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Research Article

Immediate Effect of Nadishodhana Pranayama on Functional Mobility in Stroke Patients

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ABSTRACT

Objective: To determine the immediate effect of nadishodhana pranayama on performance of a clinical functional mobility task in stroke patients.

Design: Experimental, within subject, pre and post design.

Setting: Tertiary Care Hospital and Research Centre.

Participants: 16 Stroke patients consisting of 11 males and 5 females with an average age of 51 ± 12.43 (S.D) yrs.

Intervention: Nadishodhana Pranayama was administered to ambulatory stroke patients in a quiet, spacious, well-lit room. Functional mobility was assessed before and immediately after the practise of Pranayama.

Main outcome measure: Timed up and Go test (TUGT)

Results: The average Timed Up and Go Test (TUGT) time in seconds was 33.43 ± 19.56 before and 26.06 ± 20.69 after the practice of Nadishodhana Pranayama. The Wilcoxon Signed Rank Test was applied to this data which proved the difference to be extremely significant ($p<0.00001$).

Conclusion: Practice of Nadishodhana Pranayama significantly improves the efficiency of performance of a functional mobility task in stroke patients immediately.

Keywords: Stroke; Functional mobility; Yoga; Nadishodhana pranayama; Physical therapy

Abbreviations: Alternate Nostril Breathing (ANB); Nadishodhana Pranayama (NSP); Inhalation: Exhalation (I:E); Timed Up and Go Test (TUGT); Minimum Clinically Important Difference (MCID); Minimal Detectable Change (MDC); Wilcoxon Signed Rank Test (WSRT); Electroencephalography (EEG); Event-Related Potential (ERP); Standard Deviation (SD)

INTRODUCTION

Stroke

It is the second leading cause of death and third leading cause of disability in adult human population worldwide [1]. The cumulative incidence of stroke ranged from 105 to 152/100,000 persons per year and the crude prevalence of stroke ranged from 44.29 to 559/100,000 persons in different parts of India during the past decade. There has been more than 100 per cent increase in incidence of stroke in low- and middle-income countries including India from 1970-1979 to 2000-2008 [2]. Stroke is defined as rapid onset of focal neurological deficit, resulting from diseases of the cerebral vasculature and its contents [3]. It is the sudden loss of neurological function caused by an interruption of the blood flow to the brain [1]. Stroke of different types and in different regions of the brain can cause various deficits in neurological functions, including motor, somatosensory, cognitive, perceptual, speech & language, visual, behavioural and emotional. Because of the sudden onset dysfunction of the affected cerebral hemisphere, patients most commonly experience difficulty in carrying out activities of daily living, ambulation, planning the rate and rhythm of movements, maintaining static or dynamic balance, making postural adjustments and adaptations and a general reduction in body awareness to carry out motor tasks and bring about functional mobility.

Functional mobility

It is defined as the manner in which people are able to move around in the environment in order to participate in the activities

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of daily living and, move from place to place. These movements include standing, bending, walking and climbing [4]. Being able to satisfactorily change directions while walking is a vital component of functional mobility, along with carrying out the judgement for modifying various gait parameters, like accuracy in step lengths and step widths while in motion [5-8]. Stroke survivors demonstrate a significantly longer reaction time and lower accuracy in turning-while-walking, as compared to healthy individuals of a similar demography [9]. Turning while walking is one of the commonest causes of falls post stroke [9,10]. Also, individuals with hemiparesis as a result of stroke often have difficulty accepting and bearing weight on the paretic leg hence they commonly exhibit asymmetry in standing and during ambulation with greater proportion of the body weight being borne on the non-paretic leg [11]. This weight bearing asymmetry has been shown to have a significant correlation with a poor functional-ambulation performance in stroke patients [12]. In turning-while-walking, it has been suggested that failing to re-adjust the movement from the already coordinated straight line walking may result in loss of balance or even a fall [9,10]. Turning while walking, in fact is one of the most common causes of fall incidences in people with stroke [13]. In consideration of the varied problems faced by stroke patients, numerous adjunctive therapies along with conventional physiotherapy have been proposed in the recent years for targeting restoration of specific or overall functioning in stroke patients. Some of these are yoga therapy, tai chi, aroma therapy, hydrotherapy, music therapy, art therapy etc. [14-20].

Yoga

It is a discipline to improve or develop one's inherent power in a balanced manner [21]. It offers the means to attain complete self-realization. Yoga can therefore be defined as a means of uniting the individual spirit with the universal spirit of God. According to maharishi Patanjali, Yoga is the restraintment of the personality complex from modifications of the mind [21,22]. Patanjali's yoga sutras deal with what is known as the Ashtanga yoga or the eight steps of yoga, which are Yama (restraints), Niyama (observances), Asana (postures), Pranayama (regularization of bio-energy), Pratyahara (abstraction i.e., withdrawal of senses), Dharana (concentration), Dhyana (meditation) and Samadhi (trance). Pranayama is the control of Prana i.e., bio-energy or vital force through (expansion and regularization of) inspiration and expiration [22]. Alternate nostril breathing (ANB) is a technique used in various types of Pranayamas. Nadishodhana Pranayama (NSP) is a kind of ANB where 1 cycle of breath consists of inhaling and exhaling from both nostrils alternately. In the past two decades there has been an increase in the practise of ANB in India as well as countries abroad [23]. Studies have shown that breathing from one nostril stimulates the cognitive and autonomic function of the contralateral cerebral hemisphere and breathing from both nostrils alternately brings about a balance in the functioning of both cerebral hemispheres with respect to each other [24-29]. Practise of ANB has been shown to have immediate as well as long term positive effects on spatial memory, reaction time, cognitive functioning, executive functions, movement planning and decision making in clinical tests [30-37]. Also on EEG, a statistically significant improvement in the latency and amplitude of N200 and P300 ERPs and an increase in the alpha wave activity and theta power immediately after, or on periodic practise of ANB has been observed [25,29,30,38,39]. All of these physiological functions affected by ANB have a vital role to play in safe voluntary locomotion. The present study aimed to determine the immediate effect of Nadishodhana Pranayam (NSP) on functional mobility in ambulatory stroke patients, assessing it by the means of their performance of Timed Up and Go Test (TUGT) which has been found to be a reliable, valid and easy-to-administer clinical tool for said population [40]. Nadishodhana is the first Pranayama described in the classical texts [41]. The word "Nadi" means energy channel and "shodhana" means to cleanse or to purify. Therefore, Nadi Shodhana is a practice whereby the Pranic channels are purified and regulated. Beginners should be familiar with the abdominal or diaphragmatic breathing before taking up Nadi Shodhana. In Nadi Shodhana, soundless breathing is practiced to ensure that the breath is not forced or restricted in any way. This is a balancing Pranayama because it can restore equilibrium. Based on the findings of previous literature on healthy and individuals with stroke, we hypothesized that ANB will have a positive effect on functional mobility in stroke patients. To the best of our knowledge, there has not been a research study examining the immediate effect of Pranayamas on dynamic balance in stroke patients. The immediate effects of NSP found out in this study, a simple form of ANB, could prove useful in prevention of or reducing the risk and incidence of falls in stroke patients during therapy and at home and also improving their confidence for carrying out functional ambulation independently, as it is a simple and cost effective technique that can be inculcated in regular practice and is with minimal or no limitations, drawbacks or side effects.

METHODOLOGY

This was an experimental study with a within-subject design. 16 stroke patients in the age group of 18-60 years; with unilateral hemiplegic involvement; who were independently ambulatory with or without the use of walking aids were included. Individuals with:

1. Neurological conditions apart from stroke,
2. Any symptomatic musculoskeletal or cardiorespiratory conditions,
3. Uncorrected visual impairments,
4. Cognitive affection or
5. Vestibular dysfunctions

were excluded from participation.

All the subjects provided their informed consent. The procedures followed were in accordance with the ethical standards of the institutional review board.

Nadishodhana Pranayama is practiced by alternating the inhalation and exhalation between the left and the right nostrils, thus influencing the Ida and Pingala nadis and the two brain hemispheres [41]. This leads to control of the oscillations of the body – mind network, bringing balance and harmony throughout the system.

One round of Nadi Shodhana comprises of two complete breaths:

Breathing in through the left nostril, out through the right, then in through the right nostril and out through the left.

As a standard procedure, each round starts from the left nostril. 10 cycles and 3 sets of this practice was administered. The Inhalation:Exhalation (I:E) ratio maintained in this study was 1:1.

Technique 1: Preparatory practice

1. Sit in any comfortable position with the head and the spine erect.
2. Keep the whole body relaxed and close the eyes.
3. Practise slow diaphragmatic breathing with awareness at the nostrils for 5 minutes.
4. Adopt nasagra mudra with the right hand and place the left hand on the knee in chin or jnana mudra. In this study, subjects were allowed to use the normal hand for closing the nares and placing the paretic hand in a comfortable position. (Figures 1 and 2)
5. Inhale and exhale through the left nostril 5 times, keeping the respiratory rate normal. Be aware of each breath.
6. After completing 5 breaths release the pressure of the thumb on the right nostril and press the left nostril with the ring finger, blocking the flow of air.
7. This time, inhale and exhale through the right nostril 5 times, keeping the respiratory rate normal and being aware of each breath.
8. Lower the hand and breathe through both the nostrils together for 5 times.

Technique 2: Alternate nostril breathing

1. In this technique the basic pattern of alternate nostril breathing is established.

Figure 1: Participant taking the hand position for right nostril breathing.

Figure 2: Participant taking the hand position for left nostril breathing, which is altered in every cycle of the breathing technique.

2. Begin with equal inhalation and exhalation, keeping I:E ratio as 1:1.
3. Close the right nostril with the thumb and inhale through the left nostril for 5 counts till the inhalation ends comfortably. Breathe deeply without strain.
4. Close the left nostril with the ring finger and release the pressure of the thumb on the right nostril. While exhaling through the right nostril, simultaneously count for five. The length of inhalation and exhalation should be equal.
5. Next, inhale through the right nostril, keeping the same count in the same manner.
6. At the end of inhalation, close the right nostril and open the left nostril. Exhale through the left nostril, counting as before. This is one round.
7. 10 rounds of this is 1 set of Nadishodhana Pranayama.
8. A total of 3 sets were performed by the subject, interspersed by 1 minute of quite mindful breathing with the eyes closed.

The participant practised quiet mindful breathing for 1 minute after the practice of technique 2.

The timed up and go test

The participant was explained and demonstrated the task (Figures 3a and 3b), including instructions to rise from the sitting position, walk to the cone placed on the floor 3 metres away, turn, return and sit down [42].

The task comprised the following steps (Figure 4):

Figure 3a: Participating stroke patient commencing the TUGT with a sit-to-stand.

Figure 3b: Participant mid-way of the test, taking a turn around the cone marking 3 metres.

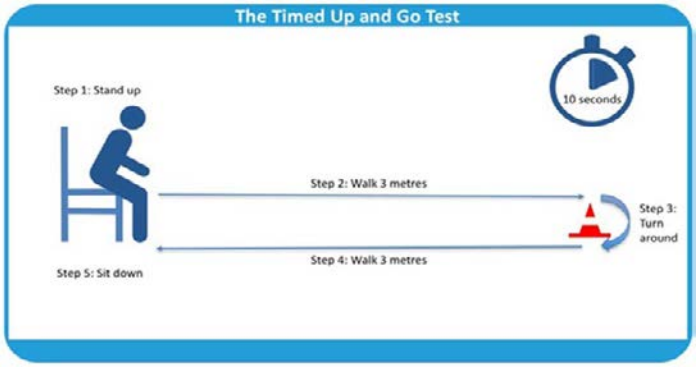

Figure 4: Diagrammatic representation of the timed up and go test performance in a step-wise manner.

1. Begin the test with the subject sitting correctly in the chair.
2. Timing of the assessment starts on the command "GO".
3. The timer is stopped when the subject is seated back in the starting position.

Notes on the performance of the TUG test:

- The participant was allowed to use his/her arms to stand up.
- The participant was instructed to walk at a comfortable and safe pace.
- The participant was allowed to use his/her usual walking aid and footwear.
- There was no time limit.
- The participant could stop and rest (but not sit down) if required.

If physical assistance was needed at any time during the assessment such as assisting the participant to stand up from the chair, stabilizing the participant in standing or when walking, the assessment was to be ceased. The time required to complete the task was recorded in seconds using a stopwatch. All the assessments and intervention was conducted by the same investigator. It was ensured that the pre and post- intervention assessment of TUGT took place in a similar manner. All the data thus collected was subjected to statistical analysis.

Sampling

The sample size was calculated based upon a pilot study that was conducted taking 5 participants who fitted the inclusion criteria, using BIOMATH.INFO. The calculated sample size required came to be n=13. Considering drop out from the participants, the final sample recruited was 20% more than the calculated value, i.e., 16 hemi paretic stroke patients. The sample population consisted of 11 males and 5 females with an average age of 51 ± 12.43 (mean ± S.D) years, suffering from hemiparesis post stroke for a mean of 2.1 ± 0.6 (mean ± S.D) years. The proportion of right sided paretic involvement was 33.33% and that of left side was 66.66% (Table 1).

STATISTICAL ANALYSIS AND RESULTS

The average TUGT time in seconds was 33.43 ± 19.56 before and 26.06 ± 20.69 after the practice of Nadishodhana Pranayama. P value was set at, 0.05 level of significance. The obtained data did not pass the normality test and thus, the Wilcoxon Signed Rank Test (WSRT), ($p<0.05$) was used for statistical analysis. The difference in TUGT after the intervention was found to be statistically significant ($p<0.0001$) supporting our research hypothesis (Figure 5 and Table 2).

DISCUSSION

Yoga is said to be a practice that aims at bringing about a balance and connection between our body, mind and soul [43]. It thus, lies in order to enquire and investigate the possible physiological effects brought about by it. Researchers in modern science have probed into the ancient Indian philosophy and confirmed or discovered various effects of yogic practices on human physiology and psychology. From the point of view of physical rehabilitation, integration of simple yogic practices which bring about a difference in the body's functional performance could be of colossal significance. Yoga may be especially effective in improving function post stroke, because it promotes coordination of multiplex movements, balance, strengthening and breathing [44]. Pranayama being a rather complex part of yoga, being

Table 1: Demographic characteristic of participants.

Sex (%)	Males	68.75
	Females	31.25
Age (years)	Mean	51.5
	S.D	12.19
Affected side (%)	Right	68.75
	Left	31.25
Duration of stroke (years)	Mean	2.1063
	S.D	0.591

Table 2: Average Pre and Post intervention scores for the TUGT and the statistical analysis of the obtained data.

Test		**TUGT (sec)**
Pre intervention	**Mean**	32.531
	SD	19.891
Post intervention	**Mean**	25.265
	SD	20.94
Statistical test		Wilcoxon signed rank test
P value		<0.0001
Interpretation		Significant

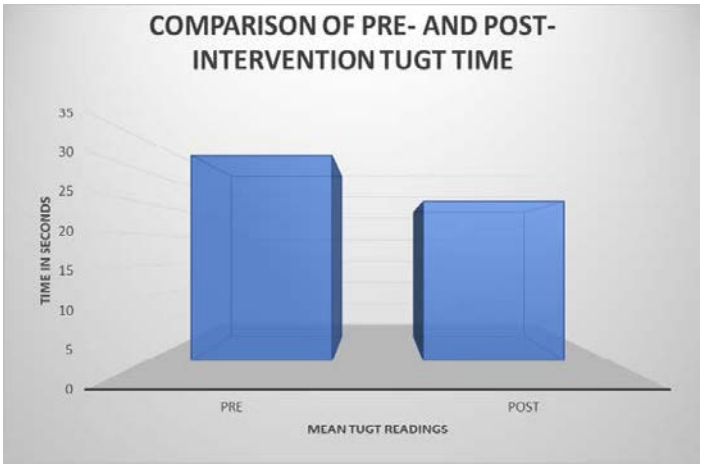

Figure 5: Comparison between the average TUGT readings obtained before and after practice of Nadishodhana Pranayama.

administered in precise dosage, the correct way, under the guidance and supervision of trained individuals could prove consequential in accelerating recovery and restoration of function. According to the traditional wisdom of yoga, pranayama is the key to bringing about psychosomatic integration and harmony [33]. Sharma et al. [30] observed a significant reduction in perceived stress and improvement in the following cognitive domains: attention, visuo-motor speed and memory retention capacity on administering both fast as well as slow Pranayamas. In her book "Yoga and Rehabilitation", Nilima Patel quotes the effects of Pranayamas on various systems of the body, including the neuromuscular, the musculoskeletal, the cardiovascular and respiratory systems [45]. In view of the inculcation of practise of pranayamas in physiotherapeutic stroke rehabilitation and in accordance with numerous other recent researches, this book particularly mentions that breathing in through one nostril stimulates the contralateral cerebral hemisphere along with increasing the awareness to carry out motor tasks. That Anuloma Viloma (rhythmic alternate nostril breathing) affects the basal ganglia, regulating the rate and rhythm of movements by balancing the synthesis of dopamine and acetyl choline. Also, that Pranayama facilitates spinal postural control, influencing the alpha motor neuron (that supplies skeletal muscle fibres) activity as they are responsible for postural adjustments and adaptations. Pranayamic exercises bring about an integration of involuntary (i.e., autonomic) nervous mechanisms geared towards postural tone and balance with higher cortical (i.e., central nervous) centres which are under voluntary control.

Research today has shown several effects, both immediate as well as long term, that Pranayama has on human functioning, especially on the central, peripheral and autonomic nervous systems, apart from its direct effects on the cardiovascular and respiratory systems [23]. In a study designed to determine whether or not uninostril and alternate nostril breathing brings about a change in the ability to react to a given stimulus immediately after practise, Telles et al. [25] established that right nostril yoga breathing facilitates the activity of contralateral (left) cerebral hemisphere, in the performance of the P300 task, thereby concluding that unilateral breathing stimulates the opposite side of the brain in real time. Pranayama practices stretch the lung tissue, producing inhibitory signals from action of slowly adapting receptors and hyperpolarising currents. These inhibitory signals coming from cardiorespiratory region involving the vagi are believed to synchronize neural elements in the brain leading to changes in the autonomic nervous system; and a resultant condition characterized by reduced metabolism and parasympathetic dominance [46].

The present study tries to reach further and learn what difference the culturally revered conscious control, modulation and expansion of the breath, that is Pranayama, makes to the performance of some of the most basic, necessary, fundamental and functional tasks like sit-to-stand, walking, turning-while-walking and stand-to-sit performed in tandem, the complexity of which is exponentially experienced by individuals with hemiparesis post stroke. The results obtained by us showed a mean reduction of 6.63 ± 2.77 (S.D) seconds, in the time taken for completing a round of 3 metres starting from a sitting position and ending the round back into the sitting position (as per the Timed Up and Go Test) after practising 30 cycles of Nadishodhana Pranayama with breaks and simple mindful breathing before and after, proved extremely significant statistically ($p<0.0001$). Although there are no evidences regarding an established Minimum Clinically Important Difference (MCID) for TUGT readings in stroke patients, a Minimal Detectable Change (MDC), that is, as established by Alghadir et al. [47] for this population is 2.9 seconds which has very evidently been surpassed by the average difference in TUGT time that we found immediately after the practise of Nadishodhana Pranayama. The TUGT comprises of a series of mobility components which, for a sound performance, require not only good dynamic balance, voluntary control and functional ambulatory ability, but also higher functions like reaction time, cognition, decision making and spatial memory recall. These mental functions may not be as crucial in bringing about ambulation in normal individuals, as they are for stroke patients, because of a comparatively better automaticity of movements. In stroke, disturbance of all of these functions, along with a depression in the activity of the affected side and compensatory overactivity of the normal side causes poor quality of functional mobility. Patients with stroke have been shown to have a particularly high risk and incidence of falls and consequently developing complications like fractures, at home as well as in rehabilitation settings [44]. Amongst the various factors contributing to falls, confusion and unsafe gait confinement have been found significant [48]. All of these factors cumulatively lead to loss of confidence and increased fear of falls and further to a reduced perceived health status and quality of life among stroke patients [49,50]. Several neuropsychological investigations have also demonstrated that walking relies on the use of several cognitive domains, including executive-attentional function, visuospatial abilities and even memory resources [51].

Studies have shown that yoga can improve health status and quality of life in various psychological, musculoskeletal and neurological disorders [52-54]. There has been a great rise in the popularity and practise of alternative therapeutic and wellness practices like yoga worldwide in the recent years. These differences thus present a further scope in evaluating improvements in much versatile functional performances of those afflicted by disabling conditions like stroke, brought about by yogic breathing. We attribute these results to have been brought about by the immediate effect that breathing-in through a single nostril might have on the brain, positively altering the reaction time, spatial memory–registration as well as recall, a probable increase in the parasympathetic tone and a cognitive alertness yet physiological calmness, as proven in numerous studies, all of which are likely to play vital roles in performing said activity [23,44,49,50]. Yet, our knowledge of what physiological effects exactly do Pranayamas have in order to elicit such gross modifications in the clinical picture of body functioning remains limited. There is hence, scope to research further on a variety of yogic techniques with respect to their application in disability rehabilitation. The rather small size of the population considered in this study was one of the shortcomings faced, with respect to the extensive prevalence of stroke in the Indian population today. Also, a more objective and critical outcome measure could be instrumental in bringing about an accurate and more precise information about the parameters that are improved immediately after the intervention.

Furthermore, a similar study could be carried out using tests covering a larger distance, monitoring the gait parameters as well as cardiovascular and respiratory variables, since literature has

shown Pranayamas to be affecting the physiology of these systems significantly. Along with that how long the effects of Nadishodhana Pranayama administered as an acute intervention lasts can be observed.

CONCLUSION

From the results obtained in the present study, we conclude that the practice of Nadishodhana Pranayama significantly improves the performance of a functional mobility task in stroke patients immediately.

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CONFLICT OF INTEREST

The authors hereby declare that there are no conflicts of interest.

REFERENCES

1. Johnson W, Onuma O, Owolabi M, Sachdev S. Stroke: A global response is needed. Bull World Health Organ. 2016;94(9):634-634A.
2. Kamalakannan S, Gudlavalleti ASV, Gudlavalleti VSM, Goenka S, Kuper H. Incidence & prevalence of stroke in India: A systematic review. Indian J Med Res. 2017;146(2):175-185.
3. Shah S. API Textbook of Medicine. 8th edition. Mumbai: The Association of Physicians of India. 2009;Pp:1154.
4. Forhan M, Gill SV. Obesity, functional mobility and quality of life. Best Pract Res Clin Endocrinol Metab. 2013;27(2):129-137.
5. Duval K, Luttin K, Lam T. Neuromuscular strategies in the paretic leg during curved walking in individuals post-stroke. J Neurophysiol. 2011;106(1):280-290.
6. Hollands KL, Hollands MA, Zietz D, Wing AM, Wright C, van Vliet P. Kinematics of turning 180° during the timed up and go in stroke survivors with and without falls history. Neurorehabil Neural Repair. 2010;24(4):358-367.
7. Manaf H, Justine M, Omar M, Md Isa KA, Salleh Z. Turning ability in stroke survivors: A review of literature. ISRN Rehabil. 2012;284924:1-8.
8. Courtine G, Schieppati M. Human walking along a curved path. I. Body trajectory, segment orientation and the effect of vision. Eur J Neurosci. 2003;18(1):177-190.
9. Chan WN, Tsang WW. The performance of stroke survivors in turning-while-walking while carrying out a concurrent cognitive task compared with controls. PLoS ONE. 2017;12(12):e0189800.
10. Hollands KL, Pelton T, Wimperis A, Whitham D, Jowett S, Sackley C, et al. Visual cue training to improve walking and turning after stroke: A study protocol for a multi-centre, single blind randomised pilot trial. Trials. 2013;14:276.
11. Mercer VS, Freburger JK, Chang SH, Purser JL. Measurement of paretic-lower-extremity loading and weight transfer after stroke. Phys Ther. 2009;89(7):653-664.
12. Adegoke BOA, Olaniyi O, Akosile CO. Weight bearing asymmetry and functional ambulation performance in stroke survivors. Glob J Health Sci. 2012;4(2)87-94.
13. Shumway-cook A, Woollacott M. Motor control: Translating research into clinical practise. 3rd Edition. Philadelphia. Pa: Lippincott Williams & Wilkins. 2007.
14. Mooventhan A, Nivethitha L. Evidence based effects of yoga in neurological disorders. J Clin Neurosci. 2017;43:61-67.
15. Strzemecka J. Music therapy in stroke rehabilitation. J Pre Clin Clin Res. 2013;7(1):23-26.
16. Lee JH, Seo EK, Shim JS, Chung SP. The effects of aroma massage and foot bath on psychophysiological response in stroke patients. J Phys Ther Sci. 2017;29(8):1292-1296.
17. Shin BC, Lee MS. Effects of aromatherapy acupressure on hemiplegic shoulder pain and motor power in stroke patients: A pilot study. J Altern Complement Med. 2017;13(2):247-251.
18. Lyu D, Lyu X, Zhang Y, Ren Y, Yang F, Zhou L, et al. Tai Chi for stroke rehabilitation: A systematic review and meta-analysis of randomized controlled trials. Front Physiol. 2018;9:983.
19. Kongkasuwan R, Voraakhom K, Pisolayabutra P, Maneechai P, Boonin J, Kuptniratsaikul V. Creative art therapy to enhance rehabilitation for stroke patients: A randomized controlled trial. Clin Rehabil. 2015;30(10):1016-1023.
20. Lo TLT, Lee JLC, Ho RTH. Creative arts-based therapies for stroke survivors: A qualitative systematic review. Front Psychol. 2018;9:1646.
21. www.ayush.gov.in/about-the-systems/yoga/definition-yoga
22. Yogendra J, Yogendra H. Yogasutras of Patanjali, 1st Edition. Mumbai: Zen Publications. The Eightfold path, 2017;Pp:518.
23. Ghiya S. Alternate nostril breathing: A systematic review of clinical trials. Int J Res Med Sci. 2017;5(8):3273-3286.
24. Singh K, Bhargav H, Srinivasan TM. Effect of uninostril yoga breathing on brain haemodynamics: A functional near-infrared spectroscopy study. Int J Yoga. 2016;9(1):12-19.
25. Telles S, Joshi M, Somvanshi P. Yoga breathing through a particular nostril is associated with contralateral event-related potential changes. Int J Yoga. 2012;5(2):102-107.
26. Telles S, Nagarathna R, Nagendra HR. Breathing through a particular nostril can alter metabolism and autonomic activities. Indian J Physiol Pharmacol. 1994;38(2):133-137.
27. Jella SA, Shannahoff-Khalsa DS. The effects of unilateral forced nostril breathing on cognitive performance. Int J Neurosci. 1993;73(1-2):61-68.
28. Werntz DA, Bickford RG, Shannahoff-Khalsa D. Selective hemispheric stimulation by unilateral forced nostril breathing. Hum Neurobiol. 1987;6(3):165-171.
29. Stancak A Jr, Kuna M. EEG changes during forced alternate nostril breathing. Int J Psychophysiol. 1994;18(1):75-79.
30. Sharma VK, Manivel R, Subramaniyam V, Subramanian SK, Bhavanani AB, Madanmohan, et al. Effect of fast and slow pranayama practice on cognitive functions in healthy volunteers. J Clin Diagn Res. 2014;8(1):10-13.
31. Garg R, Malhotra V, Tripathi Y, Agarawal R. Effect of left, right and alternate nostril breathing on verbal and spatial memory. J Clin Diagn Res. 2016;10(2): CC01-CC03.
32. Telles S, Gupta R, Yadav A, Pathak S, Balkrishna A. Hemisphere specific EEG related to alternate nostril yoga breathing. BMC Res Notes. 2017;10:306.
33. Bhavanani AB, Ramanathan M, Balaji R, Pushpa D. Differential effects of uninostril and alternate nostril pranayamas on cardiovascular parameters and reaction time. Int J Yoga. 2014;7(1):60-65.

34. Naveen KV, Nagarathna R, Nagendra HR, Telles S. Yoga breathing through a particular nostril increases spatial memory scores without lateralized effects. Psychol Rep. 1997;81(2):555-561.

35. Subbalakshmi NK, Saxena SK, D'Souza UJA. Immediate effect of 'Nadi-Shodhana Pranayama' on some selected parameters of cardiovascular, pulmonary, and higher functions of brain. Thai J Physiol Sci. 2005;18(2):10-16.

36. Yadav G, Mutha PK. Deep breathing practice facilitates retention of newly learned motor skills. Scientific Reports. 2016;6:37069.

37. Malhotra V, Goel N, Dhar U, Garg R, Tripathi Y. Comparison of mind control techniques: An assessment of reaction times. Bangladesh J Med Sci. 2016;15(4):596-600.

38. Trakroo M., Bhavanani AB, Pal G, Udupa K, Krishnamurthy N. A comparative study of the effects of asan, pranayama and asan-pranayama training on neurological and neuromuscular functions of Pondicherry police trainees. Int J Yoga. 2013;6(2): 96-103.

39. Desai R, Tailor A, Bhatt T. Effects of yoga on brain waves and structural activation: A review. Complement Ther Clin Pract. 2015;21(2):112-118.

40. Chan PP, Si Tou JI, Tse MM, Ng SS. The reliability and validity of the timed up and go motor task for people with chronic stroke. Arch Phys Med Rehabil. 2017;98(11):2213-2220.

41. Sukhadia D. Pranayama: Breathing is life. Techniques of yogic breathing. 1st Edition. Mumbai: Nirman Impresse Pvt. Ltd. Nadi Shodhana Pranayama. 2018;p:28.

42. https://www.health.qld.gov.au/__data/assets/pdf_file/0029/675119/S-MT03.pdf

43. Lazaridou A, Philbrook P, Tzika AA. Yoga and mindfulness as therapeutic interventions for stroke rehabilitation: A systematic review. Evid Based Complement Alternat Med. 2013;357108:9.

44. Schmid AA, Van Puymbroeck M, Altenburger PA, Schalk NL, Dierks TA, et al. poststroke balance improves with yoga: A pilot study. Stroke. 2012;43(9):2402-2407.

45. Patel N. Yoga and Rehabilitation. 1st Edition. Delhi: Jaypee Brothers Medical Publishers (P) Ltd. 2008.

46. Jerath R, Edry J, Barnes VA, Jerath V. Physiology of long Pranayamic breathing: Neural respiratory elements may provide a mechanism that explains how slow deep breathing shifts the autonomic nervous system. Med Hypotheses. 2006;67(3):566-571.

47. Alghadir AH, Al-Eisa ES, Anwer S, Sarkar B. Reliability, validity and responsiveness of three scales for measuring balance in patients with chronic stroke. BMC Neurol. 2018;18(1):141.

48. Teasell R, McRae M, Foley N, Bhardwaj A. The incidence and consequences of falls in stroke patients during inpatient rehabilitation: Factors associated with high risk. Arch Phys Med Rehabil. 2002;83(3):329-333.

49. Visschedijk JHM, Caljouw MAA, Bakkers E, van Balen R, Achterberg WP. Longitudinal follow-up study on fear of falling during and after rehabilitation in skilled nursing facilities. BMC Geriatr. 2015;15:161.

50. Kim EJ, Kim DY, Kim WH, Lee KL, Yoon YH, et al. Fear of falling in subacute hemiplegic stroke patients: Associating factors and correlations with quality of life. Ann Rehabil Med. 2012;36(6):797-803.

51. Amboni M, Barone P, Hausdorff JM. Cognitive contributions to gait and falls: Evidence and implications. Mov Disord. 2013L;28(11):1520-1533.

52. Lynton H, Kligler B, Shiflett S. Yoga in stroke rehabilitation: A systematic review and results of a pilot study. Top Stroke Rehabil. 2007;14(4):1-8.

53. Bastille JV, Gill-Body KM. A yoga-based exercise program for people with chronic poststroke hemiparesis. Phys Ther. 2004;84(1):33-48.

54. Field T. Yoga clinical research review. Complement Ther Clin Pract. 2011;17(1):1-8.