this was followed up with an observation session or an assessment of facial muscle strength for 5 weeks. The subject recruitment procedure is summarized in Figure 1.

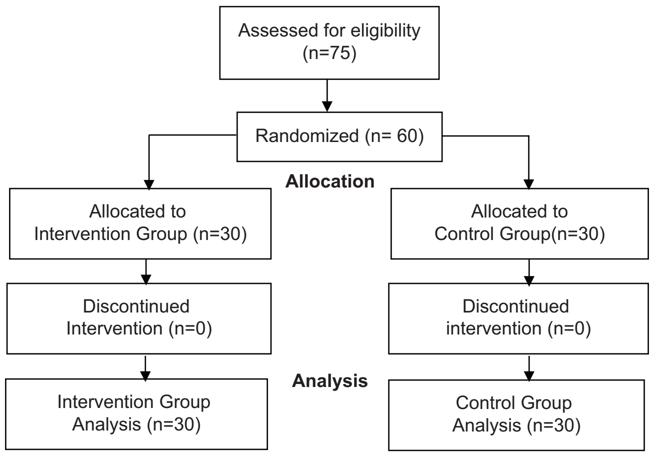

Figure 1: Subject recruitment

Instrument

The research data were collected using the Fisch Facial Grading System sheet [11]. The scoring criteria for this scale are 0% if it is asymmetrical and there is no movement, 30% if it is mildly symmetrical and there is light movement, 70% if it is moderately symmetrical (close to normal), and 100% if the symmetrical movement is normal or complete. Then the percentage of each position is converted into a score with the criteria of 20 points for still, 10 points for frowning, 30 points for closing eyes, 30 points for smiling, and 10 points for whistling. Furthermore, all the results of calculations are totaled and added up and then put into the following categories: Grade I/normal (100 points), Grade II/mild paralysis (75−99 points), Grade III/moderate paralysis (50−74 points), Grade IV/ moderate-severe paralysis (25−49), Grade V/severe paralysis (1−24), and Grade VI/total paralysis (0 points).

Description intervention

Intervention group: Phase I (pre-test, dividing hemiparetic stroke patients into five groups, each of which was facilitated by one competent nurse who had been given standard operating procedures on facial expression exercises to accompany and assess facial expressions), Phase II (accompanying patients and training their facial expressions by moving five different facial positions: still, frowning, closing eyes, whistling, and smiling which was done 3 times per day for 5 weeks, as well as reporting on the progress of each group's exercise), and Phase III (post-test, assessing facial expressions using the Fisch Facial Grading System sheet).

Control group: Phase I (pre-test, dividing hemiparetic stroke patients into five groups, each facilitated by one competent nurse who had been given standard operating procedures on facial expression exercises to accompany and assess facial expressions), Phase II (accompanying patients and training their facial expressions by moving five different facial positions: still, frowning, closing eyes, whistling, and smiling which was done 3 times per day for 5 weeks, as well as reporting on the progress of each group's exercise), and Phase III (post-test, assessing facial expressions using the Fisch Facial Grading System sheet).

Statistical test

Statistical testing was carried out using descriptive statistical tests, One-Way ANOVA, Kolmogorov–Smirnov, Paired-Samples T test, and N-Gain score test (N-Gain score <40 ineffective; 40−55 less effective; 56−75 quite effective, and >75 effective) with a significance level of 95%.

Results

Demographic characteristics

The intervention group (IG). Most of the subjects belonged to the late elderly category with a mean of 56.07 years ± SD 11.89 with a minimum age of 56 years and a maximum of 65 years. The male portion of 56.7% was bigger than women with an average of 1.43 ± SD 0, 50. Most of the subjects with a percentage of 57.4%, were elementary school education level. 70% of it was mostly experienced a non-hemorrhagic stroke, and the 60% was experienced paresis on the right side. The average facial muscle weakness (Fisch Facial Grading score) in the pre-test session was 47.63 points (moderate-severe category) ± SD 14.76 with a minimum score of 25 points and a maximum of 49 points, and the average facial muscle weakness (Fisch Facial Grading score) in the post-test session was 67.03 points (moderate category) ± SD 14.71 with a minimum score of 50 points and a maximum of 74 points.

Control group (IG): Most of the subjects belonged to the late elderly category with a mean of 60.60 years ± SD 8.42 with a minimum age of 56 years and a maximum of 65 years. The male portion of 60% was greater than that of women with an average of 1.43 ± SD 0.50, with the education level of most elementary schools of 46.7%. About 60% of it was experiencing a non-hemorrhagic stroke, and 66.7% experienced paresis on the right side. The average facial muscle weakness (Fisch Facial Grading score) in the pre-test session was 42.15 points (moderate-severe category) ± SD 41.50 with a minimum score of 25 points and a maximum of 49 points, and the average facial muscle weakness (Ugo Fisch Scale score) in the post-test session was 49.55 points (moderate category) weight) ± SD 14.71 with a minimum score of 25 points and a maximum of 49 points. The comparison of the demographic characteristics of the intervention and control group subjects is summarized in Table 1.

Differences in facial muscle weakness based on gender, age, education, type of stroke, and location of facial muscle weakness

The one-way ANOVA statistical test comparing the two groups showed a significant difference between age in facial muscle weakness in hemiparetic stroke patients (p = 0.043). However, gender, education, type of stroke, and location of facial muscle weakness did not show significant differences in facial muscle weakness. Differences in facial muscle weakness of the subjects are presented in Table 2.

Differences in facial muscle strength

Normality testing was carried out by the Kolmogorov–Smirnov statistical test, which showed that the data were normally distributed (CG group pre-test, p = 0.191; CG group post-test, p = 0.155; IG group pre-test, p = 0.174; and IG group post-test, p = 0.121). The patient's mean facial muscle strength score was assessed immediately after the facial muscle expression

Table 1: Demographic characteristics

Characteristics	Intervention group		Control group	
	Mean ± SD	*n* (%)	Mean ± SD	*n* (%)
Age	56.07 ± 11.89	30 (100)	60.60 ± 8.42	30 (100)
Adolescent (17–25 year old)		2 (6.7)		0
Early adulthood (36–45 year old)		3 (10.0)		1 (3.3)
Middle adulthood (46–55 year old)		10 (33.3)		11 (36.7)
Late adulthood (56–65 year old)		11 (36.7)		11 (36.7)
Elderly (> 65 year old)		4 (13.3)		7 (23.3)
Sex	1.43 ± 0.504	30 (100)	1.43 ± 0.504	30 (100)
Male		17 (56.7)		18 (60)
Female		13 (43.3)		12 (40)
Education	2.37 ± 1.129	30 (100)	2.03 ± 1.098	30 (100)
Primary school		11 (36.7)		14 (46.7)
Junior high school		4 (13.3)		4 (13.3)
Senior high school		10 (33.3)		9 (30)
Bachelor		5 (16.7)		3 (10)
Stroke type	1.30 ± 0.466	30 (100)	1.40 ± 0.498	30 (100)
NHS		21 (70)		18 (60)
HS		9 (30)		12 (40)
Parese side	1.40 ± 0.498	30 (100)	1.33 ± 0.479	30 (100)
Dextra		18 (60)		20 (66.70
Sinistra		12 (40)		10 (33.3)
Fisch facial grading (pretest)	47.63 ± 14.76	30 (100)	42.15 ± 41.50	30 (100)
Normal (100 points)		0		0
Mild (75–99 points)		0		0
Moderate (50–74 points)		11 (36.7)		10 (33.3)
Moderate-severe (25–49 points)		17 (56.7)		16 (53.3)
Severe (1–24 points)		2 (6.6)		4 (13.4)
Total (0 point)		0		0
Fisch facial grading (posttest)	67.03 ± 14.71	30 (100)	49.55 ± 12.42	30 (100)
Normal (100 points)		0		0
Mild (75–99 points)		8 (26.7)		3 (10)
Moderate (50–74 points)		10 (33.3)		13 (43.3)
Moderate-severe (25–49 points)		12 (40)		14 (46.7)
Severe (1–24 points)		0		0
Total (0 point)		0		0

SD: Standard deviation, *n*: Sample, HS: Hemorrhagic stroke, NHS: Non-HS.

Table 2: Differences in facial muscle weakness based on demographic characteristics

Aspect	Sum of squares	df	Mean Square	*F*	p
Muscle strength*sex					
Between groups	57.792	1	57.792	0.242	0.627
Within groups	6699.575	28	239.271		
Total	6757.367	29			
Muscle strength*age					
Between groups	5487.367	20	21.368	0.144	0.043
Within groups	1270.000	9	141.111		
Total	6757.367	29			
Muscle strength *education					
Between groups	1055.308	3	351.769	1.604	0.213
Within groups	5702.059	26	219.310		
Total	6757.367	29			
Muscle strength*stroke type					
Between groups	184.573	1	184.573	0.786	0.383
Within groups	6572.794	28	234.743		
Total	6757.367	29			
Muscle strength*location					
Between groups	28.006	1	28.006	0.117	0.735
Within groups	6729.361	28	240.334		
Total	6757.367	29			

exercise. There was a significant difference in score for IG, increasing from the initial mean of 47.63 to 67.03 (p = 0.009). There was a significant difference in scores for the control group, increasing from the initial mean of 42.15 to 49.55 (p = 0.000). This study indicated that patients from the intervention group given facial muscle expression exercises using a mirror showed a higher difference in muscle strength gain than patients from the control group, with an average difference of 19.4. Differences in facial muscle strength of the subjects are presented in Table 3.

Table 3. Differences in facial muscle strength based on Paired-Samples T test

Sector	Point of Time	Intervention Group		Control Group	
		Mean	p-value	Mean	p-value
Facial muscle strength	Pre-test	47.63	0.009	42.15	0.000
	Post-test	67.03		49.55	

Comparison between mirror exercise and face exercise

Table 4 shows that the intervention group experienced an effective increase in facial muscle strength with a score of N-Gain= 56.31%; a minimum of 10.6%, and a maximum of 90.11%, compared to the control group, which was categorized as ineffective in improving, with an N-Gain score = 13.41%; a minimum of 3.87% and a maximum of 30%. Thus, the intervention group was more effective in increasing facial muscle strength than the control group.

Discussion

This study found a significant difference in age with facial muscle weakness. One could speculate that these findings may be related to the stroke. In other words, older age decreases the elasticity of blood vessels resulting in arteriosclerosis and hypertension, making them more susceptible to stroke. This finding aligns with previous studies, which explained that with age, blood pressure tends to increase [12]. In addition, these findings may be related to the decline in muscle

Table 4. The effectiveness of facial muscle expression exercises

Sector	Intervention Group			Control Group		
	N-Gain score	Minimum	Maximum	N-Gain score	Minimum	Maximum
Facial muscle strength	56,31%	10,6%	90,11%	13,41%	3,87%	30,57%

quality and loss of muscle mass due to the aging process. Older age allows the decrease to happen. This finding is in line with the previous studies, which explained that muscle mass and muscle strength decrease with age in both men and women [10], [11], [13]. These results align with the findings of the previous studies that the lower muscle quality is associated with older age [14], [15].

This study found that patients from the intervention group who were given a mirror for the facial muscle expression exercise procedure showed a higher increase in muscle strength than the control group who were not. Thus, the difference in the average value obtained is possible because facial expression exercises using mirror as the media stimulates the patient's active involvement to make it easier to control and correct the movements they make. With this voluntary movement, the patient is more motivated and has more self-confidence to perform repetitive facial muscle exercises. This finding is in line with the findings of a previous study, which explained that motor muscle training using "mirror therapy" enhances changes in neuromuscular functionality after post-stroke motor impairment [13], [14].

The researcher found that patients from the intervention group who were given a mirror for the facial muscle expression exercise procedure were quite effective in increasing muscle strength compared to the control group who were not. This is possible because facial muscle exercises with a mirror can provide visual stimulation to the brain through observing body parts when the patient performs a series of facial muscle movements. In addition, facial muscle exercises using a mirror can also provide a biofeedback effect. The resulting biofeedback effect can stimulate the brain to give signals in moving the facial muscles repeatedly to prevent potential facial muscle contractures. This finding aligns with the previous study, which explained that a mirror therapeutic intervention conveys visual stimuli to the brain through observing normal body parts when individuals perform a series of movements. This finding is also in line with the results of previous studies, which explained that mirror therapy is an effective approach to improve motor function, sensory function, and at least as an adjunct to conventional rehabilitation in post-stroke patients in the acute, sub-acute, and chronic stroke phases compared to the conventional treatment group [16], [17], [18].

Based on these findings, it can be concluded that facial expression exercises using a mirror showed a higher increase in facial muscle strength than patients from the control group. Further, the results show that facial muscle expression exercise using a mirror is an effective exercise applied to increase facial muscle strength.

Facial muscle expression exercises using a mirror are easy-to-use, simple, and inexpensive for patients and staff. It can be adapted to the home environment. Apart from the small sample and relatively short time in the study, based on the results obtained, it can be concluded that facial muscle expression exercises have a very important effect on increasing facial muscle strength obtained. Therefore, it would be suitable to use it repeatedly in facial muscle expression training procedures. In addition, future research on this topic must compare facial muscle expression exercises using a modified mirror and facial expression training procedures with newly developed non-invasive technological approaches and try to determine the optimal frequency and duration to achieve maximum recovery of facial motor function [19], [20], [21].

Conclusion

This study showed that the difference in facial muscle strength was significantly greater in the intervention group. The facial muscle expression exercise using a mirror was more effective in increasing muscle strength than the group without it.

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Author Contribution

Martono Martono: Head of research, design, data collection, review and editing, data interpretation, data analysis, writing, and manuscript revision.

Aulia Isnaeni: Review, editing, design, and data analysis.

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