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Effects of stroke on diaphragm in chronic stroke individuals

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Abstract:.

*Objective :*To evaluate the effect of stroke on diaphragm in chronic stroke individuals

Method : A systemic review of observational,cross sectional and case series was performed.

SCOPUS, Google schola, EBSCO and PubMed were searched using the terms respiratory muscle strength and trunk control and stroke.Preferred reporting items for scoping review, PRISMA,CASP-systemic review checklist was used to examine the section of each report.

Result: A total of 52 studies were identified of which 14 were copyright hence excluded and 9 were full text reviews hence were included.

Conclusion: In our study we have found that their is reduced diaphragm thickness, reduced mobility and reduced excursion of diaphragm in the affected side hemidiaphragm in chronic stroke individuals,all the studies are based on ultrasonographic or radioscopic findings,also in the studies which focused on pulmonary function test it was found that stroke patients had poor results in respiratory capacities.

Index Terms : stroke,diaphragm, diaphragm thickness,changes in diaphragm after stroke

I. INTRODUCTION

The diaphragm is the major respiratory muscle, contributing up to 70% to resting lung ventilation. Since the diaphragm has a major role in respiration, knowledge of the effects of stroke on diaphragmatic function is important for the rehabilitation of hemiplegic patients.[1]

Control of the diaphragm occurs via two major descending pathways: the corticospinal pathway from the cortex to the respiratory motor neurons, which is responsible for voluntary breathing; and the bulbospinal pathway, which descends from the medulla through the ventrolateral quadrant of the spinal cord to the respiratory motor neurons and controls automatic breathing. There is also a putative connection between the motor cortex and the pontomedullary respiratory centers [2-4] .

Because of the complexity of diaphragmatic motor control, the effect of stroke on diaphragmatic motion is controversial. Houston et al. [5] suggested that a significant bilateral reduction in diaphragmatic motion occurs during deep breathing. However, Cohen et al. [6] proposed a significant decrease in diaphragmatic excursion on the hemiplegic side during volitional breathing compared to that of automatic breathing.[6]

The diaphragm can stabilize the trunk and spine during activities [7]. One study investigated the effects of diaphragm training on balance ability in subjects with hemiplegia due to stroke 8 and found that diaphragm training could lead to improved static stability and dynamic Brain Sci. **2022**, 12, 882 3 of 15 balance [9]. However, balance impairment was associated with reduced strength [10].Although certain studies have demonstrated that there is a relationship between diaphragm and pulmonary function [11], swallowing function [12], trunk control [13], and respiratory muscular strength, no study has been done which reviews on the effect of stroke on diaphragm of chronic stroke individuals.

Hence in this study we will be focusing on reviewing articles which have addressed the effect of stroke or documented the changes in diaphragm of chronic stroke individuals.

II. METHODOLOGY

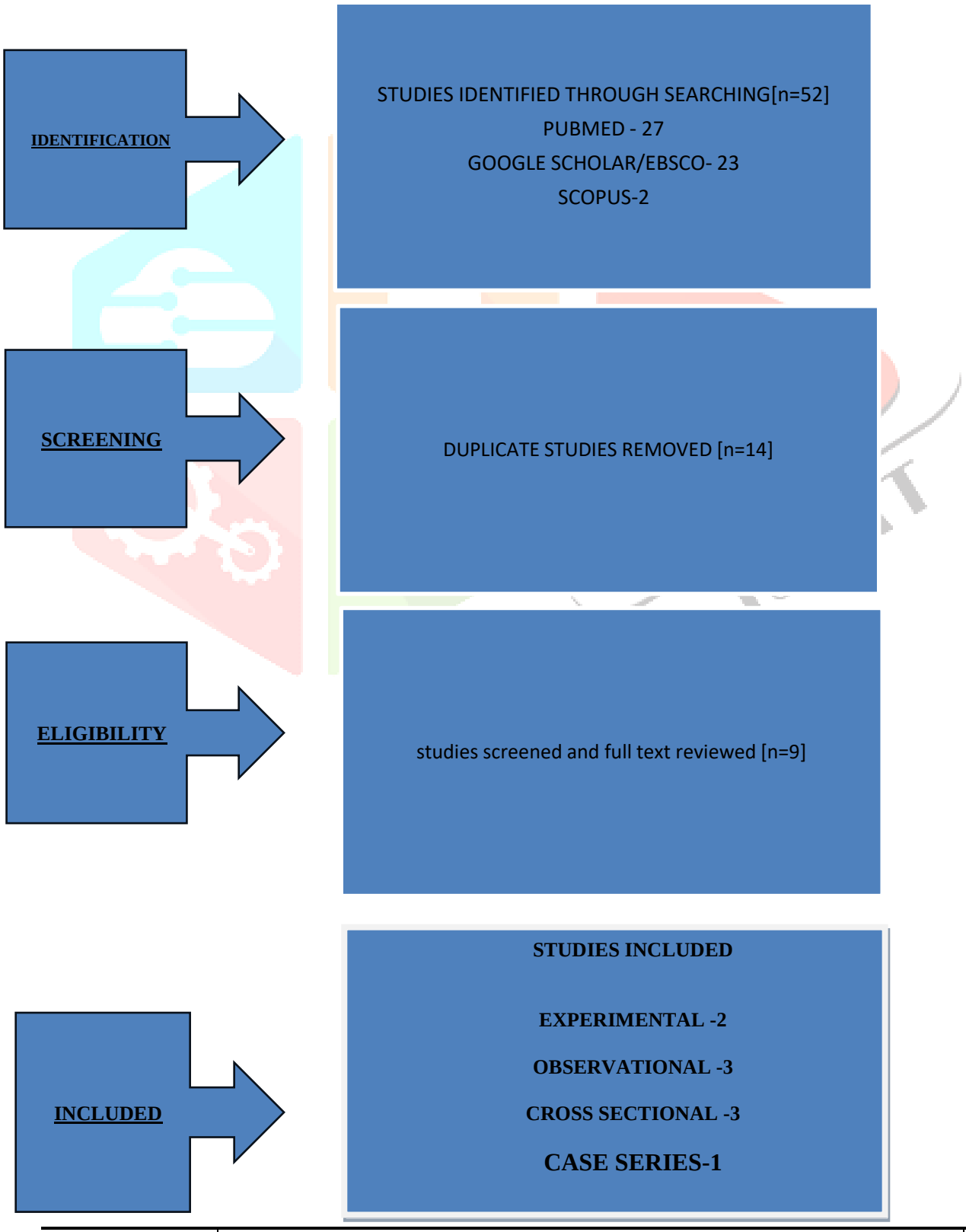
AIM: To see the changes recorded in diaphragm of chronic stroke individuals

Search strategies- The first researcher conducted a limited research in Pub Medd and Google Scholar database between April and may 2023 using following terms- stroke and diaphragm, diaphragm thickness in stroke, from this searches , studies were identified and screened for other relevant searches.

In addition the ;all observational studies e.g; correlational,cohort case—control ,and cross-sectional studies or studies done using experimental design, related to diaphragm thickness, hemidiaphram in stroke individuals .

Screening and data extraction
Selection criteria were set to identify the studies with a relation to changes in diaphragm after stroke

Ethical consideration
This review included inly the summary data and or statistics from previously published studies ,therefore , this study did not require a review or approval by institutional review board.



TABULATION OF STUDIES

Sr. no	Author	Title	Inclusion criteria	Outcome measures	Results	Analysis
1.	Eytan Cohen, Anne Mier, Peter Heywood, Kevin Murphy, Joe Boultbee, Abraham Guz	Diaphragmatic movement in hemiplegic patients measured by ultrasonography	(1) dense hemiplegia involving both arm and leg with a unilateral lesion above the brain stem demonstrated by computed tomographic scanning; (2) absence of chest disease on medical history, physical examination and chest radiography; and (3) the ability to take a volitional breath to command.	1. M mode ultrasonography 2. 2.Respiratory air flow measurement	In the control subjects no significant difference in diaphragmatic excursion was found between volitional and automatic breathing for the same range of inspired volume. By contrast, there was a significant decrease in diaphragmatic excursion during volitional breathing compared with automatic breathing on the affected side in four of the eight hemiplegic patients.	In four of eight hemiplegic patients reduced diaphragmatic movement was present on the paralysed side during volitional inspiration when compared with automatic inspiration. The hemidiaphragm may be involved on the affected side in patients with hemiplegia.
2.	Mckelden Smith	The effect of hemiplegia on the diaphragm	Case series was performed on patients having radiographs and were admitted in the the hospital for same		9 cases of left hemiplegia, the left diaphragm averaged only 1.4 mm. lower. This difference between the two groups is consistent with the possibility that the diaphragm may sometimes be involved in hemiplegia	In this very small series of cases there is suggestive evidence that the diaphragm may be involved in some cases of hemiplegia. This involvement could result from a lesion involving the corticobulbar pathways in the internal capsule if the decussation of th ese pathways happ ened to be nearl y complete-a situation which in some subjectsis found in other corticobulbar fibers, e.g., tho se destined for the frontalis muscles
3.	Amos d. Korczyn, 977nnerv 977nnerva, and ruth don	Diaphragmatic involvement in hemiplegia And hemiparesis	Stroke patients admitted in the hospital and have undergone radiological findings	1.radiographs	In the 100 control radiographs, Both hemidiaphragms were at the same level in 61. In 23, the right hemidiaphragm was significantly Higher; in 16 there was a relative elevation of The left hemidiaphragm. The difference between Elevation of the right and left hemidiaphragm in This control group is not statistically significant	In hemiplegia unilateral elevation of the Corresponding hemidiaphragm exists more frequently Than could be ascribed to chance alone. The left hemidiaphragm is involved in left hemiplegia Much more frequently than the right hemidiaphragm In right hemiplegia. This may be due to Asymmetry of representation: whereas the left hemidiaphragm Is represented mainly in the right Motor cortex, the right hemidiaphragm derives

					(P >0.1, X2 = 1 26). However, there is a tendency For the right hemidiaphragm to be elevated more Frequently than the left.	Corticospinal efferents from both hemispheres of the brain.
4.	Joan santamaria,carlos riatz	Diaphragmatic elevation in stroke	Hemiplegic stroke patients admitted recoded with supratentorial hematoma or middle cerebral artery infarction	X RAY	Difference between height of two diaphragm was 7.1+- 13.6 in control group{rt diaphragm was 7.1 mm higher than the left .	Patients with severe hemiperesis or lesion larger than 40 ml exhibited an excessive elevation of the diaphragm of paretic side compared with controls. This finding was more comman in lesin involving the genu of internal capsule or near anterolateral area.
5.	**Minkyu Kim , Kyeongbong Lee, Jieun Cho , Wanhee Lee**	Diaphragm Thickness and Inspiratory Muscle Functions in Chronic Stroke Patients	no history of cardiovascular or respiratory problems, first episode of unilateral stroke with hemiparesis during the previous six months, mini mental status evaluation score ³24, no facial palsy, no recep- tive aphasia, and no prior thoracic or abdominal surgery	1,B mode ultrasonography 2. inspiratory muscle function test	In stroke patients, the diaphragm was significantly thinner on the affected side than the less affected side at end expiration and at TLC. The change between the thickness at end expiration and at TLC were also significant on both sides. Between	Stroke patients showed decreases in the thickening ability of the diaphragm at TLC and in inspiratory muscle function. The change between the diaphragm thickness at end expiration and at TLC was positively correlated with MIP, PIF, and VC.
6.	Thomas similowski, martin catala, 978nnerv rancurel., and jean-phiuppe derenne	Impairment of Central Motor Condudion to the Diaphragm in Stroke	patients with ischemic stroke (Group I), (Tables I and 2) were prospectively included in the study.	1.electromyogra phy 2. chest radiographs	PNS was possible in all but four cases (three subjects from Group II and one subject from Group III) (Table 1). In these subjects, CMS was associated with a typical motor response on both sides, ascertaining that the absence of response to PNS was due to technical difficulties rather than to lesions in the nerves. Phrenic nerve conduction time never exceeded 9.6 ms with a right to left difference below 2 ms. The velocity of median nerve conduction was normal in all cases	Diaphragm contraction in response to cortical stimulation can be abolished or markedly delayed on the plegic side in some patients with ischemic stroke. This supports impairment of the voluntary aspect of diaphragm control in this setting. In addition, complete absence of response of the diaphragm contralateral to the cerebral lesion in patients with flaccid capsular hemiplegia suggests that motor cortical representation of the human diaphragm is unilateral.

					(> 45 *m/s*). Phrenic and median nerves conduction velocities were significantly faster in Group III than in the other groups. This probably accords with the decrease of peripheral nerve conduction velocity observed with age	
7.	Kang-Jae Jung, MD, Ji-Young Park, MD, Do-Won Hwang, MD, Jeong-Hawn Kim, MD, Jae-Hyung Kim, MD, PhD	Ultrasonographic Diaphragmatic Motion Analysis and Its Correlation With Pulmonary Function in Hemiplegic Stroke Patients	Ten stroke patients (eight men and two women; mean age, 59.7±12.9 years) who were within 4 weeks after onset were recruited. Four patients had right-sided hemiplegia, and six had left-sided hemiplegia. Only patients with a first monohemispheric stroke above the brain stem, as documented via computed tomography or magnetic resonance imaging, were included	1.B-mode ultrasonography 2. pulmonary function test	All stroke patients had restrictive pulmonary dysfunction. Compared to that exhibited by control subjects, stroke patients exhibited a significant unilateral reduction in motion on the hemiplegic side, primarily during volitional breathing. Diaphragmatic excursion in right-hemiplegic patients was reduced on both sides compared to that in control subjects. However, diaphragmatic excursion was reduced only on the left side and increased on the right side in left-hemiplegic patients compared to that in control subjects. Left diaphragmatic motion during deep breathing correlated positively with forced vital capacity (rho=0.86, p=0.007) and forced expiratory volume in 1 second (rho=0.79, p=0.021).	Reductions in diaphragmatic motion and pulmonary function can occur in stroke patients. Thus, this should be assessed prior to the initiation of rehabilitation therapy, and M-mode ultrasonography can be used for this purpose. It is a non-invasive method providing quantitative information that is correlated with pulmonary function
8.	Xiaoman Liu Qingming Qu ,Panmo Deng , Yuehua Zhao , Chenghong Liu , Conghui Fu and Jie Jia	Assessment of Diaphragm in Hemiplegic Patients after Stroke with Ultrasound and Its Correlation of Extremity Motor and Balance Function	1.A radiological and clinically diagnosis of ischemic or hemorrhagic stroke within 1–6 months from the onset, 2. between 30 and 80 years old, 3. unilateral	1.Fugl–MeyerMotor Function Assessment Scale (FMA Scale), 2. Berg Balance Scale . 3.ultrasonography	The thickness fraction of hemiplegic side was extremely diminished when contrasted with the healthy control and non-hemiplegic side ($p < 0.05$). We respectively compared the diaphragm mobility	The mobility and thickness fraction of the hemiplegic diaphragm after stroke by diaphragm ultrasonography were significantly reduced during deep breathing. Diaphragm mobility on bilateral sides of the right hemiplegia patients were reduced

			hemiplegia, and 4.good listening comprehension and can follow instructions		under deep breath on the hemiplegic and non-hemiplegic side of patients with left and right hemiplegia and found there was no significant difference between the hemiplegic side of right and left hemiplegia ($p > 0.05$), but the non-hemiplegic side of right hemiplegia was significantly weaker than that of left hemiplegia patients ($p < 0.05$). The diaphragm mobility of stroke patients under quiet breath was positively correlated with age and FMA Scale score ($R2 = 0.296$, $p < 0.05$), and significant positive correlations were found between the diaphragm mobility under deep breath and Berg Balance Scale score ($R2 = 0.11$, $p < 0.05$), diaphragm thickness at end-inspiratory and FMA Scale score ($R2 = 0.152$, $p < 0.05$), and end-expiratory thickness and FMA Scale score ($R2 = 0.204$, $p < 0.05$).	during deep breathing. Moreov The hemiplegic diaphragmatic function was positively correlated with extremity motor and balance function of the hemiplegia patients.
9.	Voyvoda, md, c yu¨ cel, md, G Karatas¸ , md, I˙ Og˘ Uzu¨ Lgen, md and S Oktar, md	An evaluation of diaphragmatic movements in hemiplegic patients	Volunteer patients who were diagnosed with a stroke and who had had an ischaemic cerebrovascular attack associated with a single hemisphere were selected for the study in accordance with criteria set by the World Health Organization.	1.Ultrasonography 2.Lung function test	When a comparison was made between the right hemiplegic group and the control group and between the left hemiplegic group and the control group in terms of diaphragmatic excursions, for both groups, no significant difference was determined between the movements of the right hemidiaphragm during spontaneous and	The diaphragm is both contralaterally innervated and ipsilaterally innervated, and 980nnervations exhibits marked variations from person to person. This provides an explanation for varying diaphragmatic movements in hemiplegic cases during deep respiration

					deep breathing and those of the left hemidiaphragm in spontaneous respiration. In contrast, for both hemiplegic groups, a significant decrease was noted in the movements of the left hemidiaphragm in deep respiration.	

III. DISCUSSION

The purpose of this study was to find out the effect of stroke on diaphragm in patients.In this review we have included 9 studies which report the different types of changes which are cause due to stroke. Eytan Cohen et al, in their study diaphragmatic movement in hemiplegic patients measured by ultrasonography concluded that their was reduced diaphragmatic movements on paralysed side during volitional inspiration.[15] also Amos d.,et al, in his study found that there is significant elevation of affected hemidiaphragm.it said that in hemiplegia unilateral elevation of the corresponding hemidiaphragm exists more frequently than could be ascribed to chance alone.The left hemidiaphragm is involved in left hemiplegia much more frequently than the right hemidiaphragm. In right hemiplegia. this may be due to asymmetry of representation: whereas the left hemidiaphragm is represented mainly in the right motor cortex, the right hemidiaphragm derives corticospinal efferents from both hemispheres of the brain[16].same suggestive findings were given by Joan Santamaria,Carlos Riatz in which they found that their were respiratory complications other than bronchial persection in 4 patients , unilateral pneumonia , ipsilateral to the paretic side was found in 3 cases.2 of them had extensive MCA infraction with severe hemiparesis . these 3 patients also had excessive relative elevation of diaphragm on the paretic side . they concluded study stating that Patients with severe hemiperesis or lesion larger than 40 ml exhibited an excessive elevation of the diaphragm of paretic side compared with controls. This finding was more comman in lesin involving the genu of internal capsule or near anterolateral area[17].

Other studies done with the outcome measure of ultrasonography found that there were changes in thickness of the diaphragm in stroke patients. **Minkyu Kim et al , in his research** Diaphragm Thickness and Inspiratory Muscle Functions in Chronic Stroke Patients took forty-five stroke patients and 49 healthy volunteers were included in this study. Diaphragm thickness was measured at end expiration and at TLC by ultrasonography. The maximal inspiratory pressure (MIP), peak inspiratory flow (PIF), vital capacity (VC), and inspiratory muscle endurance (IME) were assessed to evaluate inspiratory muscle function.in which they found that the diaphragm was significantly thinner on the affected side than the less affected side at end expiration and at TLC. The change between the thickness at end expiration and at TLC were also significant on both sides. Between groups, the difference in diaphragm thickness at end expiration was not significant, but at TLC, the diaphragms were significantly thicker in healthy individuals than on either side in stroke patients, and the change in diaphragm thickness was significantly greater for healthy individuals. Inspiratory muscle functions were also significantly greater in healthy individuals. MIP, PIF, and VC were positively correlated with the change in thickness in healthy individuals, and MIP was positively correlated with the change in thickness and IME in stroke patients.hence they concluded that Stroke patients showed decreases in the thickening ability of the diaphragm at TLC and in inspiratory muscle function. The change between the diaphragm thickness at end expiration and at TLC was positively correlated with MIP, PIF, and VC.[18]

Hence this study gave a strong evidence of changes in thickness of diaphragm , mobility and delayed response of diaphragm on the affected side in 2 of the studies reviewed we have found that pulmonary function test was also performed and the readings got from patients were suggestive of reduced pulmonary function .

IV. CONCLUSION

We concluded this review by emphasizing that there are not much studies done targeting the diaphragm in stroke patients, which eventually leads to detoriaration of the patients along with reduced exercise tolerance reduced thickening ability and also reduced mobility of the diaphragm. This highlights the need for more such studies which are based on fnding out the changes in diaphragm of stroke patients and its effect in their daily living activities , also this is driving our focus on setting the treatment protocol to maintain or improve the condition of diaphragm

V. CLINICAL IMPLICATION

- As it was found that most of the female bharatnattyam dancers were having increased lumbar lordosis which may lead to back pain in later life, to avoid that exercises can be given to the dancers during their warm up.
- People having affected dynamic balance can be adviced to join bharatnnatyam classes as it will help them improve balance.

VI. LIMITATION OF STUDY

Study was conducted covering a small number of studies only.

VII. RECOMENDATION AND FUTURE SCOPE OF STUDY

- A detailed study can be done for emphasizing on the diaphragm conditions in stroke individuals .
- Also other studies can be conducted for studying the diaphragmatic conditions in different neurological diseases.

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