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Thermotherapy Combined With Therapeutic Exercise Improves Muscle Strength and Depression in Patients With Ischemic Stroke

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Abstract

Purpose: The study examined the effect of home-based thermotherapy combined with therapeutic exercise on muscle strength and depression in patients with ischemic stroke via a weekly evaluation over 4 weeks.

Design/Methods: A quasi-experimental, pre-/posttest research design without a control group was employed. A total of 22 patients participated. Self-reported daily logs were used to evaluate intervention adherence over the study period. The manual muscle testing and Aphasic Depression Rating Scale were administered at baseline and weekly for 4 weeks.

Results: Muscle strength in both the upper and lower limbs significantly increased ($p < .05$), whereas the depression score significantly decreased ($p < .05$).

Conclusion: The intervention increased muscle strength and decreased depression during the first 3 months after stroke onset. The significant effects were found beginning during the third week of the intervention.

Clinical Relevance: This intervention is inexpensive and can be easily applied by caregivers at home.

Keywords: Depression; hot water packs; muscle strength; stroke rehabilitation; therapeutic exercise.

Introduction

Stroke is the second leading cause of death worldwide (Kaste, 2010) and the leading cause of disability in developed countries (Johnston, Mendis, & Mathers, 2009). The adverse consequences of stroke, in terms of the global stroke burden, are estimated to increase by 19% over the next 20 years (Wondergem et al., 2017). In Indonesia, the economic impact of stroke is evident, given its gradually increasing prevalence from 23.3% to 57.9% between 2007 and 2013 (Ministry of Health Indonesia, 2013). Although patient mortality after hemorrhagic stroke is higher than that after ischemic stroke (28.4% vs. 21.2%; Misbach & Ali, 2001), patients with the latter condition nevertheless face substantial challenges with regard to long-term disability and psychosocial problems due to residual neurological dysfunction (Shen & Leishear, 2011). They may experience visual, mental, speech, coordination, and sensation changes (Schretzman, 2001). The clinical manifestations for Indonesian stroke patients were mainly motor disability (90.5%), headache (39.8%), dysarthria (35.2%), and sensory disability (27.3%; Misbach & Ali, 2001). Up to 40% of ischemic stroke survivors are unable to independently meet their daily needs and must rely on their relatives to perform long-term care (Cherubini et al., 2001; Wondergem et al., 2017). Likewise, approximately 40% of patients with acute stroke experience depression (Robinson & Spalletta, 2010).

Stroke survivors must receive long-term rehabilitation to facilitate neurological and functional recovery, minimize disability, and reduce residual adverse effects (Frontera, Gans, Walsh, & Robinson, 2010; Mauk, 2006). Stroke rehabilitation, particularly therapeutic exercise, is not only proposed for functional impairment but also recommended for patients with poststroke depression (Arseniou, Arvaniti, & Samakouri, 2011). Early exercise rehabilitation immediately after the patient's condition stabilizes can lead to greater improvements in motor function than late interventions (Shen & Leishear,

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2011). Therapeutic exercises can be initiated from passive movements in the early stage of stroke onset and then quickly progress to active movements with the patient's participation (Pagliarulo, 2012).

Thermotherapy can decrease functional impairment by improving range of motion (ROM), muscle strength, and flexibility as well as increasing the pain threshold (Cameron, 2013; Matsumoto, Kawahira, Etoh, Ikeda, & Tanaka, 2006). Heat is applied primarily to increase muscle stretching by increasing tissue temperature, blood flow, and muscle relaxation (Nakano, Yamabayashi, Scott, & Reid, 2012). Although therapeutic ultrasound and diathermy are more effective than hot water packs at heating deep soft tissues, hot water packs are more beneficial at improving shoulder ROM, especially for problems related to the external rotator and joint structure (Nakano et al., 2012).

A home-based rehabilitation program during the first 3-month period after stroke onset improves functioning and quality of life as well as reduces the depression and disability of stroke survivors (Chaiyawat, Kulkantrakorn, & Sritipsukho, 2009). In Indonesia, a large proportion of stroke patients are poorly educated and of low economic status, although they live in urban areas (Ministry of Health Indonesia, 2013). A recent review of home-based rehabilitation regarding its cost-effectiveness and greater impact on disability outcome indicated that home-based rehabilitation services hold special promise for stroke patients in low- and middle-income countries (Yan et al., 2016). As a result, simple and low-cost home-based rehabilitation programs that can be carried out at home should be designed. Using hot water packs together with therapeutic exercise can be implemented by patients or their caregivers because they are user-friendly, practical, useful, and inexpensive (Pagliarulo, 2012).

Purpose

This study examined the effect of thermotherapy combined with therapeutic exercise on muscle strength and depression in patients with ischemic stroke using a weekly evaluation for 4 weeks. We hypothesized that thermotherapy applied via hot water packs combined with therapeutic exercise will increase muscle strength and decrease depression among patients with ischemic stroke.

Methods

Study Design and Sample

This study employed a quasi-experimental, pre-/posttest design without a control group. All participants finished the 4-week intervention, and the outcomes were measured at baseline and each week for 4 weeks. Two private hospitals and one public health center in Jakarta, Indonesia, provided the study setting. A convenience sampling method was employed to recruit patients who were diagnosed with ischemic stroke admitted to two hospitals and home healthcare patients referred by a public health center in Jakarta. Participants who met the following inclusion criteria were enrolled: those with (1) first or second onset ischemic stroke, (2) hemiplegia of the upper or lower limb for less than 3 months, (3) stable vital signs and no complaint of chest pain for 24 hours, and (4) a muscle manual testing (MMT) score of <4. The exclusion criteria were patients with an episode of transient ischemia attack (TIA), loss of consciousness, or a previous diagnosis of depression. The principal investigator collaborated with physicians and nurse clinical instructors and nurses in the public health center to inform the potential participants who met the inclusion criteria about the participation in the study. Then, the principal investigator explained the purpose of the study, potential side effects, incentive, and procedure of intervention to the participants. Potential participants who agreed to participate in this study for 30 days signed an informed consent and filled out the demographic questionnaire. Because there were no stroke rehabilitation programs for patients in both the hospital and the health center, all of the participants did not receive any kind of inpatient or hospital therapy, except for medications.

Intervention

All participants received two types of interventions, including thermotherapy using hot water packs and therapeutic exercise. The primary researcher trained primary caregivers on how to perform the intervention each day until they could perform it independently. During the intervention procedure, the patients first applied hot water packs on both their shoulders (deltoid muscle) and knees (hamstring muscle) at a temperature of 41°C (or 106°F) for 10 minutes (Barcroft, 2009; Lehmann, 1989). A thermometer was used to measure the water temperature before the hot water packs were applied, and towels were used to cover the packs. The patients then performed therapeutic exercise for their upper and lower limbs based on the "HOPE: A Stroke Recovery Guide" (American Stroke Association, 2010), as shown in the appendix.

After the intervention, the caregivers documented the intervention using self-report daily logs developed by the primary researcher. This intervention was implemented twice a day, 7 days a week for 4 weeks. The total intervention included 56 applications over

the course of 4 weeks. At least 50 patient interventions were required to maintain the accuracy of the findings assuming a 10% missing data rate. The research protocols are shown in Figure 1.

Measurement

Demographic Questionnaire

Demographic questionnaire included age, duration of stroke onset (days), gender, education, living status, caregiver, financial status, stroke experience, and comorbidity.

Muscle Manual Testing

The MMT was used to measure muscle strength. According to Barr et al. (1991), the MMT is applicable for measuring motor function, ROM, and the strength of upper and lower extremities. The MMT includes five items, with scores ranging from 0 to 5, indicating none (0), trace (1), poor (2), fair (3), good (4), and normal (5). Pollard, Lakay, Tucker, Watson, and Bablis (2005) examined the interexaminer reliability of the MMT for two common muscles: the deltoid and psoas. The findings showed Cohen's kappa values for the deltoid and psoas were $k = .62$ and $k = .67$, respectively, indicating that the MMT is a reliable tool for the measurement of muscle strength. In the current study, the comparison of muscle strength between the pretest and Week 1 was $k = 1.00$ for both upper and lower limbs.

Aphasic Depression Rating Scale

The Aphasic Depression Rating Scale (ADRS) consists of nine items to identify depression among patients with aphasic and possible for nonaphasic patients due to stroke (Benaim, Cailly, Perennou, & Pelissier, 2004). It should not be used with patients who maybe are depressed but do not have a stroke. The nine items of the ADRS are listed below. Three items have two response scale options of 0–2: Item 1 assesses insomnia, Item 4 measures gastrointestinal somatic symptoms, and Item 6 evaluates weight loss during the acute poststroke phase. Five items have 5-scale options ranging from 0 to 4: Item 2 assesses anxiety-psychic, Item 3 measures somatic

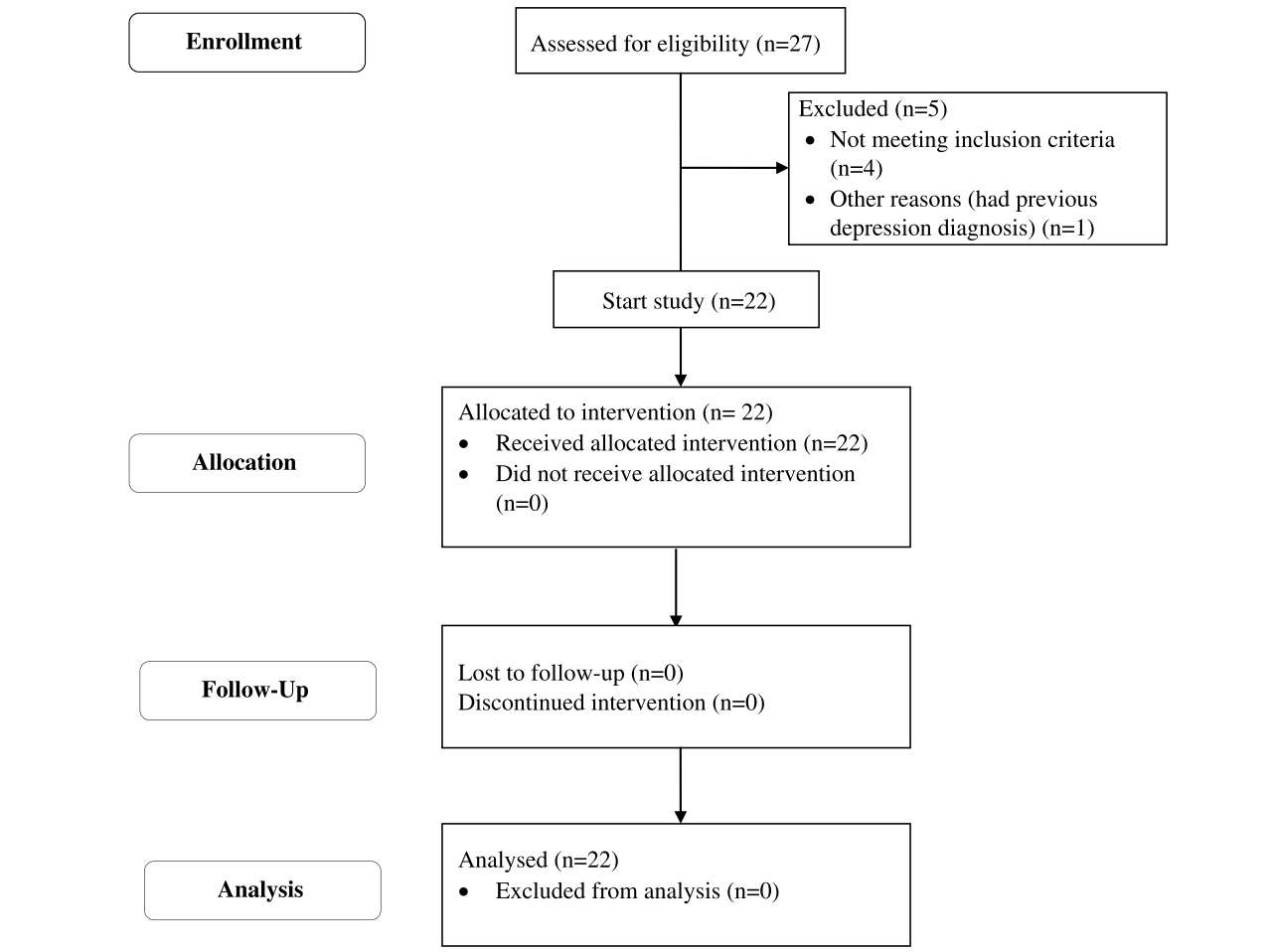

Figure 1. Consort flow diagram.

anxiety, Item 5 assesses hypochondriasis, Item 8 measures mimic slowness of facial mobility, and Item 9 evaluates fatigability. Item 7 assesses apparent sadness on a scale from 0 to 6, from no sadness to despondent. The total score represents the sum of the scores of the nine items and ranges from 0 to 32. A score of <8 denotes a low tendency toward depression, and a total score of ≥9 indicates a strong tendency toward depression (Benaim et al., 2004).

The ADRS has shown satisfactory content, criterion, factorial, and construct validities during the developmental stage (Benaim et al., 2004). The sensitivity of the ADRS compared with the psychiatrists' diagnoses was 0.83, whereas the specificity was 0.71. The interrater and test–retest reliabilities were high (both $r = .89$, $p < .001$; Benaim et al., 2004).

Statistical Analyses

The data were analyzed using IBM SPSS version 20.0 for Windows (IBM Corp., Jakarta, Indonesia). The descriptive statistics employed included frequencies, percentages, means, and standard deviations. Because of the small sample size, nonparametric tests were used, including Mann–Whitney *U* tests and Spearman rho correlation tests to examine the associations between demographic data, muscle strength, and depression in pretest and Week 4 posttest, Wilcoxon matched pairs tests to evaluate the differences in scores between two time points, and Friedman's ANOVA with rank tests to detect changes in muscle strength and depression over time. Effect sizes for the score changes between two time points were calculated by using the standard deviation of the first time point score in the denominator of the equation for Cohen's *d*. A significance level of $p < .05$ was set to reject the null hypothesis.

Ethical Considerations

The Research Ethics Committee of the Ministry of Health, Indonesia, approved the ethical principles of this study (No. LB. 02.01/5.2/KE 414/2014). All patients provided their written informed consent. Explanations of this study were provided to potential participants at clinical settings by principle investigator, and the participants were allowed to withdraw from the study at any time. All information about the participants obtained in this study was kept confidential. Participant names were anonymized in the research records, and each participant was identified in this study using a code number.

Results

The demographic distribution is shown in Table 1. The average age of participants was 57 years, and the mean duration of stroke onset was 12 days ranging from 2 to 30 days. The majority of patients were women (59.1%), had an elementary school education (68.2%), had family as their primary caregiver (86.4%), had a monthly average income of >2.8 million rupiahs (approximately 210 USD; i.e., the minimum salary defined by the governor's regulations for Jakarta Province in 2015), and were recovering from their first stroke (59.1%). Most of the participants had hypertension (59.1%), and all lived with their families (100.0%). All suffered from aphasia after stroke onset.

In the pretest, no demographic characteristics were associated with baseline lower limb muscle strength. Baseline upper limb muscle strength was associated with age ($\rho = -.48$, $p = .023$) and duration of stroke onset ($\rho = .53$, $p = .012$), indicating that younger participants with a longer duration of stroke onset had better upper limb strength than their counterparts. The baseline ADRS scores were associated with age ($\rho = -.48$, $p = .022$) and caregivers ($Z = -2.17$, $p = .030$), suggesting that younger participants with nonfamily caregivers had higher depression scores than their counterparts.

After the intervention (Week 4), no demographic characteristics were associated with both upper and lower limb muscle strength. However, education was associated

Table 1 Demographic characteristics ($N = 22$)

Characteristics	*M* ± *SD*/*n* (%)
Age (year)	57 ± 5.18
Duration of stroke onset (days)	12 ± 11.19
Gender	
Male	9 (40.9)
Female	13 (59.1)
Education	
Elementary	15 (68.2)
High school	7 (31.8)
Caregiver	
Family	19 (86.4)
Nonfamily	3 (13.6)
Living with family	22 (100)
Income	
≤2.8 million rupiahs	9 (40.9)
>2.8 million rupiahs	13 (59.1)
Stroke experience	
First time	13 (59.1)
Second time	9 (40.9)
Aphasia	22 (100)
Comorbidity	
Diabetes	9 (40.9)
Hypertension	13 (59.1)

with ADRS scores ($Z = -2.74$, $p = .005$), indicating that participants with a high school diploma reported greater depressive symptoms than those graduated from elementary school.

Changes in Muscle Strength Over Time

As shown in Figure 2, the mean score for muscle strength of upper limbs was 1.73 ($SD = 1.12$) in the pretest and sustained until Week 2. It was gradually increased from Week 3 ($M = 2.45$, $SD = 0.74$) to Week 4 ($M = 3.18$, $SD = 0.85$). The effect sizes were 0.64 and 1.29 at Weeks 3 and 4, respectively. The mean score for lower limb muscle strength for all participants in the pretest and first 2 weeks was 2.64 ($SD = 0.58$) and increased from Week 3 ($M = 3.32$, $SD = 0.57$) to Week 4 ($M = 3.50$, $SD = 0.51$). The effect size increased from Week 3 to Week 4, 1.17–1.48. The Friedman ANOVAs showed that the muscle strength of both the upper ($\chi^2 = 63.47$, $p < .001$) and lower limbs ($\chi^2 = 59.23$, $p < .001$) significantly improved over time. The Wilcoxon matched pairs tests revealed significant differences in the muscle strength of both the upper and lower limbs between Weeks 2 and 3 ($Z = -3.18$, $p < .01$ and $Z = -3.87$, $p < .001$) as well as between Weeks 3 and 4 ($Z = -3.77$, $p < .001$ and $Z = -2.00$, $p = .046$).

Changes in Depression Over Time

All participants appeared to show a tendency to depression, which was identified by using the cutoff point score of ADRS ≥ 9. As Figure 3 shows, the mean depression score was sustained from pretest to Week 2 at 16.91 ($SD = 4.01$) and significantly decreased to 13.95 ($SD = 2.13$) in Week 3 ($Z = -3.75$, $p < .001$). The effect size was 0.74. The score was then maintained through Week 4. Overall, the Friedman ANOVA showed that depression significantly improved over time ($\chi^2 = 72.00$, $p < .001$).

Discussion

The results of the present study indicate that the use of hot water packs combined with therapeutic exercise among stable patients with ischemic stroke less than 3 months after stroke onset significantly increased muscle strength and decreased depression. The significant effects were found beginning during the third week of the intervention. In this study, the intervention of combined thermotherapy and therapeutic exercise was provided at home between the 2nd and 90th days after stroke onset. Self-reported daily logs were used to evaluate the 4-week intervention adherence. On the basis of these daily logs, the researchers were able to confirm whether patients performed the intervention at least 50 times over the 4-week period.

Because this study was quasi-experimental and did not use a control group, the effects of the intervention should not be overestimated. Stroke can lead to neurological damage in the brain and disrupts the somatosensory cortex; however, this damage can naturally recover over time after stroke onset (Cramer, 2008; Loubinoux et al., 2012). The recovery process, however, can be accelerated by the intervention used in this current study because neurofacilitation (including exercise, which normalizes activity in the sensorimotor cortex) can benefit the recovery process (Miyai et al., 2002). One study found that patients

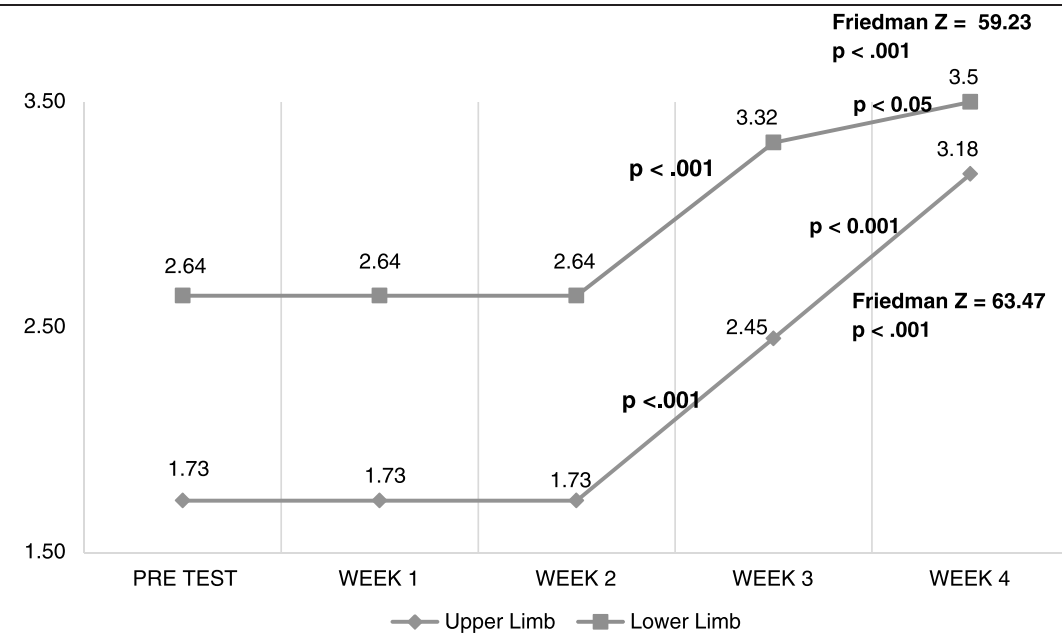

Figure 2. Changes of upper and lower limb muscle strength at different time points ($N = 22$).

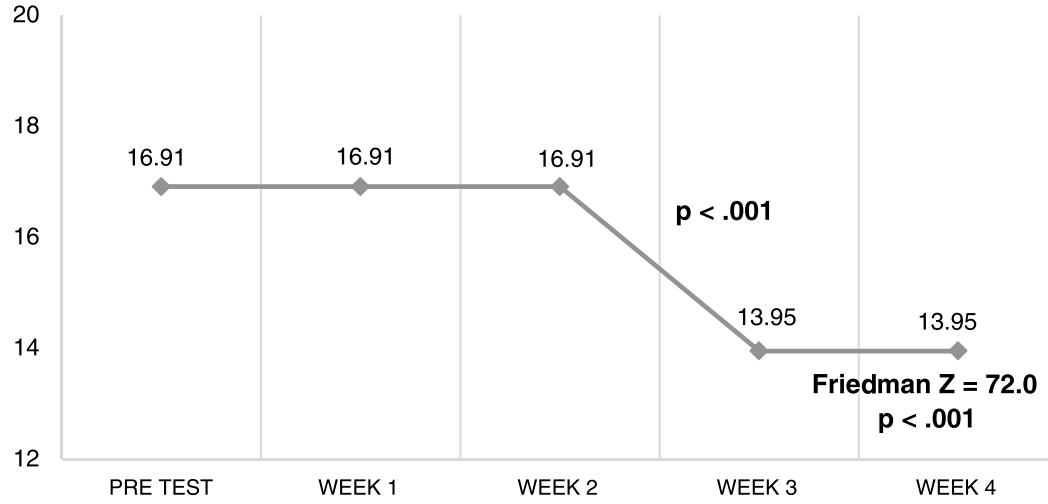

Figure 3. Changes of depression score at different time points (N = 22).

with mild-to-severe stroke completed a stroke rehabilitation package for 2–5 months and showed mild or a lack of disability (Jørgensen, Nakayama, Raaschou, & Olsen, 1999). Therefore, these authors suggested a minimum 6-month intervention to reach better clinical outcomes (Jørgensen et al., 1999).

Effects on Muscle Strength

Increased muscle strength began from the third week of intervention. Similarly, a study with randomly assigned acute stroke survivors who underwent physical therapy showed better functional movement after 6 months of treatment. Particularly, ROM exercise positively affected joint flexibility and functional activity after 4 weeks (Tseng, Chen, Wu, & Lin, 2007). Although prior studies did not directly measure muscle strength, a review article argued that muscle strength is related to the performance of functional activity; thus, increases in muscle strength should be accompanied by improvements in functional activity. Muscle strength is one of the key elements in initiating movement (Bohannon, 2007).

Effects on Depression

Depression scores significantly decreased beginning in Week 3, and these decreases were sustained through Week 4. Without appropriate treatment, depression can decrease quality of life and exacerbate poor physiological outcomes (Daly et al., 2010). A 1-year observational study found that most patients developed poststroke depression within the first 3 months, and the incidence of depression gradually increased over 1 year (Tsai, Wu, Hung, Chou, & Su, 2016). Therefore, our current study findings may support the view that adequate treatments and participation in stroke rehabilitation reduce the development of poststroke depressive symptoms (American Stroke Association, 2010).

Although previous studies have shown the individual benefits of exercise and hot water packs on depression, the current study supports the combination of both for ischemic stroke patients. Previous home-based intervention studies have found that the exercise rehabilitation provided during the first 3 months after stroke onset had a greater effect on decreasing the risk of poststroke depression as well as improved motor function, quality of life, and disability (Chaiyawat et al., 2009; Hou et al., 2013). Exercise had effects similar to those of antidepressants with regard to reducing depressive symptoms, as shown in 156 elderly patients who had major depressive disorders (Blumenthal et al., 2007). Exercise induces the sympathetic nervous system to synthesize neurotransmitters and triggers mood-related chemicals, including catecholamine substances such as dopamine, endorphin, and serotonin, which play important roles in relaxation and stress reduction (Davis, Eshelman, & McKay, 2008; Meeusen, 2005; Raff & Levitzky, 2011).

Various bodily mechanisms can explain the effect of thermotherapy via hot water packs on depression, particularly hemodynamic and metabolic mechanisms. The application of heat locally to the shoulders and knees warms the blood in the skin (Masuda, Nakazato, Kihara, Minagoe, & Tei, 2005) and subsequently stimulates cellular responses with regard to metabolic activity as well as increases blood flow into the body and the supply of oxygen, nutrients, and antibodies to the affected area (Cameron, 2013). Brain chemicals called beta-endorphins are then produced indirectly; these chemicals and catecholamine compounds play an important role in reducing stress (Masuda et al., 2005). By exhibiting psychosomatic relaxation and sedative effects,

Key Practice Points

- This quasi-experimental study examined the effect of home-based thermotherapy combined with therapeutic exercise on muscle strength and depression in patients with ischemic stroke less than 3 months after stroke onset.
- Thermotherapy was administered using hot water packs (water temperature, 41°C for 10 minutes) followed by therapeutic exercise twice a day, 7 days a week for 4 weeks.
- The intervention significantly increased muscle strength and decreased depression.
- The significant effects were found beginning during the third week of the intervention.

repeated thermal therapy decreases mental complaints including depression (Masuda et al., 2005).

Associations of Muscle Strength and Depression With Demographic Data After Stroke Onset

During the pretest, age and longer duration of stroke onset were associated with greater upper limb muscle strength. A previous study found that skeletal muscle was related to age and stroke condition (Sions, Tyrell, Knarr, Jancosko, & Binder-Macleod, 2012). Aging causes muscle atrophy, and a stroke produces increased muscle atrophy, leading to a progressive decrease in muscle fibers. The longer duration after stroke onset is associated with better muscle strength, which may be related to the natural neurological recovery in the brain (Cramer, 2008), which accelerates muscle fiber recovery. This effect is more commonly seen in younger patients.

Older patients experienced less depression during the pretest period. This effect might be because older people view disease as a part of the aging process, whereas younger individuals may perceive stroke as having a greater effect on their daily lives, especially with regard to work and finances. Therefore, members of the former group are less depressed (Davis et al., 2008). The finding showing that patients who were cared for by their family members experienced less depression at baseline suggests that family support is important to prevent or reduce the development of depression (Salter, Foley, & Teasell, 2010). It also suggests that family members should take part in stroke rehabilitation (Vloothuis et al., 2016).

Although this study has numerous intriguing findings, several limitations should be considered. First, the relatively small sample size and lack of a control group limit the generalizability of our findings. We recruited small samples at the study sites during the data collection period and had difficulty recruiting participants from different hospitals because of the intervention research design. In the future, a larger sample size and the presence of a control group should be employed, and multiple study sites should be involved. Likewise, a longer period (at least 6 months) after stroke onset is required to provide more powerful evidence of the long-term effects of this intervention.

Conclusions

The study findings support the effect of home-based therapeutic exercise combined with thermotherapy on increasing muscle strength and decreasing depression using hot water packs during the first 3 months after stroke onset. The improvement was observed beginning at the third week of the intervention. This intervention is inexpensive and can be applied by caregivers at home. Strategies such as maintaining daily logs and telephone follow-ups help maintain intervention adherence. The early initiation of the intervention (once the patient's condition is stable) and enhancement via family support are important for increasing the degree of neurological recovery.

Relevance to Clinical Practice

Therapeutic exercise and thermotherapy using hot water packs is a cheap and user-friendly technique to be applied by the caregiver at home and can improve muscle strength and decreasing poststroke depression. In our study, thermotherapy was administered using hot water packs on both participants' shoulders (deltoid muscle) and knees (hamstring muscle) at a temperature of 41°C for 10 minutes followed by 10 minutes of therapeutic exercise for each upper and lower limbs twice a day, 7 days a week for 4 weeks. A longer period of intervention, however, is suggested to receive better outcomes.

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Appendix

The therapeutic exercise:

1. The upper limbs included Exercise 1: raising the shoulder, Exercise 2: strengthening the shoulder, Exercise 3: bending the elbow, Exercise 4: pulling the shoulder, and Exercise 5: shoulder diagonal movement.
2. The lower limbs included Exercise 1: bending the knee, Exercise 2: hip rotation, Exercise 3: lifting the knee, Exercise 4: cross bending of the knee, and Exercise 5: raising the hips.