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REVIEW
ОБЗОРНАЯ СТАТЬЯ

Impact of yoga on cognitive functions among chronic obstructive pulmonary disease patients

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Abstract. *Relevance.* Chronic Obstructive Pulmonary Disease (COPD), due to its chronic and progressive nature, affects multiple organs in the body due to its complex pathophysiology. A hypoxic effect on the brain due to COPD directly leads to nerve damage, followed by impaired cognitive functions. The cognitive impairment not only affects the physical function and health status but also aggravates mortality and disability in COPD patients. According to the literature, some modifiable factors, such as physical activity, balanced diet, cognitive training, and social engagement, can be improved to benefit patients with COPD who have presented evidence of cognitive impairment. Yoga training improves lung function and exercise capacity and could be used as an adjunct pulmonary rehabilitation program for COPD patients. Yoga entails pranayama and asana, two yoga practices that work together to keep the body and mind stable. *Materials and Methods.* The following electronic databases were searched: Pub Med, Embase, Cochrane Central Register of Controlled Trials, Google Scholar, Scopus, and Science Direct. Irrelevant studies were excluded in this review article. The employed keywords «yoga» and «COPD,» yoga and pulmonary disease, or «yoga» and «cognition,» or «COPD» and «cognitive decline», or COPD and cognitive impairment were typed in titles and abstracts. *Results and Discussion.* Chronic and progressive airway obstruction present in COPD could enhance the adverse hypoxic effect on the brain. Yoga improves breathing by causing bronchodilation that efficiently enhances the perfusion of many alveoli. Research shows that yoga intervention activates the central nervous system and helps improve cognitive functions. *Conclusion.* According to our review of different articles there are many environmental, genetic and behavioral factors which increases the risk of COPD in general population. Basic pathophysiology of COPD is chronic inflammation of airways which leads to multiple comorbidities. COPD itself causing hypoxia to multiple organs including brain and with other mechanism related to its comorbidities causes impairment of cognitive functions. Beside pharmacological treatment early stage involvement of non-pharmacological factors like yoga, Exercise, life style modification, cessation of smoking may be beneficial to these patients in decreasing the progression of disease and reducing the development of comorbidities. Based on available searched literature, there is a strong relationship between COPD and cognitive impairment, COPD and yoga, cognition and yoga.

Keywords: COPD, chronic obstructive pulmonary disease, cognitive functions, yoga

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Introduction

The 2023 Global Initiative for Chronic Obstructive Pulmonary Disease or GOLD report defines COPD as «a heterogeneous lung condition characterized by chronic respiratory symptoms (dyspnoea, cough, expectoration, exacerbation) due to abnormalities of the airways (bronchitis, bronchiolitis) and alveoli (emphysema) that cause persistent, often progressive, airflow obstruction [1]. The clinical symptoms of excessive cough and sputum production are characteristic features of Chronic bronchitis, in Emphysema, enlarged air spaces and destruction of lung tissue lead to chronic dyspnoea. A wide range of comorbidities and risk factors are associated with the disease, including genetics, smoking, infections, malnutrition, aging, occupational exposures, indoor and outdoor air pollutants, asthma, and low socioeconomic status.

According to a cohort study by Charles Fletcher and Richard Peto, a continuous slow decline in Forced Expiratory Volume in one second (FEV1) accelerates with aging and in smokers rather than nonsmokers. Nonsmokers have a slow decrease in FEV1 but never develop airflow obstruction; nonsusceptible smokers have FEV1 decline like nonsmokers, and susceptible smokers have a more rapid FEV1 decline, which progresses to airflow obstruction and eventually disability and death [2].

COPD is a complex multi-component disorder associated with many psychological and social issues that are frequently related to multiple comorbidities, such as cardiovascular disease, anemia, osteoporosis, and other extra-pulmonary manifestations [3].

According to WHO Global Health Estimates 2019, it is the third leading cause of death worldwide and the second most prevalent cause of death after road traffic accidents in India as well. Jindal S K with colleagues, in a large, multicentric study from India, the population prevalence of COPD was 4.1 % with a male-to-female ratio of 1.56:1 [4].

Global Initiative for Chronic Obstructive Lung Disease, 2020, stated that the average prevalence of cognitive impairment in COPD is 32 % [5].

The word cognition is the mental action or intellectual process of acquiring, understanding, and using knowledge or information through thinking, experience, and the senses, by which human behavior can be adapted to new situations and/ or preferences changed. Cognition involves different cognitive processes divided into six essential neuropsychological domains: learning and memory, visuospatial and motor function, attention/concentration, language, social cognition/emotions, and executive functions.

Each domain contains specific functions that provide individuals with basic and more complex capabilities that determine personal intellectual skills and knowledge [6–8].

Studies have found that the mortality rate of elderly COPD patients with cognitive impairment is nearly three times higher than that of elderly patients with cognitive impairment or COPD.

Yoga is usually considered a form of physical exercise, but it also has a deeply meditative and spiritual part. Postures and breathing exercises help the mind to be still for meditation. Yoga entails pranayama and asana, two yoga practices that work together to keep the body and mind stable. Yoga has been demonstrated to produce long-lasting alterations in the body. Yogic asana and pranayama have been shown to slow down breathing at rest, increase vital capacity, and increase maximal voluntary ventilation, breath-holding time, maximal inspiratory pressure, and maximal expiratory pressure. Previous studies have reported a strong relationship between decline in cognitive functions and COPD severity. Yoga training improves lung function and exercise capacity and could be used as an adjunct pulmonary rehabilitation program for COPD patients [9].

Materials and Methods

The following electronic databases were searched: Pub Med, Embase, Cochrane Central Register of Controlled Trials, Google Scholar, Scopus, and Science Direct. Irrelevant studies were excluded in this review article. The employed keywords «yoga» and «COPD,» yoga and pulmonary disease, or «yoga» and «cognition,» or «COPD» and «cognitive decline,» or COPD and cognitive impairment were typed in titles and abstracts. The searches were limited to English publications in humans in the last ten years. The inclusion criteria were a clinical trial and epidemiological study. Cohort study, case-control study, and providing information on the subject at hand (I.e., cognitive impairment in COPD patients, the effect of yoga on COPD, and the impact of yoga on cognitive functions). Bibliographies of all potentially relevant studies, articles, and international guidelines were manually searched.

Results and Discussion

Chronic and progressive airway obstruction present in COPD could enhance the adverse hypoxic effect on the brain to the extent that manifests in impaired cognitive functions. A variety of influencing factors may cause Cognitive Impairment (CI) in patients with COPD, including age, disease duration, disease severity, hypercapnia, smoking, and vascular dysfunction [10]. Three-phase system biology using a crowdsourcing approach and network construction gives a comprehensive set of fifty molecular network models that describe the biological processes relevant to COPD and lung biology (Fig 1). it appears most efficient to target the COPD-specific path mechanisms at the earliest distinguishable state when the extent of irreversible damage is still small and their molecular processes are not yet convoluted with secondary processes and comorbidities [11].

The dominant paradigm found by multiple researchers was that exposure to particulate matter — typically in the form of cigarette smoke — led to an acceleration of typical age-related lung function decline among those susceptible to its effects. Furthermore, multiple birth-cohort studies have identified lung function trajectories from birth or childhood to early adulthood that may reflect the influence of potentially modifiable factors such as preterm birth, smoke exposure, recurrent pulmonary infections, and persistent asthma during childhood, which could be the focus of interventions to maximize lung growth and reduce the risk of COPD in older age [12–15].

The earliest detectable histologic change following cigarette smoke exposure is epigenetic reprogramming of basal epithelial cells, due to which distal airways exhibit squamous metaplasia, ciliary dysfunction, basal and goblet cell hyperplasia, and mucus hypersecretion, thereby creating a local inflammatory milieu prone to damage and infection [16–18]. Epigenetic reprogramming also changes the volume and water and mucin contents of the airway surface liquid, a protective interface for inflammation, infection,

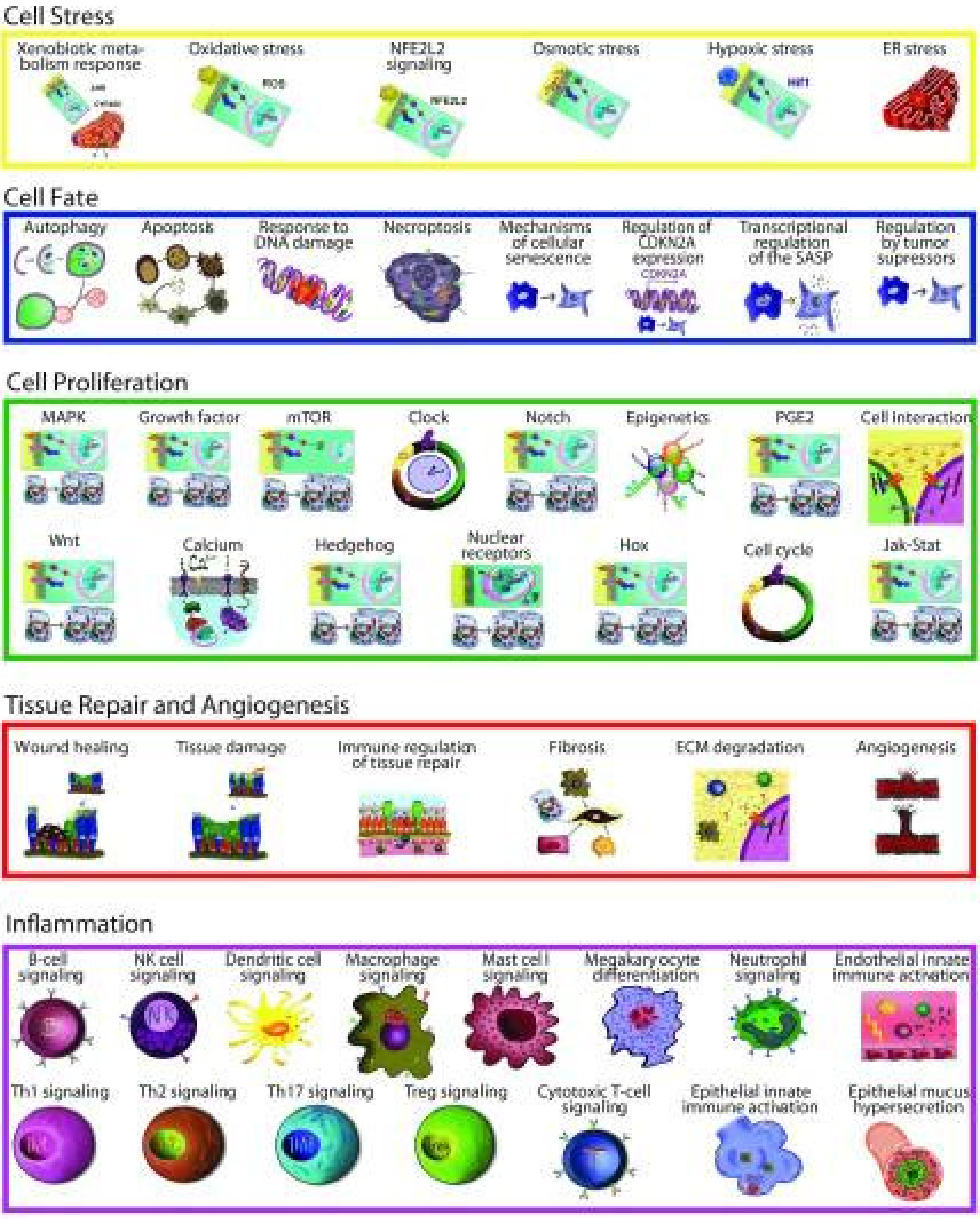

Fig. 1. Fifty molecular network model that describes the biological process relevant to COPD and lung biology [11]

and airway obstruction [19].Smoking also reduces polymeric immunoglobulin receptor (pIgR) expression, leading to localized secretory IgA (SIgA) deficiency in small airways. Without SIgA, bacteria can invade respiratory epithelial cells [20].

Recent basic science and clinical research have focused on the early physiologic and pathobiological changes in COPD to improve diagnosis, provide targets for disease-modifying therapy, and identify patients most likely to benefit from early intervention. Ferrera M.C. and colleagues summarize recent advances in disease pathogenesis and treatment paradigms [21].

Fig. 2 shows that besides lower oxygen and higher carbon dioxide levels in the blood, a complex interaction between pulmonary and non-pulmonary risk factors may account for COPD-related cognitive deficits. According to the literature, other major risk factors that may potentially be associated with cognitive impairment are 1) the presence of increased inflammation and oxidative stress; 2) reduced physical activity; 3) peripheral vascular disease; 4) high or low blood pressure (non-normotensive patients); 5) increased intracranial pressure associated with the narrowing of blood vessels in the brain; 6) coexisting comorbidities; 7) tobacco smoking; and 8) genetic predisposition [22]. A wide range of tools has been developed for screening cognitive function. The most widely used tests that cover multiple cognitive domains are the Mini-Mental State Examination (MMSE), the Addenbrooke's Cognitive Examination (ACE), the Montreal Cognitive Assessment (MoCA), the Clock Drawing Test (CDT), and the Mini-Cog test.

For writing this review article, we included 20 studies to find out the relation of COPD with cognition, Cognition with yoga, and COPD with yoga. A few studies assessed the effect of yoga on cognitive impairment in COPD, also included in our review article.

Four studies out of 20 found a significant relationship between COPD and cognitive impairment by using different tools for assessment [23–26].

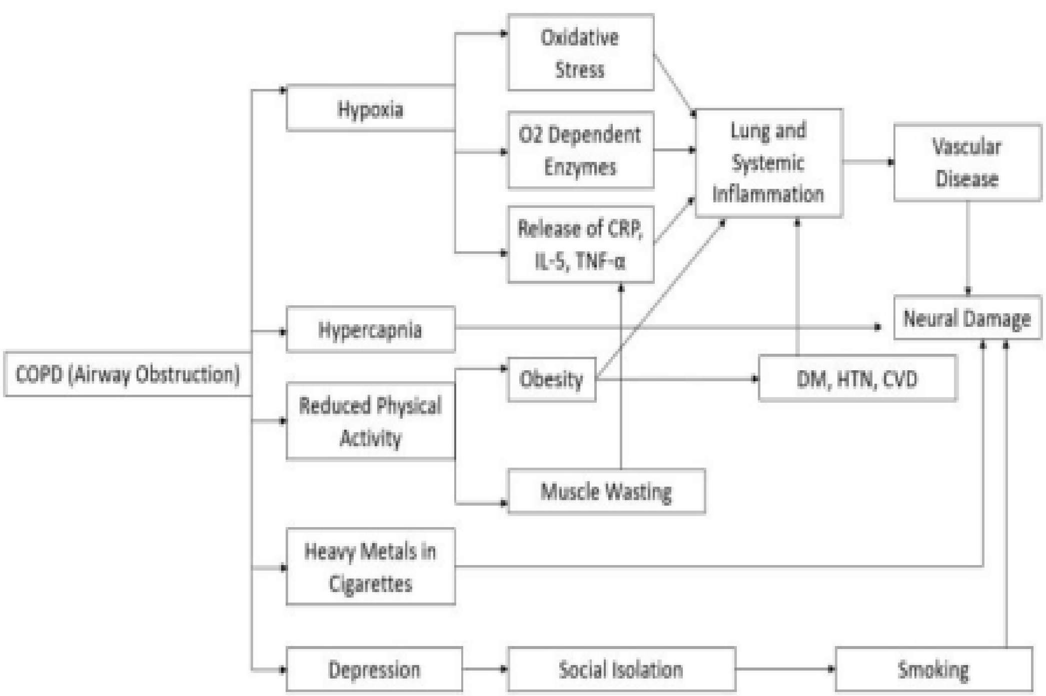

Fig. 2. Pathophysiology of cognitive dysfunction in COPD

Hung W.W. with colleagues, assessed cognitive decline in COPD patients using a 35-point validated scale from 1996 to 2002 in a cohort. Cognition score over repeated observations declined by 0.7 and 1 point from 1996 through 2002 among respondents without COPD and respondents with COPD [23].Gupta P. with colleagues, revealed that the mean latency of P300 was significantly prolonged ($P < 0.001$), and the mean amplitude of P300 was significantly decreased ($P < 0.001$) in COPD patients as compared to Healthy Volunteers (HVs). Mini-Mental Scale Examination (MMSE) scores in the COPD group were significantly reduced ($P < 0.001$) compared to those in the HVs group [24].Fekri M. and colleagues assessed a significant relationship between the MMSE score and just three variables: age, O2 saturation, and Forced Expiratory Volume in 1 sec (FEV_1 %) [25].Panjabi C. with colleagues, assessed the worsening in both MMSE and Trail Making Test A (TMT-A) scores, which were found to be statistically significant with advancing age (most severe among the age group 61–70 years), smoking status, low level of education (primary school or less), severe and very severe COPD, hypoxia, and hypercapnia [26].

Six out of 20 studies were related to a significant relationship between yoga and COPD [27–32].

Soni R. and colleagues assessed yoga's effect on COPD patients' diffusion capacity. Statistical analysis showed significant improvement in TLCO (Transfer factor of the lung for carbon monoxide) of the yoga group after two months of yoga [27]. Fulambarker Ashok M.D. and colleagues prospectively evaluated the effects of yoga training on the quality of life (QOL) and the parameters of lung function in patients with COPD. The St. George Respiratory questionnaire assessed the QOL. Standard spirometry and maximum inspiratory (maximal inspiratory pressure), as well as expiratory pressure (maximal expiratory pressure), were measured. When practiced by patients with COPD, yoga improves the QOL and lung function on a short-term basis [28]. Gupta A. with colleagues, assessed after three months of yoga intervention, the calculations from the unpaired t-test provided statistically significant results for both the COPD Assessment Test score (CAT) and the 6MWT (6 min walk test) (borderline significant) in the interventional arm when compared with control arm [29]. Sunil Kumar with colleagues, Mean FEV_1 before intervention Was 1.16±.6 and after intervention was 2.13±0.73. The difference in the mean values of FEV_1 between pre and post-intervention was found to be statistically significant (<0.05) [30]. Yudhawati R., with colleagues, accessed a substantial increase in FEV_1, 6 Min Walk Distance [6-MWD], and quality of life using a St George Respiratory Questionnaire [SGRQ] after 12 weeks of yoga ($p < 0.05$) in the treatment group ($p < 0.05$) when compared with the control group ($p > 0.05$) [31]. Prasad R. with colleagues, assessed Yoga, asana, and pranayama exercises, when used adjunctively with standard pharmacological treatment and pulmonary rehabilitation, had improved breathing pattern and pulmonary function parameters Forced Vital Capacity [FVC], FEV_1, FEV_1/FVC, and Peak Expiratory Flow Rate [PEFR] in COPD patients. The complementary therapy of yoga, asana, and pranayama showed improvement in physical condition by reducing weight and BMI, which enhanced pulmonary function through parameters [32]

Ten out of 20 studies were related to the effect of yoga on cognitive functions (33–42).

Kumar N. with colleagues, assessed the acute effect of moderate exercise on cognition, which was studied by event-related brain potential (ERP/P300), in subjects having sedentary lifestyles. The latency of P300 was significantly reduced after acute moderate exercise in the test group. They suggested that acute moderate exercise improves the cognitive brain functions of adults with a sedentary lifestyle [33]. Nangia D. and colleagues studied the influence of regular yoga practice on cognitive skills and mental health. Their results indicated that regular yoga practitioners perform significantly better on tests of attention and concentration, remote memory, mental balance, delayed recall, immediate recall, verbal retention of dissimilar pairs, visual retention, and recognition, and they have better mental health [34].Telles S. and colleagues assessed the peak amplitudes and peak latencies of the P300, which were evaluated before and after the respective yoga sessions.

There was a significant increase in the P300 peak amplitudes at Fz, Cz, and Pz and a significant decrease in the peak latency at Fz alone following alternate nostril yoga breathing. Following breath awareness, there was a significant increase in the peak amplitude of P300 at Cz [35]. Prasad R. with colleagues, reported changes from baseline to 6'th month, showing that the yoga group improved significantly in the Controlled Oral Word Association test (COWA), Rey Auditory Verbal Learning Test (RAVLT): Total score, immediate recall and delayed recall; Category Fluency Test (CFT): Immediate and delayed recall; spatial span-forward and backward, Stroop interference and TMT-A [36]. In a five-year trial involving 792 older adults, Pandya S. reported significant improvements in the MMSE test and Rivermead Behavioral Memory Test-Third Edition (RBMT-3) test following a yoga-based intervention in gross memory functioning and visual, verbal, recall, recognition, immediate, and delayed everyday memory (medium effect sizes) [37].Eyre H. and colleagues demonstrated significant improvement in depression and visuospatial memory in the yoga group. They correlated improved verbal memory performance with increased connectivity between the language processing network and the left inferior frontal gyrus on functional magnetic resonance imaging bythe Hopkins Verbal Learning Test-Revised (HVLT-R) (20-min delay recall raw scores) and a visuospatial memory measure, the Rey-Osterrieth Complex Test (Rey-O) (30-min delay recall raw scores) [38]. Srinivas Ch. and colleagues assessed a significant improvement in the Mini-Mental State Examination, Trail Making Test A and B after 12 weeks of regular Pranayama practice. By the end of 12 weeks of training of pranayama in both males and females, there is a highly significant reduction in the time taken to complete TMT A and TMT B ($P<0.001^{**}$) [39].Kyizom T. with colleagues, assessed the effect of yoga on cognitive functions in Hypertensive patients and found a significant association with P-300 latency and amplitude patients. He also studied the impact of yoga on cognitive functions in Type 2 DM patients [40]. Ashwini P.R. Gholam with colleagues assessed Pairwise comparison revealed a significant difference in P300 latency between Pz and Fz ($p=0.021$), Fz and P1 ($p=0.005$), Fz and P2 ($p=0.007$), P1 and F1 ($p=0.021$) as well as P2 and F2 ($p=0.048$). There was no significant difference in the latency between the other electrode sites. The mean amplitude of P300 at all the electrode sites was better for Group I and Group II SKY practicing participants than for non-practitioners of Group III [41]. Manshi Kashyap and colleagues assessed the effect of yoga in the case group and conventional care in the control group on post-stroke cognitive impairment by Montreal Cognitive Assessment (MoCA) score and P 300 amplitude after six months of yoga intervention. A significant improvement was observed in the MoCA score and improved P300 amplitude and latencies in both groups. Significant improvements were observed in MoCA, FAB, MRS, CPDSS, and CBS scores in both groups after six months [42].

Yogic training may allow broncho-dilatation by correcting abnormal breathing patterns and reducing the muscle tone of inspiratory and expiratory muscles due to a reduction of sympathetic reactivity. Due to improved breathing patterns, respiratory bronchioles may be widened, and perfusion of many alveoli can be carried out efficiently [43].

The brain parts, including the cerebral cortex, prefrontal cortex, anterior cingulated cortex, temporal lobe, and parietal cortex, are associated with cognitive functions, such as memory, attention, psychomotor performance, processing speed, visual reaction time, and perception [44–46]. Brain waves (e.g., alpha, beta, theta, and gamma), structural activation, and cerebral blood flow are physiological markers in cognitive operations. Research shows that yoga intervention activates the central nervous system and helps enhance mental functions [47]. Yoga also positively impacts the temporal lobe and frontal lobe of the brain, and yoga increases the cerebral blood flow in these brain areas, leading to better cognitive functions [48].

Conclusion

According to the literature that we included in our article; cognitive impairment is prevalent among COPD patients due to its complex pathophysiology. The cognitive impairment in COPD patients depends on many factors like duration, severity, age, etc. yoga training has a positive improvement effect on lung function and exercise capacity and could be used as an adjunct pulmonary rehabilitation program for COPD patients. Cognitive benefits of yoga may be attributed to more than physical activity; the combination of postures, breathing, and meditation practices appear in improving stress regulation and neurocognitive efficiency.The roles of yoga in health include prevention, promotion, cure, rehabilitation, palliation, and social well-being.There is an unmet need for early diagnosis and a better understanding of the consequences of cognitive impairment in COPD patients to provide targeted interventions. Healthcare professionals are required to assess cognitive functions in every COPD patient to diagnose impairment at an early stage so that early intervention can be started. According to previous literature, Yoga has a range of benefits for people living with COPD and cognitive functions. Regular yoga practice improves respiratory breathing capacity by increasing chest wall expansion and forced expiratory lung volumes. Yoga programs may be a valuable adjunct to effective rehabilitation programs for patients with COPD. Hence, based on available data, we can conclude that there is a strong relationship between COPD and cognitive impairment, COPD and yoga, cognition and yoga.

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Влияние йоги на когнитивные функции у пациентов с хронической обструктивной болезнью легких

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Аннотация: *Актуальность*. Хроническая обструктивная болезнь легких (ХОБЛ) из-за своей хронической и прогрессирующей природы поражает множество органов в организме из-за своей сложной патофизиологии. Гипоксическое воздействие на мозг из-за ХОБЛ напрямую приводит к повреждению нервов, за которым следует нарушение когнитивных функций. Когнитивные нарушения не только влияют на физическую функцию и состояние здоровья, но и усугубляют смертность и инвалидность у пациентов с ХОБЛ. Согласно литературе, некоторые модифицируемые факторы, такие как физическая активность, сбалансированное питание, когнитивные тренировки и социальная активность, могут улучшить состояние пациентов с ХОБЛ, у которых имеются доказательства когнитивных нарушений. Занятия йогой улучшают функцию легких и физическую работоспособность и могут использоваться в качестве дополнительной программы легочной реабилитации для пациентов с ХОБЛ. Йога включает в себя пранаяму и асану, две практики йоги, которые работают вместе для поддержания стабильности тела и ума. *Материалы и методы*. Был проведен поиск в следующих электронных базах данных: Pub Med, Embase, Cochrane Central Register of Controlled Trials, Google Scholar, Scopus и Science Direct. Нерелевантные исследования были исключены из этой обзорной статьи. Использованные ключевые слова «йога» и «ХОБЛ», йога и легкие заболевания или «йога» и «погнение», или «ХОБЛ» и «когнитивное снижение», или ХОБЛ и когнитивное нарушение были введены в заголовках и аннотациях. *Результаты и обсуждение*. Хроническая и прогрессирующая обструкция дыхательных путей, присутствующая при ХОБЛ, может усилить неблагоприятное гипоксическое воздействие на мозг. Йога улучшает дыхание, вызывая бронходилатацию, которая эффективно усиливает перфузию многих альвеол. Исследования показывают, что занятия йогой активируют центральную нервную систему и помогают улучшить когнитивные функции. *Выводы*. Согласно нашему обзору различных статей существует множество экологических, генетических и поведенческих факторов, которые повышают риск ХОБЛ у населения в целом. Основная патофизиология ХОБЛ — хроническое воспаление дыхательных путей, которое приводит к множественным сопутствующим заболеваниям. ХОБЛ сама по себе вызывает гипоксию многих органов, включая мозг, а с другим механизмом, связанным с ее сопутствующими заболеваниями, вызывает нарушение когнитивных функций. Помимо фармакологического лечения раннее вовлечение нефармакологических факторов, таких как йога, физические упражнения, изменение образа жизни, отказ от курения, может быть полезным для этих пациентов для замедления прогрессирования заболевания и снижения развития сопутствующих заболеваний. На основании литературных данных, можно сделать вывод, что существует сильная связь между ХОБЛ и когнитивными нарушениями, ХОБЛ и йогой, когнитивными функциями и йогой.

Ключевые слова: ХОБЛ, хроническая обструктивная болезнь легких, когнитивные функции, йога

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