Brain Neurorehabil. 2022 Mar;15(1):e3
https://doi.org/10.12786/bn.2022.15.e3
pISSN 1976-8753·eISSN 2383-9910

Brain & NeuroRehabilitation

Special Review

Check for updates

Nutritional Supplementation in Stroke Rehabilitation: A Narrative Review

Sung-Hwa Ko, Yong-Il Shin

OPEN ACCESS

Received: Mar 14, 2022
Revised: Mar 16, 2022
Accepted: Mar 17, 2022
Published online: Mar 25, 2022

Correspondence to
Yong-Il Shin
Department of Rehabilitation Medicine, Rehabilitation Hospital and Research Institute for Convergence of Biomedical Science and Technology, Pusan National University Yangsan Hospital and Department of Rehabilitation Medicine, Pusan National University School of Medicine, 20 Geumo-ro, Mulgeum-eup, Yangsan 50612, Korea.
Email: rmshin01@gmail.com
rmshin@pusan.ac.kr

HIGHLIGHTS

- In stroke rehabilitation, nutritional supplementation for malnutrition is required.
- Nutritional supplementation may affect positive outcomes after stroke.

Brain Neurorehabil. 2022 Mar;15(1):e3
https://doi.org/10.12786/bn.2022.15.e3
pISSN 1976-8753·eISSN 2383-9910

bnr
Brain & NeuroRehabilitation

Special Review

Check for updates

Nutritional Supplementation in Stroke Rehabilitation: A Narrative Review

Sung-Hwa Ko [1,2] **Yong-Il Shin** [1,2]

[1]Department of Rehabilitation Medicine, Rehabilitation Hospital and Research Institute for Convergence of Biomedical Science and Technology, Pusan National University Yangsan Hospital, Yangsan, Korea
[2]Department of Rehabilitation Medicine, Pusan National University School of Medicine, Yangsan, Korea

OPEN ACCESS

Received: Mar 14, 2022
Revised: Mar 16, 2022
Accepted: Mar 17, 2022
Published online: Mar 25, 2022

Correspondence to
Yong-Il Shin
Department of Rehabilitation Medicine, Rehabilitation Hospital and Research Institute for Convergence of Biomedical Science and Technology, Pusan National University Yangsan Hospital and Department of Rehabilitation Medicine, Pusan National University School of Medicine, 20 Geumo-ro, Mulgeum-eup, Yangsan 50612, Korea.
Email: rmshin01@gmail.com
rmshin@pusan.ac.kr

ORCID iDs
Sung-Hwa Ko
https://orcid.org/0000-0003-4900-5972
Yong-Il Shin
https://orcid.org/0000-0001-7894-0930

Funding
This study was supported by a 2021 research grant from Pusan National University Yangsan Hospital.

ABSTRACT

Malnutrition is associated with increased mortality and poor functional recovery after stroke. Most guidelines for stroke rehabilitation strongly recommend nutritional screening for malnutrition. Nutritional status after stroke is related to long-term outcomes, and nutritional supplementation is recommended for stroke patients with malnutrition and those at risk of malnutrition. However, routine nutritional supplementation in stroke patients, regardless of nutritional status, is not correlated with improved functional outcomes, and nutritional supplementation is not recommended if the nutritional status is adequate. Nutritional supplementation with protein, amino acids, vitamins, and minerals positively affects recovery after stroke, with improvements seen in motor function, cognition, activities of living, and mood. However, the evidence is insufficient due to the small number of studies and the lack of well-designed randomized controlled studies. Therefore, nutritional supplementation for stroke patients in rehabilitation should not be uniform, and individual nutritional interventions based on an assessment of the patient's nutritional status should be provided.

Keywords: Dietary Supplements; Malnutrition; Nutritional Status; Stroke; Rehabilitation

INTRODUCTION

Stroke, which is one of the most common and severe neurological diseases, is among the leading causes of death and disability worldwide. Stroke patients are at risk for dehydration and malnutrition due to dysphagia, cognitive impairment, and decreased consciousness.

Nutritional status may deteriorate during the acute phase after stroke for various reasons, including surgery and energy consumption, and malnutrition is associated with increased mortality and poor functional recovery in stroke patients [1-4]. Malnutrition can also persist after stroke if it is not managed effectively. The key components of nutritional management include nutritional screening, assessment, and supplementation. Many guidelines for stroke rehabilitation recommend screening for malnutrition and providing nutritional supplementation [5-9]. Herein, we review nutritional supplementation in stroke rehabilitation for functional recovery, with a focus on general nutritional supplementation with protein/amino acids, vitamins, and minerals.

Conflict of Interest

The first and corresponding authors of this manuscript are the editors of *Brain & NeuroRehabilitation*. The authors did not engage in any part of the review and decision-making process for this manuscript.

SCREENING OF NUTRITIONAL STATUS

The prevalence of malnutrition varies from 6% to 62% upon admission to the hospital in stroke patients, and it has been reported to be 25% in the first weeks after stroke [10]. Malnutrition is associated with poor outcomes in terms of mortality, length of hospital stay, and cost of hospitalization compared to normal nutritional status. The Feed Or Ordinary Food (FOOD) trial, a large cohort study, analyzed the association between nutritional status and mortality in 3,012 stroke patients [2], and found higher 6-month mortality in malnourished patients than in patients with normal nutritional status. Another retrospective cohort study involving 540 stroke patients reported that poor nutritional status was a predictor of lower functional outcome improvement in stroke patients [11]. Along with this evidence, most guidelines for stroke rehabilitation strongly recommend nutritional screening and assessment (**Table 1**). To this end, most hospitals have formed a nutrition support team to provide adequate nutritional interventions and nutritional screening for inpatients as well as stroke patients.

GENERAL NUTRITIONAL SUPPLEMENTATION

Guidelines for stroke present recommendations for nutritional supplementation according to stroke patients' nutritional status. In patients with malnutrition, nutritional supplementation is recommended; however, if patients' nutritional status is adequate, it is recommended not to provide supplementation (**Table 2**).

The FOOD trial comprised three well-designed, large randomized controlled trials (RCTs) on the nutritional management of stroke patients [12-14]. As mentioned above, the FOOD trial provided reliable evidence that nutritional status after stroke is associated with long-

Table 1. Recommendations for nutritional screening in stroke patients

Guideline	Recommendation
Clinical Practice Guideline for Stroke Rehabilitation in Korea 2016 [5]	All stroke patients should be screened for malnutrition and nutritional status in the acute-onset stage (recommendation level B, evidence level 2+).
Canadian Stroke Best Practice Recommendations: Rehabilitation, Recovery, and Community Participation Following Stroke. Update 2019 [7]	Patients should be screened for malnutrition, ideally within 48 hours of inpatient rehabilitation admission using a valid screening tool (evidence level C).
(Australian) Clinical Guidelines for Stroke Management (2017) [8]	All stroke patients should be screened for malnutrition at admission and on an ongoing basis (at least weekly) while in hospital (strong recommendation).
ESPEN Guideline Clinical Nutrition in Neurology (2018) [9]	The available evidence suggests that all stroke patients should be screened for risk of malnutrition on admission to hospital (within 48 hours), and the MUST can be used to identify patients who are more likely to benefit from medical nutrition therapy. Grade of recommendation: GPP - strong consensus (100% agreement).

ESPEN, European Society for Clinical Nutrition and Metabolism; MUST, Malnutrition Universal Screening Tool; GPP, good practice point.

Table 2. Recommendations for nutritional supplementation in stroke patients

Guidelines	Recommendation
(AHA/ASA) Guidelines for Adult Stroke Rehabilitation and Recovery (2016) [6]	Nutritional supplements are reasonable to consider for patients who are malnourished or at risk of malnourishment (IIa, B)
(Australian) Clinical Guidelines for Stroke Management (2017) [8]	For stroke patients whose nutrition status is poor or deteriorating, nutritional supplementation should be offered (strong recommendation). For stroke patients who are adequately nourished, routine ONS is not recommended (weak recommendation against).
ESPEN Guideline Clinical Nutrition in Neurology (2018) [9]	Routine ONS is not recommended for patients with an acute stroke without dysphagia and who are adequately nourished on admission. Degree of recommendation: GPP - strong consensus (100% agreement). In stroke patients who are able to eat and who have been identified to be malnourished or at risk of malnutrition, ONS is recommended. Degree of recommendation: GPP - strong consensus (100% agreement).

AHA/ASA, American Heart Association/American Stroke Association; ONS, oral nutrition supplementation; ESPEN, European Society for Clinical Nutrition and Metabolism; GPP, good practice point.

https://doi.org/10.12786/bn.2022.15.e3

term outcomes, supporting the recommendation of nutritional supplementation for stroke patients with malnutrition and those at risk of malnutrition. However, it was found that routine oral nutritional supplementation for stroke patients in the hospital was not correlated with improved functional outcomes 6 months after stroke. Furthermore, routine oral nutritional supplementation in patients with non-malnutrition was found to induce hyperglycemia [14].

In 2012, a Cochrane review reported no significant differences in the case fatality, death, or dependency according to the use of nutritional supplementation in patients with acute and subacute stroke [4]. However, nutritional supplementation was correlated with reduced pressure sores and increased energy and protein intake. A study of 178 patients with malnutrition after stroke found an association between improved nutritional status and activities of daily living [15]. Ha et al. [16] analyzed the effectiveness of individualized nutritional interventions compared to usual care in patients with acute stroke. Patients who received individualized nutrition treatment had significantly lower weight loss and higher quality of life and handgrip strength. A recent study reported the impact of individualized nutritional support during a post-stroke rehabilitation program [17]. Among 454 stroke patients admitted to rehabilitation wards, nutritional management was provided (a high-calorie, high-protein diet for malnourished patients and calorie restriction with an appropriate protein diet for obese patients) nutritional screening and assessment. Multivariate analysis found that frequent and individualized nutritional support was independently associated with improved skeletal muscle mass, motor function, and dysphagia, and a shortened length of stay after stroke.

Therefore, malnourished patients should receive nutritional supplementation, but indiscriminate nutritional supplementation without a nutritional assessment is unnecessary. Providing individualized diet support is essential in stroke rehabilitation.

PROTEIN/AMINO ACID SUPPLEMENTATION

Supplementation of protein and amino acids could enhance muscle protein synthesis and increase anabolic activity. In stroke patients, rehabilitation with protein/amino acid supplementation may contribute to post-stroke cortical plasticity and the maintenance of muscle mass.

Several studies have reported that protein supplementation had a positive effect on stroke recovery [18-20]. In an RCT of protein supplementation with 42 stroke patients, patients who received 21 days of protein supplementation showed improvements in the National Institute of Health Stroke Scale compared to those who consumed a spontaneous diet [18]. In another study by Aquilani et al. [19], daily high-protein nutritional supplementation improved cognitive function in subacute stroke patients. Rabadi et al. [20] studied the effects of intensive nutritional supplementation with high-energy, high-protein supplements in 58 stroke patients. High-energy, high-protein supplementation showed good outcomes in motor function and ambulation compared to routine nutritional supplementation, but improvements were not found in the length of hospital stay, body weight, or cognitive function.

Recent studies have moved beyond protein supplementation to actively investigate amino acid supplementation in stroke recovery. Aquilani et al. [21] studied 38 dysphagic subacute

https://doi.org/10.12786/bn.2022.15.e3

stroke patients enrolled and randomized to receive 8 g/day of essential amino acids or an isocaloric placebo. The patients who did not receive essential amino acid supplementation continued to lose muscle mass even 76 days post-stroke, whereas those who received supplementation of essential amino acids did not exhibit unaffected muscle protein over-degradation. Yoshimura et al. [22] reported that the intervention group, which received a leucine-enriched amino acid supplement, showed significantly greater improvements in the Functional Independence Measure, handgrip strength, and skeletal muscle mass than the control group. However, that study of stroke patients with sarcopenia cannot be generalized to all stroke patients. No RCTs have yet investigated the effects of amino acid supplementation on the functional improvement of stroke rehabilitation. The study protocol has been published for a randomized double-blinded placebo-controlled clinical study (AMINO-Stroke Study) of essential amino acid supplementation on muscle strength, muscle function, and physical performance in stroke patients [23]. The results of this study are expected to elucidate the effects of amino acid supplementation on stroke rehabilitation.

Based on previous studies of protein and amino acid supplementation for stroke, nutritional interventions involving protein and amino acid supplementation are expected to be helpful for recovery and functional improvement after stroke. However, there is still insufficient evidence for this possibility. A large-scale RCT is needed to draw evidence-based conclusions.

VITAMIN SUPPLEMENTATION

Many studies are being conducted on vitamin supplementation in relation to stroke, because the antioxidant and anti-inflammatory effects exerted by vitamins are thought to have positive impacts on stroke patients. Studies on stroke prevention are relatively better known. However, the long-term, large-scale Vitamins to Prevent Stroke (VITATOPS) [24] and Vitamin Intervention for Stroke Prevention (VISP) [25] studies showed that folic acid and vitamin B supplementation did not lead to a significant reduction in risk of secondary stroke among patients with recent stroke. However, few studies have been conducted on vitamin supplementation in the context of stroke recovery compared to those focusing on stroke prevention, and the extant studies are relatively small.

The B vitamins play an important role in brain function, and vitamin B levels may be associated with functional outcomes after stroke [26]. A study of vitamin B in stroke pathology using in vivo and in vitro mouse models reported that vitamin B and choline effectively promoted functional stroke recovery [27]. Another animal study showed that vitamin B promoted the recovery of learning and memory functions of rats with cerebral ischemia [28]. Almeida et al. [29] studied the relation between vitamin B supplementation and post-stroke depression in 273 stroke patients, and found that vitamin B supplementation was associated with a lower hazard of major depression than was observed in participants who received a placebo.

Vitamin D carries out neuromuscular, neuroprotective, and osteoprotective roles. Gupta et al. [30] investigated the effect of vitamin D and calcium supplementation on ischemic stroke in patients with vitamin D deficiency or insufficiency. The proportions of good outcomes (modified Rankin Scale score 0–2) and survival were higher in the supplementation group than in the control group. Sari et al. [31] reported that vitamin D supplementation improved activity levels and balance; however, it did not improve motor function or

https://doi.org/10.12786/bn.2022.15.e3

ambulation. Another RCT by Torrisi et al. [32] found that vitamin D supplementation affected independence and depression after stroke.

Vitamins C and E have documented positive effects on the antioxidant capacity in patients with acute ischemic stroke [33]. However, the effects of vitamin C supplementation on stroke recovery have only been investigated in a retrospective case-control study [34], which reported that vitamin C supplementation did not enhance functional recovery in stroke patients.

Vitamins B and D have the potential to exert positive effects on emotion and function after stroke. However, the paucity of studies makes it impossible to reach a definitive conclusion on vitamin supplementation for functional recovery after stroke. Nonetheless, vitamin supplementation may be considered in stroke patients to prevent complications due to vitamin deficiency.

MINERAL SUPPLEMENTATION

Among various minerals, the neuroprotective effect of magnesium sulfate has been documented in animal models [35]. In addition, a meta-analysis confirmed that dietary magnesium intake was associated with a reduced risk of ischemic stroke [36]. A study investigated the effect of magnesium intake on functional improvement after stroke in 291 discharged stroke patients, who were divided into three groups and provided regular salt, potassium-enriched salt, or potassium- and magnesium-enriched salt [37]. After the 6-month intervention, the potassium- and magnesium-enriched salt group showed better neurologic recovery than the potassium-enriched salt group and the regular salt group. Although studies have reported positive findings on magnesium supplementation, more research on mineral supplementation for stroke recovery is needed.

CONCLUSION

Nutritional status should be assessed in stroke rehabilitation, and appropriate nutritional supplementation is required. Although caloric, protein/amino acid, vitamin, and mineral supplementation may have the potential for positive outcomes in stroke rehabilitation, evidence supporting these interventions is still lacking. Therefore, nutritional support for stroke patients in rehabilitation should not be uniform; instead, individual nutritional interventions should be provided.

REFERENCES

1. Gomes F, Emery PW, Weekes CE. Risk of malnutrition is an independent predictor of mortality, length of hospital stay, and hospitalization costs in stroke patients. J Stroke Cerebrovasc Dis 2016;25:799-806.
PUBMED | CROSSREF
2. FOOD Trial Collaboration. Poor nutritional status on admission predicts poor outcomes after stroke: observational data from the FOOD trial. Stroke 2003;34:1450-1456.
PUBMED | CROSSREF
3. Yoo SH, Kim JS, Kwon SU, Yun SC, Koh JY, Kang DW. Undernutrition as a predictor of poor clinical outcomes in acute ischemic stroke patients. Arch Neurol 2008;65:39-43.
PUBMED | CROSSREF

4. Geeganage C, Beavan J, Ellender S, Bath PM. Interventions for dysphagia and nutritional support in acute and subacute stroke. Cochrane Database Syst Rev 2012;10:CD000323.
PUBMED | CROSSREF

5. Kim DY, Kim YH, Lee J, Chang WH, Kim MW, Pyun SB, Yoo WK, Ohn SH, Park KD, Oh BM, Lim SH, Jung KJ, Ryu BJ, Im S, Jee SJ, Seo HG, Rah UW, Park JH, Sohn MK, Chun MH, Shin HS, Lee SJ, Lee YS, Park SW, Park YG, Paik NJ, Lee SG, Lee JK, Koh SE, Kim DK, Park GY, Shin YI, Ko MH, Kim YW, Yoo SD, Kim EJ, Oh MK, Chang JH, Jung SH, Kim TW, Kim WS, Kim DH, Park TH, Lee KS, Hwang BY, Song YJ. Clinical practice guideline for stroke rehabilitation in Korea 2016. Brain Neurorehabil 2017;10:e11.
CROSSREF

6. Winstein CJ, Stein J, Arena R, Bates B, Cherney LR, Cramer SC, Deruyter F, Eng JJ, Fisher B, Harvey RL, Lang CE, MacKay-Lyons M, Ottenbacher KJ, Pugh S, Reeves MJ, Richards LG, Stiers W, Zorowitz RD; American Heart Association Stroke Council, Council on Cardiovascular and Stroke Nursing, Council on Clinical Cardiology, and Council on Quality of Care and Outcomes Research. Guidelines for adult stroke rehabilitation and recovery: a guideline for healthcare professionals from the American Heart Association/American Stroke Association. Stroke 2016;47:e98-e169.
PUBMED | CROSSREF

7. Teasell R, Salbach NM, Foley N, Mountain A, Cameron JI, Jong A, Acerra NE, Bastasi D, Carter SL, Fung J, Halabi ML, Iruthayarajah J, Harris J, Kim E, Noland A, Pooyania S, Rochette A, Stack BD, Symcox E, Timpson D, Varghese S, Verrilli S, Gubitz G, Casaubon LK, Dowlatshahi D, Lindsay MP. Canadian stroke best practice recommendations: rehabilitation, recovery, and community participation following stroke. Part one: Rehabilitation and recovery following stroke; 6th edition update 2019. Int J Stroke 2020;15:763-788.
PUBMED | CROSSREF

8. Stroke Foundation. Clinical guidelines for stroke management. Melbourne: Stroke Foundation; 2017.

9. Burgos R, Bretón I, Cereda E, Desport JC, Dziewas R, Genton L, Gomes F, Jésus P, Leischker A, Muscaritoli M, Poulia KA, Preiser JC, Van der Marck M, Wirth R, Singer P, Bischoff SC. ESPEN guideline clinical nutrition in neurology. Clin Nutr 2018;37:354-396.
PUBMED | CROSSREF

10. Gomes F, Hookway C, Weekes CE; Royal College of Physicians Intercollegiate Stroke Working Party. Royal College of Physicians Intercollegiate Stroke Working Party evidence-based guidelines for the nutritional support of patients who have had a stroke. J Hum Nutr Diet 2014;27:107-121.
PUBMED | CROSSREF

11. Kokura Y, Maeda K, Wakabayashi H, Nishioka S, Higashi S. High nutritional-related risk on admission predicts less improvement of functional independence measure in geriatric stroke patients: a retrospective cohort study. J Stroke Cerebrovasc Dis 2016;25:1335-1341.
PUBMED | CROSSREF

12. Dennis M, Lewis S, Cranswick G, Forbes J; FOOD Trial Collaboration. FOOD: a multicentre randomised trial evaluating feeding policies in patients admitted to hospital with a recent stroke. Health Technol Assess 2006;10:iii-iv, ix-x, 1-120.
PUBMED | CROSSREF

13. Dennis MS, Lewis SC, Warlow C; FOOD Trial Collaboration. Effect of timing and method of enteral tube feeding for dysphagic stroke patients (FOOD): a multicentre randomised controlled trial. Lancet 2005;365:764-772.
PUBMED | CROSSREF

14. Dennis MS, Lewis SC, Warlow C; FOOD Trial Collaboration. Routine oral nutritional supplementation for stroke patients in hospital (FOOD): a multicentre randomised controlled trial. Lancet 2005;365:755-763.
PUBMED | CROSSREF

15. Nishioka S, Wakabayashi H, Nishioka E, Yoshida T, Mori N, Watanabe R. Nutritional improvement correlates with recovery of activities of daily living among malnourished elderly stroke patients in the convalescent stage: a cross-sectional study. J Acad Nutr Diet 2016;116:837-843.
PUBMED | CROSSREF

16. Ha L, Hauge T, Spenning AB, Iversen PO. Individual, nutritional support prevents undernutrition, increases muscle strength and improves QoL among elderly at nutritional risk hospitalized for acute stroke: a randomized, controlled trial. Clin Nutr 2010;29:567-573.
PUBMED | CROSSREF

17. Shimazu S, Yoshimura Y, Kudo M, Nagano F, Bise T, Shiraishi A, Sunahara T. Frequent and personalized nutritional support leads to improved nutritional status, activities of daily living, and dysphagia after stroke. Nutrition 2021;83:111091.
PUBMED | CROSSREF

18. Aquilani R, Scocchi M, Iadarola P, Franciscone P, Verri M, Boschi F, Pasini E, Viglio S. Protein supplementation may enhance the spontaneous recovery of neurological alterations in patients with ischaemic stroke. Clin Rehabil 2008;22:1042-1050.
PUBMED | CROSSREF

19. Aquilani R, Scocchi M, Boschi F, Viglio S, Iadarola P, Pastoris O, Verri M. Effect of calorie-protein supplementation on the cognitive recovery of patients with subacute stroke. Nutr Neurosci 2008;11:235-240.
PUBMED | CROSSREF

20. Rabadi MH, Coar PL, Lukin M, Lesser M, Blass JP. Intensive nutritional supplements can improve outcomes in stroke rehabilitation. Neurology 2008;71:1856-1861.
PUBMED | CROSSREF

21. Aquilani R, Boselli M, D'Antona G, Baiardi P, Boschi F, Viglio S, Iadarola P, Pasini E, Barbieri A, Dossena M, Bongiorno AI, Verri M. Unaffected arm muscle hypercatabolism in dysphagic subacute stroke patients: the effects of essential amino acid supplementation. BioMed Res Int 2014;2014:964365.
PUBMED | CROSSREF

22. Yoshimura Y, Bise T, Shimazu S, Tanoue M, Tomioka Y, Araki M, Nishino T, Kuzuhara A, Takatsuki F. Effects of a leucine-enriched amino acid supplement on muscle mass, muscle strength, and physical function in post-stroke patients with sarcopenia: a randomized controlled trial. Nutrition 2019;58:1-6.
PUBMED | CROSSREF

23. Scherbakov N, Ebner N, Sandek A, Meisel A, Haeusler KG, von Haehling S, Anker SD, Dirnagl U, Joebges M, Doehner W. Influence of essential amino acids on muscle mass and muscle strength in patients with cerebral stroke during early rehabilitation: protocol and rationale of a randomized clinical trial (AMINO-Stroke Study). BMC Neurol 2016;16:10.
PUBMED | CROSSREF

24. VITATOPS Trial Study Group. B vitamins in patients with recent transient ischaemic attack or stroke in the VITAmins TO Prevent Stroke (VITATOPS) trial: a randomised, double-blind, parallel, placebo-controlled trial. Lancet Neurol 2010;9:855-865.
PUBMED | CROSSREF

25. Toole JF, Malinow MR, Chambless LE, Spence JD, Pettigrew LC, Howard VJ, Sides EG, Wang CH, Stampfer M. Lowering homocysteine in patients with ischemic stroke to prevent recurrent stroke, myocardial infarction, and death: the Vitamin Intervention for Stroke Prevention (VISP) randomized controlled trial. JAMA 2004;291:565-575.
PUBMED | CROSSREF

26. Markišić M, Pavlović AM, Pavlović DM. The impact of homocysteine, vitamin B12, and vitamin D levels on functional outcome after first-ever ischaemic stroke. BioMed Res Int 2017;2017:5489057.
PUBMED | CROSSREF

27. Jadavji NM, Emmerson JT, MacFarlane AJ, Willmore WG, Smith PD. B-vitamin and choline supplementation increases neuroplasticity and recovery after stroke. Neurobiol Dis 2017;103:89-100.
PUBMED | CROSSREF

28. Huang GW, Liu H, Wang YM, Ren DL. Effects of folic acid, vitamin B(6) and vitamin B(12) on learning and memory function in cerebral ischemia rats. Zhonghua Yu Fang Yi Xue Za Zhi 2007;41:212-214.
PUBMED

29. Almeida OP, Marsh K, Alfonso H, Flicker L, Davis TM, Hankey GJ. B-vitamins reduce the long-term risk of depression after stroke: the VITATOPS-DEP trial. Ann Neurol 2010;68:503-510.
PUBMED | CROSSREF

30. Gupta A, Prabhakar S, Modi M, Bhadada SK, Kalaivani M, Lal V, Khurana D. Effect of vitamin D and calcium supplementation on ischaemic stroke outcome: a randomised controlled open-label trial. Int J Clin Pract 2016;70:764-770.
PUBMED | CROSSREF

31. Sari A, Durmus B, Karaman CA, Ogut E, Aktas I. A randomized, double-blind study to assess if vitamin D treatment affects the outcomes of rehabilitation and balance in hemiplegic patients. J Phys Ther Sci 2018;30:874-878.
PUBMED | CROSSREF

32. Torrisi M, Bonanno L, Formica C, Arcadi FA, Cardile D, Cimino V, Bramanti P, Morini E. The role of rehabilitation and vitamin D supplementation on motor and psychological outcomes in poststroke patients. Medicine (Baltimore) 2021;100:e27747.
PUBMED | CROSSREF

33. Aquilani R, Sessarego P, Iadarola P, Barbieri A, Boschi F. Nutrition for brain recovery after ischemic stroke: an added value to rehabilitation. Nutr Clin Pract 2011;26:339-345.
PUBMED | CROSSREF

34. Rabadi MH, Kristal BS. Effect of vitamin C supplementation on stroke recovery: a case-control study. Clin Interv Aging 2007;2:147-151.
PUBMED | CROSSREF

35. Wang LC, Huang CY, Wang HK, Wu MH, Tsai KJ. Magnesium sulfate and nimesulide have synergistic effects on rescuing brain damage after transient focal ischemia. J Neurotrauma 2012;29:1518-1529.
PUBMED | CROSSREF

36. Larsson SC, Orsini N, Wolk A. Dietary magnesium intake and risk of stroke: a meta-analysis of prospective studies. Am J Clin Nutr 2012;95:362-366.
PUBMED | CROSSREF

37. Pan WH, Lai YH, Yeh WT, Chen JR, Jeng JS, Bai CH, Lin RT, Lee TH, Chang KC, Lin HJ, Hsiao CF, Chern CM, Lien LM, Liu CH, Chen WH, Chang A. Intake of potassium- and magnesium-enriched salt improves functional outcome after stroke: a randomized, multicenter, double-blind controlled trial. Am J Clin Nutr 2017;106:1267-1273.
PUBMED | CROSSREF