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Original Article

Respiratory training combined with core training improves lower limb function in patients with ischemic stroke

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Abstract: Objective: To analyze the effect of respiratory training combined with core training on lower limb function and quality of life in patients with ischemic stroke. Methods: Data of 88 patients with hemiplegia after stroke admitted to Affiliated Sichuan Provincial Rehabilitation Hospital of Chengdu University of TCM from January 2019 to January 2021 were retrospectively analyzed. Quality of life and lower limb function were evaluated in the control group (conventional rehabilitation training, n = 40) and the research group (respiratory training combined with core stabilization training, n = 48) using Short Form-36 (SF-36) and with Wisconsin Gait Scale (WGS), respectively. According to the mean value of life quality after treatment, patients were divided into a low quality of life group and a high quality of life group. Logistics regression was used to analyze the risk factors affecting patients' quality of life. Changes in pulmonary function parameters (including forced expiratory volume in the first second (FEV1) and forced vital capacity (FVC)) were observed before and after treatment. Patients' balance ability was assessed using the Berg Balance Scale (BBS). Results: Compared with the control group, the research group had evidently higher SF-36 score ($P < 0.001$), markedly lower WGS score ($P < 0.001$) and much better FEV1 and FVC ($P < 0.001$). After treatment, the BBS score of the research group increased evidently compared with that of the control group ($P < 0.001$). Logistics regression revealed that the duration of education, national institutes of health stroke scale (NIHSS) score at admission and rehabilitation program were independent risk factors affecting the quality of life of patients ($P < 0.05$). Conclusion: Breathing training combined with core muscle training can effectively improve lower limb function and daily living activities in stroke patients. In addition, duration of education, NIHSS score at admission and rehabilitation program were identified as independent risk factors affecting the life quality of stroke patients.

Keywords: Respiratory training, core training, ischemic stroke, lower limb function, impact on quality of life

Introduction

Stroke is one of the most common cerebrovascular diseases endangering human health, causing a heavy economic burden for families and society and has become a global public health problem because of its high incidence, disability rate and mortality [1, 2]. Stroke causes sequelae such as limb motor dysfunction and neurological dysfunction, which seriously impair patient's self-care ability and quality of life [3]. With the continuous improvement of medical technology, the mortality caused by stroke has gradually decreased, but the related disability rate has evidently increased [4]. Statistically, cerebrovascular disease is the third cause of death among residents of China, ranking after malignant tumors and heart diseases. In China, there are about 2 million newly diagnosed stroke patients each year, of which 70%-80% cannot live independently because of physical disability, and patients with lower limb dysfunction account for about 80% of the total survivors [5].

Hemiplegia, as one of the most common sequelae in stroke patients, seriously affects the limb function and life quality of patients and increases the burden on individuals, family members and society. Cerebral infarction, cerebral hemorrhage and other central nervous system diseases can cause upper motor neuron injury [6]. Abnormal movement patterns occur in muscle groups innervated by damaged neurons during the natural recovery of the body, such as spastic paralysis in the posterior calf muscle groups of some stroke patients [7]. Long-term severe spasm can burdens muscle groups with greater tension than the traction force of the anterior antagonist muscle, thereby inducing foot drop and foot varus. Stroke patients cannot complete ankle dorsiflexion and have a characteristic foot drop gait in the swing phase of walking, which leads to changes in the plantar pressure, decrease in standing and walking balance ability, and increase falling risk, thereby interfering with patients' independence and working ability [8]. Therefore, the question of how to relieve muscle spasm as early as possible is of great significance for the improvement of balance function and restoration of walking function in stroke patients.

Breathing training is mostly used for the rehabilitation of pulmonary function diseases. It starts late in the field of stroke rehabilitation and is generally not yet mature [9, 10]. However, it has been found that respiratory muscle training strengthens the trunk extensor and rotator muscles, thereby improving the balance of patients [11]. In recent years, most of the techniques used for stroke rehabilitation are based on muscle strength training and promoting separation movements of the affected lower limb, while the importance of trunk training has been neglected [12]. Core strength training comprehensively strengthens the neuromuscular innervation ability, which is conducive to controlling the stability of core muscle groups and improving somatomotor function [13]. Studies have shown [14] that core muscle stability rehabilitation training can effectively improve the balance and walking speed of stroke patients. However, whether respiratory training combined with core training has positive effects on lower limb function and life quality in ischemic stroke patients has not yet been confirmed.

The aim of this study was to analyze the effect of respiratory training combined with core training on lower limb function and quality of life in patients with ischemic stroke, and to analyze the risk factors affecting the quality of life of patients, so as to provide a basis for the selection of clinical treatment.

Methods and materials

Clinical data

Data of 88 patients with hemiplegia after stroke admitted to Affiliated Sichuan Provincial Rehabilitation Hospital of Chengdu University of TCM from January 2019 to January 2021 were retrospectively analyzed. Patients in the control group (n = 40) received conventional rehabilitation training, and those in the research group (RsG) (n = 48) underwent respiratory training combined with core stabilization training. This study was approved by the medical ethics committee of Affiliated Sichuan Provincial Rehabilitation Hospital of Chengdu University of TCM.

Inclusion and exclusion criteria

Inclusion criteria: Patients with unilateral cerebral injury hemiplegia confirmed by CT or MRI; patients with stable vital signs; patients with stand balance more than 1 grade; patients without vestibular dysfunction nor unilateral neglect; patients who were able to stand alone for more than 1 min; patients without cognitive dysfunction; patients with complete clinical data.

Exclusion criteria: Patients with liver and kidney dysfunction; patients with no obvious joint limitation or joint pain; patients who underwent craniocerebral surgery or suffered from malignant tumors, subarachnoid hemorrhage, etc.; patients who were infectious disease carriers; patients who were once diagnosed with stroke and residual limb dysfunction; patients with mental disorders; patients in pregnancy or lactation.

Rehabilitation programs

After admission, patients were routinely given treatments, including anti-platelet aggregation, lipid lowering drugs, antihypertensive medication, for improvement of cerebral blood supply, and maintaining water and electrolyte balance and acid-base balance. The control group was given conventional rehabilitation training, which included assistance to place the limbs well, turning, sitting and other training on the bed, as well as standing, walking and activities of daily living training, etc. The treatment duration was 1 month.

Patients in the RsG underwent respiratory training combined with core training. 1) Core training was as follows. ① Transversus abdominis and multifidus muscle training: The patient was placed in a supine position with knees bent, feet placed on the pad, and the spine remained in a neutral position. The patient was instructed to inhale deeply, relax the abdominal muscles, then slowly exhale, hold the breath at the end of expiration for about 10 s, and then resume calm breathing. The practice was repeated after 10 s. This training was conducted once a day, 10 min each time. When being able to operate skillfully, patients were able to gradually transition to prone, sitting or standing position for training. ② Iliopsoas and gluteal muscle training: The patient maintained anteroposterior standing position with both feet and breathed calmly. The patient was instructed to perform movement control training in all directions of the pelvis once a day for 10 min. ③ Trunk control training: The patient was first asked to be in a prone position and breathe calmly, and instructed to perform prone petrel type extension movement, next in a supine position they performed double-bridge movement, trunk flexion transposition movement, knee flexion transposition oblique muscle movement and scapular protraction with abdominal muscle movement, then in a sitting position they performed trunk lateral flexion movement, trunk anteroposterior movement and trunk flexion transposition movement; finally in a standing position they performed trunk lateral bending, transposition movement, and pelvic anteroposterior left and right tilt movement. This training was conducted once a day for 15 min each time. The above training program was given 5 d per week for 4 weeks. 2) Breathing trainings was as follows. ① Pursed-lip breathing training: The patient was instructed to select a sitting or standing position according to the condition, place both hands on the abdomen, relax the body, keep the mouth closed during training and breathe with the nose stably and slowly during expiration. The ratio of inspiration and expiration time was 1:2, and gradually slowed down afterwards. Specifically, breathing 8-10 times per minute was appropriate. This training lasted for 15 min each time, twice a day. ② Abdominal breathing training: The patient was placed in a supine position, with the hip and knee joints slightly flexed, one hand placed on the upper chest, and the other on the abdomen. Patients were instructed to inhale slowly and deeply through the nose and bulge the abdomen, blow the gas out slowly with the mouth during expiration, while contracting the abdominal muscles and applying pressure to the abdomen by hand, with an inspiration to expiration time ratio of 1:2. This training lasted for 8 min each time, twice a day. ③ Thoracic relaxation training: Patients were instructed to place their hands under the shoulders and pelvis, respectively, and perform thoracic expansion-relaxation movements while immobilizing the shoulder joint, twice a day for 8 min. The above training program was given 5 d per week for 4 weeks.

Outcome measures

Main outcome measures: Patients' quality of life was evaluated using the Short Form-36 (SF-36) [15], with higher scores indicating better quality of life. A total score over 117 points was considered to indicate mild functional impairment, but patients were able to perform daily activities independently. Otherwise, the patients were considered to have moderate-severe functional impairment and required significant assistance or entirely relied on assistance in performing daily activities. The Wisconsin Gait Scale (WGS) was used to assess lower limb function [16], and the scale was mainly used to assess gait after the onset of stroke. Higher scores indicate more severe gait abnormalities. According to the mean value of quality of life after treatment (76.42 ± 9.47), we divided patients with less than 76 points into a low quality of life group and patients with over or equal to 76 points into a high quality of life. Logistic regression was used to analyze the risk factors affecting the quality of life of patients (referring to the grading method of Shi et al. [17]).

Secondary outcome measures: Differences in clinical data were compared between groups. Changes in pulmonary function parameters (including forced expiratory volume in the first

Table 1. Comparison of clinical baseline data of patients

Variable	Control Group (n = 40)	Research Group (n = 48)	χ^2/t value	*P* value
Age			0.352	0.552
≥ 60 years	25	27		
< 60 years	15	21		
Sex			2.924	0.087
Male	28	25		
Female	12	23		
Duration of education (years)	12.75 ± 3.46	11.81 ± 3.48	1.293	0.199
BMI (kg/m^2)	24.55 ± 3.12	23.70 ± 2.79	1.333	0.186
NIHSS score at admission	10.17 ± 2.82	10.14 ± 3.00	0.046	0.963
Onset to thrombolysis time (h)	3.17 ± 0.93	3.00 ± 1.07	0.809	0.420
History of hypertension			0.016	0.899
Present	12	15		
Absent	28	33		
History of Diabetes			0.275	0.600
Present	12	12		
Absent	28	36		
Smoking History			2.924	0.087
Present	28	25		
Absent	12	23		
Stroke Location			0.754	0.685
Left	17	22		
Right	15	14		
Bilateral	8	12		

Note: Body Mass Index (BMI), National institutes of health stroke scale (NIHSS).

second (FEV1) and forced vital capacity (FVC)) were observed before and after treatment. Patients' balance ability was assessed using the Berg Balance Scale (BBS), with higher scores indicating better balance.

Statistical analysis

SPSS 23.0 software was used for statistical analysis. Measurement data were described as mean ± SD and compared by t-test. Enumeration data were described by number of cases and rate, and processed by χ^2 test. Multivariate logistic regression was used for analysis of influencing factors. Test level was set at $\alpha = 0.05$.

Results

Comparison of clinical data

Comparison of the clinical data showed that there were no statistical differences in age, sex, duration of education, body mass index, national institutes of health stroke scale (NIHSS) score at admission, time from onset to thrombolysis, history of hypertension, history of diabetes, smoking history and stroke site between the two groups ($P > 0.05$, **Table 1**).

Quality of life assessments

SF-36 score was used to assess the life quality of patients in the two groups after training. It was found that patients in the RsG had evidently higher SF-36 scores after treatment as compared with patients in the control group ($P < 0.001$, **Figure 1**).

Lower limb function assessment

WGS score was used to assess the lower limb function of the patients, and the results revealed that the WGS score of the RsG was significantly lower than that of the control group after treatment ($P < 0.001$, **Figure 2**).

Pulmonary function changes

The comparison of pulmonary function between the two groups showed evident increase in

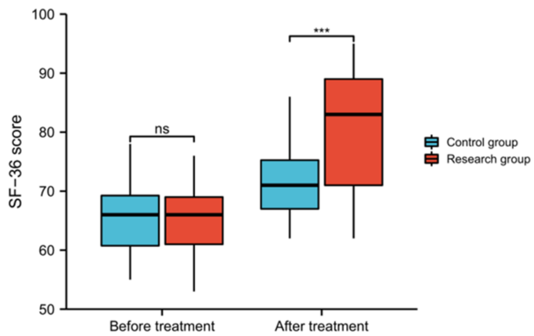

Figure 1. Patient quality of life assessment. Note: Short Form-36 Health Survey (SF-36), $^{ns}P > 0.05$, $^{***}P < 0.001$.

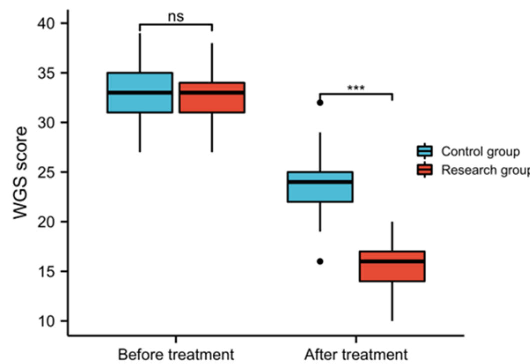

Figure 2. Recovery of lower limb function. Note: Wisconsin Gait Scale (WGS), $^{ns}P > 0.05$, $^{***}P < 0.001$.

FEV1 and FVC after treatment in both two groups (P < 0.05), and indexes in the RsG after treatment were also markedly better than those in control group (P < 0.05, **Figure 3**).

Balance assessment

BBS was used to evaluate the balance of patients, and the results showed that the BBS score of the RsG increased markedly as compared with that of the control group after treatment (P < 0.001, **Figure 4**).

Risk factors affecting patients' quality of life

According to the mean value of quality of life after treatment (76.42 ± 9.47), we divided patients with less than 76 points into a low quality of life group (n = 45) and patients with more than or equal to 76 points into a high quality of life group (n = 43). Univariate analysis revealed that years of education, NIHSS score at admission, time from onset to thrombolysis, diabetes and rehabilitation programs were risk factors affecting the quality of life of patients (**Tables 2**, **3**, P < 0.05). In order to further identify the independent risk factors affecting the life quality of patients, we performed logistics regression and found that duration of education, NIHSS score at admission, and rehabilitation programs were independent risk factors affecting the quality of life of patients (**Table 4**, P < 0.05).

Discussion

In recent years, the incidence of stroke is in a substantial continuous rise under the combined action and influence of a series of factors such as changes of living habits and accelerated aging process, and the affected group tends to progress towards a younger age [18]. Hemiplegia is the most common disability symptom after stroke. Stroke patients with hemiplegia lose balance on both sides of the body in standing and walking activities due to the compensatory movement of the upper and lower limbs on the unaffected side. With the center of gravity shifting to the unaffected side, patients' core stability is inevitably affected because it's hard to maintain a normal posture and reasonable distribution of the center of gravity [19].

Stroke patients suffer from impaired postural control and core stability due to decreased respiratory function, which subsequently leads to movement disorders and increased physical energy consumption during exercise. Patients often experience sedentary, decreased activity and decreased cardiopulmonary exercise capacity, which is not conducive to disease remission [20]. In this study, we found that breathing training combined with core training effectively improved pulmonary function compared with conventional rehabilitation. This is probably because the breathing training was oriented on multiple functions of recovery that are beneficial to the patients, including pursed-lip breathing training, abdominal breathing training and thoracic relaxation training. Pursed-lip breathing training can regulate the effective ventilation volume and respiratory efficiency of the body and optimize respiratory function. Abdominal breathing training can increase diaphragmatic activity, pulmonary ventilation volume, arterial partial pressure of oxygen, respiratory efficiency and adjust respi-

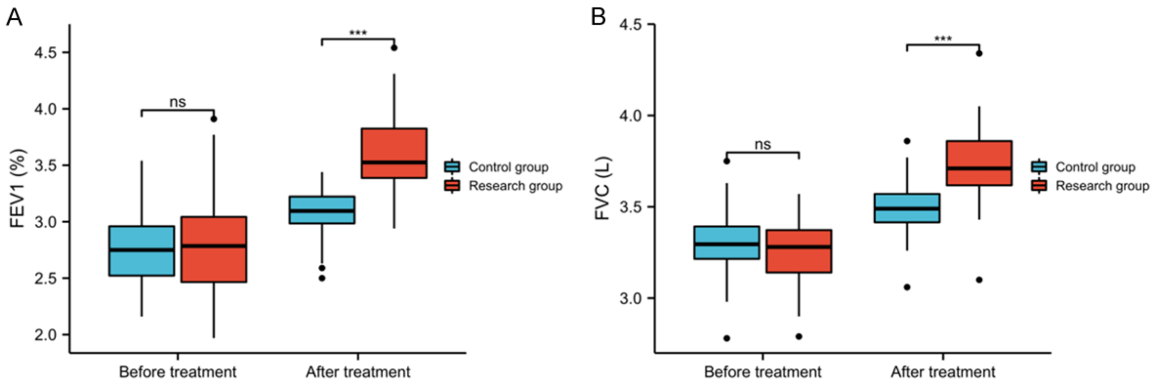

Figure 3. Changes in pulmonary function in patients. A. Comparison of FEV1 changes before and after treatment between the two groups. B. Comparison of FVC changes before and after treatment between the two groups. Note: Forced expiratory volume in 1 second (FEV1), forced vital capacity (FVC), $^{ns}P > 0.05$, $^{***}P < 0.001$.

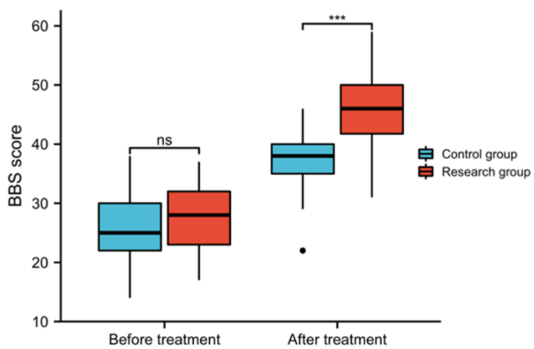

Figure 4. Recovery of balance ability of patients. Note: Berg Balance Scale (BBS), $^{ns}P > 0.05$, $^{***}P < 0.001$.

ratory rate. Thoracic relaxation training helps to improve spinal and thoracic activity, improve lung compliance, regulate expiratory rhythm, and enhance pulmonary ventilation function, so as to improve the pulmonary function of patients [21]. The study by Tovar et al. [22] proposed that inspiratory muscle training, although less intensive, was effective in improving inspiratory muscle strength in stroke patients. However, in Kepenek's [23] study, inspiratory muscle and balance training were found to be helpful for the rehabilitation of children with hemiplegic cerebral palsy. This is consistent with our findings, indicating that breathing training can effectively improve the ventilator capacity of patients to improve lung function and accelerate the rehabilitation of hemiplegic patients.

Stroke patients are often accompanied by bilateral trunk motor function impairment, which is manifested as weakening of key muscle strength in the core area, poor motor control ability, and decreased trunk core stability, which cannot provide a stable basis for lower limb movement [24]. This often leads to shorter weight-bearing time of the affected lower limb in the support phase, insufficient transfer of the body center of gravity to the affected side and anteriorly. Moreover, patients have worse balance ability, unstable walking and gait abnormalities, and have low motor efficacy with significantly increased energy consumption during walking [25]. In our study, breathing training combined with core training was found to sufficiently improve patients' balance ability, lower limb function as well as quality of life. Respiratory training combined with core training intervention can evidently improve the lower limb motor function of stroke patients with hemiplegia, as well as their motor efficacy. In Chen's [14] study, core muscle stability rehabilitation training was found to effectively improve balance function and walking speed of stroke patients, which may be related to increasing transversus abdominis muscle thickness, which is consistent with our findings. Moreover, the study by El Shemy et al. [26] pointed out that adding core stability exercises to the treatment regimen was effective in improving endurance time and gait of trunk muscles in children with hemiplegic cerebral palsy. These studies show that core training can effectively improve balance and gait stability.

Stroke disability is not only reflected in limb motor function, but also cognitive, psychological and other functions that seriously affect

Table 2. Univariate analysis

Variable	Low quality of life group (n = 45)	High quality of life group (n = 43)	χ^2/t value	*P* value
Age			3.657	0.055
≥ 60 years (n = 52)	31	21		
< 60 years (n = 36)	14	22		
Sex			3.195	0.073
Male (n = 53)	23	30		
Female (n = 35)	22	13		
Duration of education (years)	11.06 ± 2.94	13.48 ± 3.61	3.450	0.001
BMI (kg/m^2)	24.71 ± 3.08	23.67 ± 2.85	1.294	0.199
Admission NIHSS score	11.22 ± 2.64	9.04 ± 2.77	3.764	0.001
Onset to thrombolysis time (h)	3.22 ± 1.29	2.65 ± 1.25	2.252	0.026
History of hypertension			0.830	0.362
Present (n = 27)	12	15		
Absent (n = 61)	33	27		
History of diabetes			7.521	0.006
Present (n = 24)	18	6		
Absent (n = 64)	27	37		
Smoking history			0.839	0.359
Present (n = 53)	25	28		
Absent (n = 35)	20	15		
Stroke location			2.092	0.351
Left (n = 39)	19	20		
Right (n = 29)	13	16		
Bilateral (n = 20)	13	7		
Rehabilitation program			7.859	0.005
Combined treatment (n = 48)	18	30		
Conventional treatment (n = 40)	27	13		

Note: Body Mass Index (BMI), National institutes of health stroke scale (NIHSS).

Table 3. Assignment table

Variable	Assignment Value
Duration of education (years)	Raw data used for variables that are continuous
NIHSS score at admission	Raw data used for variables that are continuous
Onset to thrombolysis time (h)	Raw data used for variables that are continuous
History of diabetes	Present = 1, Absent = 0
Rehabilitation program	Combined = 0, Conventional = 1

National institutes of health stroke scale (NIHSS).

patients' life quality [27, 28]. At the end of this study, we analyzed the risk factors affecting the life quality of patients, which is the first factor analysis of life quality related to stroke patients with hemiplegia. In this study, we found that duration of education, NIHSS score at admission and rehabilitation program were risk factors affecting patients' quality of life. Patients with short education time were prone to anxiety and restlessness after surgery due to the lack of awareness and understanding of disease knowledge. These adverse emotions burdened patients heavily, affecting their rehabilitation and reducing their quality of life [29]. A high NIHSS score at admission indicates severe neurological deficits. Supposing the neurological recovery gets worse, patient's quality of life would also be reduced accordingly [30]. The

Table 4. Multivariate logistics regression

Variable	β	Standard deviation	Wald	*P* value	OR value	95% CI	
						Lower limit	Upper limit
Duration of education (years)	-0.258	0.089	8.370	0.004	0.772	0.648	0.920
Admission NIHSS score	0.293	0.108	7.287	0.007	1.340	1.083	1.657
Onset to thrombolysis time (h)	0.389	0.23	2.854	0.091	1.476	0.940	2.317
History of diabetes	1.095	0.656	2.789	0.095	2.990	0.827	10.813
Rehabilitation program	1.285	0.561	5.239	0.022	3.614	1.203	10.858

Note: National institutes of health stroke scale (NIHSS).

main reason why the combined training is beneficial to the life quality of patients could be that respiratory training enhances respiratory muscle strength, improves ventilation efficiency, cardiopulmonary function and systemic oxygen supply, and contributes to the recovery of limb motor function, as well as improves lower limb motor function and life quality by enhancing trunk stability, improving patient balance ability, and reducing additional energy expenditure.

In this study, we determined the effect of breathing training combined with core training on lower limb function and quality of life in patients with ischemic stroke by retrospective analysis. However, this study has some limitations. First of all, the sample size in this study is limited and the patients cannot be followed up as this is a retrospective study, so the long-term impact on patients needs further investigation. Second, we identified factors affecting patients' quality of life by regression analysis, but this was not verified by external data. Finally, this study did not determine the grading criteria for quality of life, and the results may be biased due to the grouping based on means. Therefore, we hope to carry out more clinical trials in future studies to improve our research conclusions.

In summary, respiratory training combined with core muscle training can effectively improve lower limb function and daily living activities in stroke patients. In addition, it was revealed that duration of education, NIHSS score at admission and rehabilitation program were independent risk factors affecting the quality of life of patients.

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Disclosure of conflict of interest

None.

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References

[1] Caprio FZ and Sorond FA. Cerebrovascular disease: primary and secondary stroke prevention. Med Clin North Am 2019; 103: 295-308.

[2] Knight-Greenfield A, Nario JJQ and Gupta A. Causes of acute stroke: a patterned approach. Radiol Clin North Am 2019; 57: 1093-1108.

[3] Tater P and Pandey S. Post-stroke movement disorders: clinical spectrum, pathogenesis, and management. Neurol India 2021; 69: 272-283.

[4] Barthels D and Das H. Current advances in ischemic stroke research and therapies. Biochim Biophys Acta Mol Basis Dis 2020; 1866: 165260.

[5] Wu S, Wu B, Liu M, Chen Z, Wang W, Anderson CS, Sandercock P, Wang Y, Huang Y, Cui L, Pu C, Jia J, Zhang T, Liu X, Zhang S, Xie P, Fan D, Ji X, Wong KL and Wang L; China Stroke Study Collaboration. Stroke in China: advances and challenges in epidemiology, prevention, and management. Lancet Neurol 2019; 18: 394-405.

[6] Marque P, Gasq D, Castel-Lacanal E, De Boissezon X and Loubinoux I. Post-stroke hemiplegia rehabilitation: evolution of the concepts. Ann Phys Rehabil Med 2014; 57: 520-529.

[7] Jan S, Arsh A, Darain H and Gul S. A randomized control trial comparing the effects of motor relearning programme and mirror therapy for improving upper limb motor functions in stroke patients. J Pak Med Assoc 2019; 69: 1242-1245.

[8] Byrd EM, Jablonski RJ and Vance DE. Understanding anosognosia for hemiplegia after stroke. Rehabil Nurs 2020; 45: 3-15.
[9] Sangthong B, Ubolsakka-Jones C, Pachirat O and Jones DA. Breathing training for older patients with controlled isolated systolic hypertension. Med Sci Sports Exerc 2016; 48: 1641-1647.
[10] Burtch AR, Ogle BT, Sims PA, Harms CA, Symons TB, Folz RJ and Zavorsky GS. Controlled frequency breathing reduces inspiratory muscle fatigue. J Strength Cond Res 2017; 31: 1273-1281.
[11] Van Hollebeke M, Poddighe D, Gojevic T, Clerckx B, Muller J, Hermans G, Gosselink R and Langer D. Measurement validity of an electronic training device to assess breathing characteristics during inspiratory muscle training in patients with weaning difficulties. PLoS One 2021; 16: e0255431.
[12] Haruyama K, Kawakami M and Otsuka T. Effect of core stability training on trunk function, standing balance, and mobility in stroke patients. Neurorehabil Neural Repair 2017; 31: 240-249.
[13] Van Criekinge T, Truijen S, Schroder J, Maebe Z, Blanckaert K, van der Waal C, Vink M and Saeys W. The effectiveness of trunk training on trunk control, sitting and standing balance and mobility post-stroke: a systematic review and meta-analysis. Clin Rehabil 2019; 33: 992-1002.
[14] Chen X, Gan Z, Tian W and Lv Y. Effects of rehabilitation training of core muscle stability on stroke patients with hemiplegia. Pak J Med Sci 2020; 36: 461-466.
[15] Lins L and Carvalho FM. SF-36 total score as a single measure of health-related quality of life: scoping review. SAGE Open Med 2016; 4: 2050312116671725.
[16] Estrada-Barranco C, Abuin-Porras V, Lopez-Ruiz J, Sanz-Esteban I, Molina-Rueda F and Cano-de-la-Cuerda R. Spanish cross-cultural adaptation of the Wisconsin gait scale. Int J Environ Res Public Health 2021; 18: 6903.
[17] Shi M, Liang L, Wang Y and Yu Y. Risk factors associated with health-related quality of life in pediatric asthma. Sci Prog 2021; 104: 368504211013657.
[18] Iadecola C, Buckwalter MS and Anrather J. Immune responses to stroke: mechanisms, modulation, and therapeutic potential. J Clin Invest 2020; 130: 2777-2788.
[19] Kerimov K, Coskun Benlidayi I, Ozdemir C and Gunasti O. The effects of upper extremity isokinetic strengthening in post-stroke hemiplegia: a randomized controlled trial. J Stroke Cerebrovasc Dis 2021; 30: 105729.
[20] Barnett HM, Davis AP and Khot SP. Stroke and breathing. Handb Clin Neurol 2022; 189: 201-222.
[21] Yang Y, Wei L, Wang S, Ke L, Zhao H, Mao J, Li J and Mao Z. The effects of pursed lip breathing combined with diaphragmatic breathing on pulmonary function and exercise capacity in patients with COPD: a systematic review and meta-analysis. Physiother Theory Pract 2022; 38: 847-857.
[22] Tovar-Alcaraz A, de Oliveira-Sousa SL, Leon-Garzon MC and Gonzalez-Carrillo MJ. Effects of inspiratory muscle training on respiratory function and balance in stroke survivors: a randomized controlled trial. Rev Neurol 2021; 72: 112-120.
[23] Kepenek-Varol B, Gurses HN and Icagasioglu DF. Effects of inspiratory muscle and balance training in children with hemiplegic cerebral palsy: a randomized controlled trial. Dev Neurorehabil 2022; 25: 1-9.
[24] Einstad MS, Saltvedt I, Lydersen S, Ursin MH, Munthe-Kaas R, Ihle-Hansen H, Knapskog AB, Askim T, Beyer MK, Naess H, Seljeseth YM, Ellekjaer H and Thingstad P. Associations between post-stroke motor and cognitive function: a cross-sectional study. BMC Geriatr 2021; 21: 103.
[25] Kakuda W. Future directions of stroke rehabilitation. Rinsho Shinkeigaku 2020; 60: 181-186.
[26] El Shemy SA. Trunk endurance and gait changes after core stability training in children with hemiplegic cerebral palsy: a randomized controlled trial. J Back Musculoskelet Rehabil 2018; 31: 1159-1167.
[27] Ramos-Lima MJM, Brasileiro IC, Lima TL and Braga-Neto P. Quality of life after stroke: impact of clinical and sociodemographic factors. Clinics (Sao Paulo) 2018; 73: e418.
[28] Lo Buono V, Corallo F, Bramanti P and Marino S. Coping strategies and health-related quality of life after stroke. J Health Psychol 2017; 22: 16-28.
[29] Gomes L, Liebana-Presa C, Araujo B, Marques F and Fernandez-Martinez E. Heart disease, now what? Improving quality of life through education. Int J Environ Res Public Health 2021; 18: 3077.
[30] van Tuijl JH, van Raak EPM, van Oostenbrugge RJ, Aldenkamp AP and Rouhl RPW. Cognition and quality of life in patients with poststroke epilepsy: a case-control study. Epilepsy Behav 2020; 104: 106444.