Effects of Physical Exercise Program on Physical Mobility of Patients with Cranial Surgery

Jittima Panyasarawut, M.N.S.*, Wallada Chanruangvanich, D.N.S., Prangtip Chayaput, Ph.D.**, Theerapol Witthiwej, M.D.*****

**Master of Nursing Science Program in Adult and Gerontological Nursing, Faculty of Nursing, Mahidol University, **Department of Surgical Nursing, Faculty of Nursing, Mahidol University, ***Division of Neurosurgery, Department of Surgery, Faculty of Medicine Siriraj Hospital, Mahidol University, Bangkok 10700, Thailand.*

ABSTRACT

Objective: This research aimed to study the effects of a physical exercise program on physical mobility in cranial surgery patients.

Materials and Methods: The researcher used a quasi-experimental method of surveying 58 patients who had cranial surgery at Siriraj Hospital. The research group was divided into two groups: an experimental group (28 patients) participating in a physical exercise program of patients after cranial surgery, and a control group (30 patients) receiving routine nursing care only. The evaluation of the patients' physical mobility was performed three days after the surgery.

Results: Most patients in the research group had an intracranial tumor (86.2%). One day after the surgery, the experimental group had minor pain at the wound site while the control group had moderate pain. Both groups felt discomfort (64.2%) or had muscle stiffness in the neck and shoulder areas (63.3%). Three days after the surgery, at the end of the program, the body movement function of both groups was reduced compared with the preoperative data. However, the experimental group showed better body movement function scores than the control one as the scores of the former were reduced less than those of the latter at $p < 0.05$.

Conclusion: Nurses who provide health care services to patients after cranial surgery should apply the physical exercise program to promote the recovery of the patients' physical mobility.

Keywords: Physical exercise; physical mobility; cranial surgery (Siriraj Med J 2021; 73: 695-701)

INTRODUCTION

Cranial surgery can be applied to treat different intracranial diseases[1] such as tumors, blood clots, brain abscesses, repair broken cranial bones or clip blood vessels in patients with cerebrovascular aneurysms.[2] However, the surgery affects the brain and blood vessels. The brain tissues are damaged, leading to limited activity, decreased mobility[3] and different neurological deficits: gait (76.3%) and balance (48.3%).[4] Hence, the patients face the inability to self-care.[3] Moreover, the patients need to be positioned correctly to facilitate the surgery. This includes forcing the head to be raised up and stay in an appropriate angle while being pressed by a Mayfield[5] for 4-6 hours.[6] The patients' neck and shoulder muscles take the weight, creating taut bands[7,8] and aches in the muscles. They have difficulties lowering, raising and turning their heads. The pressure on the blood vessels reduces blood and oxygen circulation to the muscles[7,9],

Corresponding author: Wallada Chanruangvanich
E-mail: wallada.cha@mahidol.ac.th
Received 21 February 2021 Revised 19 July 2021 Accepted 20 July 2021
ORCID ID: https://orcid.org/0000-0002-2593-389X
http://dx.doi.org/10.33192/Smj.2021.89

so the patients feel dizzy when changing the position. Moreover, the postoperative pain complicates early ambulation and delays early recovery.[10-12]

Most patients who have had cranial surgery face limitations in performing daily activities, and only 18% of these patients can resume working normally following surgery.[13] Fostering early recovery is very important. In general, 59% of patients who have normal preoperative body movement and receive postoperative recovery promotion show a better body movement function at an 81.5% rate.[14] The recovery promotion should start from the patients' admission.[15] Physicians or nurses should provide them with general preoperative knowledge and teach physical exercise, step by step, to prepare the muscles while the patients stay in bed until they can walk.[16,17] This is considered nursing therapeutics capable of fostering cranial surgery patients, who are in health and illness transition of Meleis' transition theory, achieve complete this transition[18,19], which contributes in turn to postoperative recovery, improves physical mobility, reduces complications from bed bounding[20] and admission days.[12] Before starting exercise, the patients will be evaluated in terms of dizziness and wound pain and will be eased of muscle pain in the neck and shoulder areas. Many studies have shown that massaging can reduce pain[21] and stress to blood vessels in the muscles, while increasing blood and oxygen circulation to the brain and eliminating dizziness.[22] Thus, massage is an appropriate and effective treatment for relieving neck and shoulder muscle stress and promoting early ambulation in patients who have had surgery.

Most of the previous studies were rehabilitation programs for patients who had chronic neurological symptoms and long-term impaired body functions.[23-25] In the area of patients who had cranial surgery, a previous study concerning early recovery after surgery (ERAS) programs was found to have encouraged patients to have early mobility from the first 24 hours after surgery. Furthermore, patients who received the ERAS program had early recovery with reduced LOS in hospital.[12,17,20,26] However, rehabilitation and ERAS programs in the past did not study massage for relief of muscle pain, massaging to ease muscle pain was done with patients who had a thyroidectomy[27], and nurses did not begin exercise from the first 24 hours after surgery when patients were in the ICU. Therefore, to prepare muscles for ambulation with exercise and to prepare patients for transfer from the ICU to the ward on the second day after surgery, patients received massage to relax the neck and shoulder muscles. This role was performed by nurses for comfort, relieve muscle pain and increase blood circulation to the brain tissues of patients, as a consequence, patients were more likely to have improved physical mobility. Thus, the researcher developed a physical exercise program for patients who had a cranial surgery. The first phase of the exercise started 24 hours after the surgery. Once the patients' conditions were stable[16,26], they were massaged to relieve muscle stress in the neck and shoulder areas before starting active ROM exercise, strengthen the thigh muscles and quadriceps extension until they could get up from the bed and walk. The goal was to promote physical mobility to recover quickly.

MATERIALS AND METHODS

This quasi-experimental research was certified by the Human Research Ethics Committee, Faculty of Medicine, Siriraj Hospital, Mahidol University (Si 065/2020). The research groups were calculated using influence size determination from mean difference of body functions in similar research studies.[25] The results were 26 patients for a group. Additional patients were included at a 15% rate in case some dropped out.[24] The power of test was 0.80, and confidence in the test (α) was 0.05. The final research groups had 30 patients each.

Population and samples

The population was patients who had cranial surgery at a super tertiary hospital. The samples had the same characteristics as the population. The selection criteria were 1) undergoing cranial surgery; 2) age ≥ 18 years old; 3) Glasgow Coma Scale = 15; 4) Thai Mental State Examination scores > 23; 5) ability to move the body or no limitations in terms of body movement; and 6) understanding and being able to communicate in Thai. The exclusion criteria were 1) having a mental disease history; 2) wearing ventriculostomy drain when starting active exercise; and 3) having a congenital disease which prevents exercising and massaging. The criteria to consider termination from the research were 1) severe postoperative complications; 2) consciousness level decreasing by 2 points in 24 hours; and 3) failing the readiness assessment before starting physical exercise.

Data collection method

The research group received a physical exercise program of patients after cranial surgery (CVI 0.9) from the researcher, who is a nurse. The duration of the exercise was approximately 30 - 45 minutes each time. The program included sharing of knowledge from manuals of physical exercise for patients with cranial surgery (CVI 0.8) one day before the operation. Next, one day after the operation in the ICU, the researcher stimulated the patients via a breathing exercise and passive ROM exercises for both upper and lower extremities (totality 11 positions, 10 times per position, for two sessions) while staying in bed. Two to three days after, the patients could partially move their bodies. The researcher massaged the patients' upper trapezius and splenius capitis areas to relax muscles by using vibration, stroking, petrissage and friction along with encouraging patients to perform active ROM exercises for both the upper and lower extremities (totality 11 positions, 10 times per position, for 2 sessions). Next, the patients performed an exercise to strengthen the thigh muscles for five times and did quadriceps extensions for five minutes. The researcher then helped the patients step down from the bed to sit by the bedside and stimulated them to stand beside the bed before leading the patients to tread for five minutes, take a break for 2-3 minutes, continue treading for five minutes, then walk around the bed. The exercises depended on the ability of each patient. The researcher assessed the physical readiness and treated wound pain for the patients before starting the program every time. During the exercises, the researcher monitored any changes and pain levels for safety. For the control group, the patients received routine nursing care.

Data collection

Data collection was conducted by a research assistant, starting from the control group and then the experimental group. First data collection: one day before the operation. This data was used as baseline data. Physical mobility data were collected by the Clinical Outcome Variables Scale (COVS). Three points were related: 1) gross motor and gait; 2) mobility; and 3) arm function. The higher the COVS, the better the physical mobility. The COVS assessment revealed inter-rater reliability at 0.97[28] and internal consistency at 0.93.[23] ROM of the neck and shoulders was measured by a goniometer. The confidence value of goniometer use between the expert and research assistant was 0.97. Second data collection: three days after the operation. Physical mobility was assessed by COVS, and ROM of the neck and shoulder was measured by a goniometer. Third data collection: one day before leaving the hospital physical mobility was assessed by COVS.

Statistical analysis

All of the data were analyzed using SPSS (version 25). Continuous variables were expressed as mean ± standard deviation or median (interquartile range), and were compared using independent t-test or Mann-Whitney U test. Categorical data were expressed as number (percentage), and were compared using the Pearson chi-square test or Fisher's exact test. A *p-value* < 0.05 was considered statistically significant.

RESULTS

The experimental group consisted of 22 female and 6 male patients for a total of 28. The average age was 53.86. The control group consisted of 20 female and 10 male patients for a total of 30. The average age was 50.67. Personal data of the patients are shown in Table 1. There were no differences between both groups. Two patients in the experimental group dropped out as arrhythmia and high blood pressure were identified at the beginning.

One day after the surgery, before starting the program, both the experimental and control groups felt discomfort and muscle stiffness ($p = 1.0$). There were no differences in the wound pain of both groups ($p = 0.074$) (Table 1). Three days after the surgery, the discomfort and muscle stiffness of the experimental group was better at a 63.3% rate. Also, easing the wound pain every time before starting the program differentiated the pain of both groups significantly ($p = 0.003$) (Table 2).

The results of the physical exercise program of patients after cranial surgery and muscle relief massage differentiated COVS scores of both groups. Three days after the operation, the reduction of COVS scores of the experimental group was significantly less than those of the control group ($p = 0.03$). This meant the physical mobility of the former was better. The patients resumed walking faster, both three days after and one day before discharge, with statistical significance ($p = 0.01$, 0.004, respectively) (Fig 1). Furthermore, ROM of the neck and shoulder was significantly better than that of the control group ($p = 0.001$, 0.001, respectively) (Table 2).

DISCUSSION

Due to cranial surgery, both groups' physical mobility scores of three days after the operation decreased more than preoperative scores. These findings were in line with many other studies that found issues of reduced postoperative body movement[3,4], resulting from the operation, wound pain and muscle overuse at the upper trapezius and splenius capitis areas. The latter led to leakage to Ca^{2+} from sarcoplasmic reticulum to sarcolemma, combination of Ca^{2+} and adenosine triphosphate, and attachment of actin to myosin, which created a taut band.[9] Pressure to blood vessels and circulation under the muscles produced local hypoxia and anaerobic metabolism. Lactic acid was built up in the muscles and stimulated the nerve endings to feel pain, so the patients felt acute muscle aches and pains. The symptoms could last days or weeks, but no

TABLE 1. Personal data and treatment.

	Experimental group (*n* = 28)	Control group (*n* = 30)	*p*-value
Age: year	53.86 ± 12.55	50.67 ± 14.84	0.382
Female	22 (78.6)	20 (66.7)	0.385
BMI	25.33 ± 4.42	25.31 ± 5.31	0.988
Hypertension	9 (32.1)	13 (43.3)	0.427
Diabetes	5 (17.9)	3 (10.0)	0.464
Hyperlipidemia	9 (32.1)	9 (30.0)	1.00
Diagnosis			
Intracranial tumor	24 (85.7)	26 (86.7)	0.626
Cerebrovascular	2 (7.1)	1 (3.3)	
Cranial trauma	0	2 (6.7)	
Functional	2 (7.1)	1 (3.3)	
Lesion location: lobe			
Frontal lobe	4 (14.3)	5 (16.7)	0.547
Temporal lobe	2 (7.1)	5 (16.7)	
Parietal lobe	7 (25)	3 (10)	
Occipital lobe	7 (25)	9 (30)	
Multiple lobes	8 (28.6)	8 (26.7)	
Operation: craniotomy with			
Tumor removal	24 (85.7)	26 (86.7)	0.922
Clipping aneurysm	2 (7.1)	1 (3.3)	
Temporal lobectomy	1 (3.6)	1 (3.3)	
Other	1 (3.6)	2 (6.7)	
Duration of surgery: hours			
≤ 4	13 (46.4)	13 (43.3)	1.00
> 4	15 (53.6)	17 (56.7)	
Discomfort or stiffness of muscle			
Yes	18 (64.2)	19 (63.3)	1.00
Area of muscle			
Upper trapezius	6 (21.4)	7 (23.3)	0.565
Neck (splenius capitis)	4 (14.3)	4 (13.3)	
Shoulder	1 (3.6)	2 (6.7)	
Neck and upper trapezius	1 (3.6)	2 (6.7)	
Upper trapezius and shoulder	2 (7.1)	0 (0)	
Neck, upper trapezius and shoulder	0 (0)	2 (6.7)	
Arms and legs	2[1] (7.1)	11 (3.3)	
Back	2[2] (7.1)	1 (3.3)	
Surgery position in patients with discomfort or stiffness of muscle			
Supine	10 (55.6)	9 (47.4)	1.00
Lateral	1 (5.6)	2 (10.5)	
Park – bench	5 (27.8)	5 (26.3)	
Prone	2 (11.1)	3 (15.8)	
Pain on POD1 (NRS)			
Mild	14 (50.0)	6 (20.0)	0.074
Moderate	9 (32.1)	14 (46.7)	
Severe	4 (14.3)	9 (30.0)	

[1] In conjunction with neck or upper trapezius, [2] combined with upper trapezius or shoulder
Values are expressed as number (percentage), mean ± standard deviation

TABLE 2. COVS and ROM scores before and after surgery.

	Experimental group (*n* = 28)	Control group (*n* = 30)	*p*-value
COVS (pre-operation)#	80 (7)	80 (8)	0.453
COVS (POD3)#	68 (9)	62 (27)	
Difference COVS scores (posttest – pretest)#	-10.5 (8.5)	-16.5 (18.25)	0.03*
POD3			
ROM of neck#	190 (59)	127.50 (84)	0.001*
ROM of shoulder#	1244.50 (203)	1085 (298)	0.001*
Pain (NRS)†	0.25 ± 0.64	1.60 ± 1.97	0.003*
LOS#	7 (3)	10 (4)	0.001*

*p-value < 0.05
†Value is expressed as mean ± standard deviation, #Values are expressed median (interquartile range)

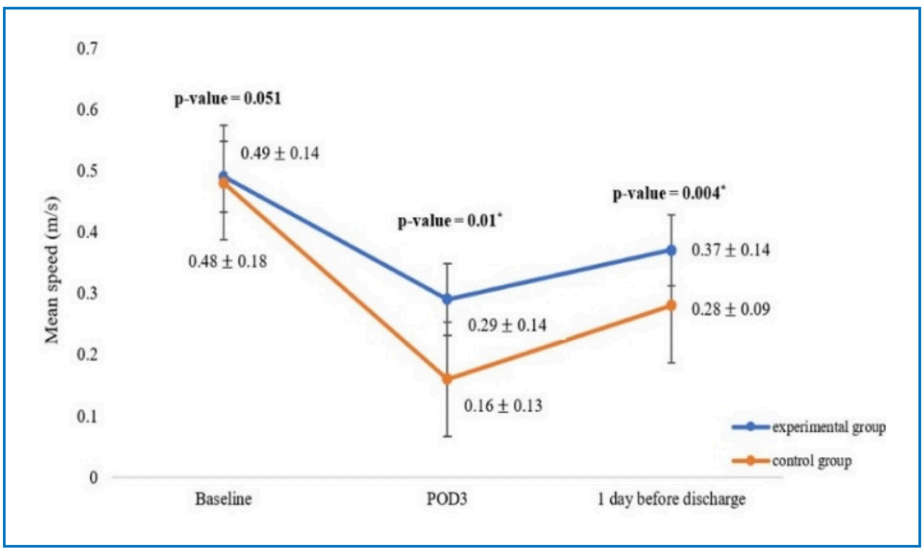

Fig 1. Comparison of speed between experimental and control groups.

more than two months.[8,27] The motion range of the neck and shoulders was reduced, which slowed the patients' movement and affected postoperative recovery.

This study showed that the physical exercise program of patients after cranial surgery including preoperative exercise knowledge sharing, early body movement stimulation and muscle preparation within the first 24 hours after the operation such as passive and active ROM exercises of both the upper and lower extremities, strengthen the thigh muscles and quadriceps extension, caused striated a skeletal muscle to contract harder. Consequently, the muscles used more energy, converting chemical energy into kinetic energy and increasing the cross-sectional area of Type 2 muscle fibers and resulting in muscle hypertrophy. With full growth of muscle fibers, the muscles became stronger, enabling patients to exercise more and move better, respectively.[29] This also prepared the patients' muscles before they could step down from the bed until walk around. Overall recovery was faster. More than three-quarters of the patients were able to walk by the bedside three days after surgery at a rate of 86.7%. The physical mobility of the experimental group decreased less than the physical mobility of those without the support program. Therefore, the patients in the experimental group had complete health and illness transition.[18] The study of Wang et al. (2018) found that the elective craniotomy patients who received the ERAS program could do early off-bed activities and ambulation by the third day after the surgery. The success rate was 95%, which was significantly more than another group that did not have the program ($p < 0.0001$).[12]

In terms of the assessment of body readiness and management of localized wound pain from injuries at brain tissues, cortex nerves and blood vessels, which could be relieved pain by medication[30], both study groups had similar levels of wound pain before they were forced to step down from the bed, and they received similar amounts of painkiller. However, the experimental group had lower wound pain scores in POD3 than the control group (Table 2). The results were similar to those of the study of Qu et al. (2020) who found that pain management after cranial surgery in the patients receiving ERAS programs generated significantly lower wound pain scores in POD3 than the other group ($p < 0.001$).[26] Moreover, massaging was an alternative medicine that had a mechanism to send nerve currents along a beta or alpha nerve fiber to signal and stimulate S.G. cells to inhibit the function of transmission cells. The mechanism controlling the gate at the spinal cord level was thus closed. No nerval signal was sent to the brain, so the patients felt no pain.[31] Also, there was endorphins and enkephalins secretion to defy Substance P. This caused the gate to close and inhibited the transmission of nerve pain from the brain. The perception of pain was reduced. The patients felt relaxed, which enhanced pain relief.

The patients' ameliorated body movement was partially from discomfort management and massaging to relax the muscles. After receiving massages, two-thirds of the patients felt more comfort and less muscle stress. Furthermore, ROM of the neck and shoulders was better than the control group, and the experimental group could recover close to the normal state. Thus, they could exercise and move their bodies actively. The results were similar to those of Gemmell et al. (2008) who used post-isometric relaxation, which is similar to massage. The study found that the pain decreased immediately, and ROM was increased significantly ($p < 0.05$).[21] Increased ROM is related to decreased pain[32], the results after massaging by Doppler ultrasound showed increased blood and lymph circulation.[22] This circulation led to nutrient and oxygen supplies to the muscles, waste removal from the tissue cells and signal stimulation of focal adhesion kinase enzyme and extracellular signal-regulated kinase enzyme to reduce the contracture of sarcomere. The trigger points were relaxed with less cytokine and more mitochondria synthesis.[33] The muscles were stimulated to recover from fatigue more quickly.[34] Moreover, massaging relaxed the upper trapezius muscle, loosened the pressure of the vertebral artery under the muscle and increased blood circulation to the cerebral and basilar arteries. The brain tissues gained more oxygen so the patients' headache and dizziness were eased.[35,22] The experimental group could move their bodies more comfortably than the other group.

The physical exercise program of patients after cranial surgery was important in terms of promoting body movements such as sitting and standing, stepping down to sit beside the bed, performing various activities to help the patients resume walking faster (Fig 1) and leaving the hospital earlier than the other group (Table 2). The nursing method helped enhance recovery after surgery.

CONCLUSION

The physical exercise program of patients after cranial surgery including body exercise, muscle relaxing massage, knowledge sharing and management of symptoms affecting postoperative recovery improved the patients' physical mobility. As a result, nurses who take care of cranial surgery patients should use this program as a guideline to promote early movement of patients after surgery.

ACKNOWLEDGEMENTS

I would like to thank the Division of Neurosurgery, Department of Surgery, Faculty of Medicine Siriraj Hospital, Mahidol University, for supporting the neurosurgery research funding from the Siriraj Foundation, and Associate Professor Doctor Wattana Jalayondeja, specialist from the Faculty of Physical Therapy, Mahidol University, who taught muscle relaxing massage techniques and how to use a goniometer. I also would like to thank the head of the patient ward, staffs and research participants who cooperated and helped with data collection.

Abbreviations: ERAS = enhance recovery after surgery, LOS = length of stay, ICU = Intensive Care Unit, CVI = content validity index, ROM = range of motion, COVS = Clinical Outcome Variable Scale, BMI = body mass index, NRS = numeric rating scale, POD = postoperative day, S.G. cell = Substantia gelatinosa cell,

REFERENCES

1. Foust. (2018). The experience of post-craniotomy pain among person with brain tumors (dissertation). Bloomington: Indiana University; 2018.
2. Hemmings G. Neurosurgery after cranial surgery information for patients. (internet). Oxford: Oxford University Hospital

NHS Trust; 2018 (cited 2019 Aug 18). Available from https://www.ouh.nhs.uk/patient-guide/leaflets/files/11585Pcranial.pdf

3. Khan F, Amatya B, Drummond K, Galea MP. Effectiveness of integrated multidisciplinary rehabilitation in primary brain cancer survivors in an Australian community cohort: a controlled clinical trial. J Rehabil Med 2014;46(8):754-60.
4. Pace A, Villani V, Parisi C, Di Felice S, Lamaro M, Falcicchio C, et al. Rehabilitation pathways in adult brain tumor patients in the first 12 months of disease. A retrospective analysis of services utilization in 719 patients. Support Care Cancer 2016;24(11):4801-6.
5. Nader R, Gragnaniello C, Berta SC, Sabbagh AJ, Levy ML. Neurosurgery tricks of the trade. New York: Thieme Medical Publishers; 2014.
6. Meng L, Berger MS, Gelb AW. The potential benefits of awake craniotomy for brain tumor resection: an anesthesiologist's perspective. J Neurosurg Anesthesiol 2015;27(4):310-7.
7. Boonprakob Y, Phadungkit S, Nongharnpitak S, Srijessadarak T, Supasatean W, Nakhengrit C. Trigger point: curable or palliative symptoms. J Assoc Med Sci 2016;49(1):155-66.
8. Sriwicha W. Myofascial pain syndrome. Hua Hin Sook Jai Klai Kangwon Journal 2016;1(1):10-28.
9. Minerbi A, Vulfsons S. Challenging the Cinderella Hypothesis: a new model for the role of the motor unit recruitment pattern in the pathogenesis of myofascial pain syndrome in postural muscles. Rambam Maimonides Med J 2018;9(3):e0021.
10. Flexman AM, Ng JL, Gelb AW. Acute and chronic pain following craniotomy. Curr Opin Anaesthesiol 2010;23(5):551-7.
11. Pavlin DJ, Chen C, Penaloza DA, Polissar NL, Buckley FP. Pain as a factor complicating recovery and discharge after ambulatory surgery. Anesth Analg 2002;95(3).
12. Wang Y, Liu B, Zhao T, Zhao B, Yu D, Jiang X, et al. Safety and efficacy of a novel neurosurgical enhanced recovery after surgery protocol for elective craniotomy:a prospective randomized controlled trial. J Neurosurg 2018:1-12.
13. Janda M, Steginga S, Dunn J, Langbecker D, Walker D, Eakin E. Unmet supportive care needs and interest in services among patients with a brain tumour and their carers. Patient Educ Couns. 2008;71(2):251-8.
14. Giordana MT, Clara E. Functional rehabilitation and brain tumour patients. A review of outcome. Neurol Sci 2006;27(4):240-4.
15. Wattradul D. Cardiac rehabilitation: transition care from hospital to home. Thai Journal of Cardio-Thoracic Nursing 2015;26(1):89-103.
16. Hickey JV. The Clinical practice of neurological and neurosurgical nursing. 8th ed. Philadelphia: Lippincott, Williams & Wilkins; 2019.
17. Liu B, Liu S, Wang Y, Lu D, Chen L, Zheng T, et al. Impact of neurosurgical enhanced recovery after surgery (ERAS) program on health-related quality of life in glioma patients: a secondary analysis of a randomized controlled trial. J Neurooncol 2020;148(3):555-67.
18. Meleis A.I. Transitions theory: The use of a middle-range and situation-specific theory in the research and care of individuals, families and communities. New York: Springer; 2010.
19. Eun-Ok Im. Situation-specific theories from the middle-range transitions theory. ANS Adv Nurs Sci 2014;37(1):19-31.
20. Lu D, Wang Y, Zhao T, Liu B, Ye L, Zhao L, et al. Successful implementation of an Enhanced Recovery After Surgery (ERAS) protocol reduces nausea and vomiting after infratentorial craniotomy for tumour resection: a randomized controlled trial. BMC Neurol 2020;20(1):1-11.
21. Gemmell H, Miller P, Nordstrom H. Immediate effect of ischaemic compression and trigger point pressure release on neck pain and upper trapezius trigger points:a randomised controlled trial. Clin Chiropr 2008;11(1):30-6.
22. Taspinar F, Aslan UB, Sabir N, Cavlak U. Implementation of matrix rhythm therapy and conventional massage in young females and comparison of their acute effects on circulation. J Altern Complement Med 2013;19(10):826-32.
23. Andersson P, Franzén E. Effects of weight-shift training on walking ability, ambulation, and weight distribution in individuals with chronic stroke: a pilot study. Top Stroke Rehabil 2015;22(6):437-43.
24. Liljehult MM, Buus L, Liljehult J, Rasmussen BK. Walking ability in patients with glioblastoma: prognostic value of the Berg Balance Scale and the 10 meter walk test. J Neurooncol 2017;135(2):335-42.
25. Noinawakul U, Pinyopasakul W, Kimpee S, Puwarawuttipanit W. The effects of a walking exercise program on perceived self-efficacy and functional capacity in stroke patients with hemiparesis. J Nurs Sci 2010;28(4):45-53.
26. Qu L, Liu B, Zhang H, Sankey EW, Chai W, Wang B, et al. Management of postoperative pain after elective craniotomy: a prospective randomized controlled trial of a neurosurgical Enhanced Recovery After Surgery (ERAS) program. Int J Med Sci. 2020;17(11):1541-9.
27. Teerateadtakul B. The effect of massage and exercise of neck on the level of the headache in surgical patients with head elevated position. Thai J Nurs Res 1996;46(1):23-32.
28. Choy NL, Kuys S, Richards M, Isles R. Measurement of functional ability following traumatic brain injury using the Clinical Outcomes Variable Scale: a reliability study. Aust J Physiother 2002;48(1):35-9.
29. Leelayuwat N. Physiology of exercise. Khon Kaen: Khon Kaen University; 2553.
30. Fox SW, Lyon D, Farace E. Symptom clusters in patients with high-grade glioma. J Nurs Scholarsh 2007;39(1):61-7.
31. Treede, Rolf-Detlef. Gain control mechanisms in the nociceptive system. PAIN 2016;157(6):99-1204.
32. Field T, Diego M, Gonzalez G, Funk CG. Neck arthritis pain is reduced and range of motion is increased by massage therapy. Complement Ther Clin Pract 2014;20(4):219-23.
33. Flinder LI, Timofeeva OA, Rosseland CM, Wierød L, Huitfeldt HS, Skarpen E. EGF – induced ERK-activation downstream of FAK requires Rac1-NADPH oxidase. J Cell Physiol 2011;226:2267–78.
34. Braun, Beth M. Introduction to massage therapy. 2nd ed. Philadelphia: Lippincott Williams & Wilkins; 2008.
35. Pianbanyat K, Choowattanapakorn T. The effect of nursing process combined with Swedish massage on pain in older persons with lung cancer. Kuakarun Journal of Nursing 2015;22(1):98-112.