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Original Scientific Paper

Measuring the Effect of Yoga on Quality of Sleep and Pain in Coal Miners with Chronic Obstructive Pulmonary Disease

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Abstract: *Most patients with chronic obstructive pulmonary disease suffer from disturbed sleep quality and chronic pain to a greater extent than the general population. Previous studies of yoga have demonstrated its effectiveness in improving sleep quality and pain reduction. This study assessed the effects of an integrated approach to yoga therapy module on quality of sleep and perceived pain in coal miners with stage II and stage III COPD. A sample of 81 male coal miners (age 36 - 60 years) were randomized to two groups, the first assigned to the 12-week yoga program that included asanas, pranayamas, meditation, breathing exercises and relaxation techniques, the second continuing conventional care, but wait-listed for yoga if they subsequently wished to participate. Variables assessed were Pittsburgh Sleep Quality Index and Numerical Rating Scale. Data were analyzed using SPSS 18.0. In post-intervention tests yoga group showed significant improvements ($p<0.001$) in both parameters on standardized measures of sleep quality and pain whereas control group changes were not significant. Changes in sleep quality and pain were negatively correlated. Results of this study support an add-on role for yoga therapy to improve sleep quality and reduce chronic pain in COPD patients. Further studies with more robust designs and with longer follow-up times should be conducted to assess and validate these findings more precisely.*

Key words: *yoga, COPD, sleep quality, pain.*

Introduction

Sleep is an active physiological process programmed into the human body by the day-night cycle. Controlled studies of human survival training show that, given sufficient water, sleep is more important than food in maintaining physical and mental performance (Ståhle et al., 2011). The sleep-wake cycle is one of the

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biorhythms determined by the circadian timing system, also influenced by factors like physiological function, work schedules, aging, chronic illness, bodily pain etc. (Foley, Ancoli-Israel, Britz, & Walsh, 2004). Decline in sleep health, including insufficient sleep duration, irregular timing of sleep, poor sleep quality, and circadian disorders, are prevalent in diverse medical conditions such as obesity (Rahe, Czira, Teismann, & Berger, 2015), arthritis (Purabdollah, Lakdizaji, Rahmani, Hajalilu, & Ansarin, 2015) cardiovascular disease, diabetes, psychiatric illness, cancer (Laposky, Van Cauter, & Diez-Roux, 2015), and respiratory diseases (Milioli et al., 2015). Patients with Chronic obstructive pulmonary disease (COPD) frequently complain of difficulty in initiation and continuance of sleep, increased number of arousals during the night, daytime sleepiness (Budhiraja, Siddiqi, & Quan, 2015; Cormick, Olson, & Hensley, 1986) and chronic pain (Roberts, Mapel, Hartry, Von Worley, & Thomson, 2013).

COPD is a prevalent progressive condition, generally attributed to smoking, though other risk factors include indoor and outdoor air pollution (Walia, Vellakkal, & Gupta, 2015). Research has identified coal mine dust as a cause of COPD in coal miners other than pneumoconiosis as has long been recognized (Coggon & Newman Taylor, 1998). A study by Klink, Dodge, & Quan (1994) revealed presence of respiratory symptoms significantly influenced the rate of sleep complaints. Changes in respiratory physiology in COPD patients include nocturnal cough and airflow obstruction, arterial oxygen desaturation, hypercapnia, and use of accessory muscles of respiration, all of which lead to fragmented sleep decreasing REM, and deeper sleep stages (Collop, 2010; Krachman, Minai, & Scharf, 2008).

A higher proportion of COPD patients have low sleep efficiency (<82%) than those without COPD (44% vs. 31%, p=0.04). Reports of prevalence of sleep disorder in COPD vary widely: studies in different populations have accounted varying percentages with at least one disturbed sleep symptom; 27.3% in 183 participants with stable COPD (Budhiraja et al., 2012), 70% in 30 clinically stable patients with moderate to very severe COPD (Nunes et al., 2009), and 74.8% reported in 139 patients with mild to severe COPD (Zohal, Yazdi, Kazemifar, Mahjoob, & Ziaeeha, 2014).

Chronic pain is highly prevalent in COPD (HajGhanbari, Holsti, Road, & Darlene Reid, 2012). Adjusted regression models place COPD second only to arthritis in increasing measures of chronic pain (Roberts et al., 2013). Experimental studies of healthy subjects and cross-sectional research in clinical populations suggest that the

relationship between sleep disturbance and pain is reciprocal (Ohayon, 2005) such that pain disturbs sleep quality and poor sleep further exacerbates pain (Lautenbacher, Kundermann, & Krieg, 2006).

Hypnotics have been found to have varying degrees of efficacy on short term treatment of insomnia but long term use have drawbacks which include tolerance, dependence, withdrawal symptoms, rebound insomnia, hang over effect, alteration of memory process, that may limit their use (Tsoi, 1991). The use of complementary healthcare interventions for both clinical and non-clinical populations has increased substantially in recent years (Paul, Elizabeth, Jablonski, & Sandra, 2009). The American Academy of Sleep Medicine has studied non-pharmacologic option for insomnia and found evidence to support their use in achieving sustained improvements in sleep parameters over time (Kierlin, 2008). Various psycho-therapeutic interventions such as cognitive behavioral therapy (Kapella et al., 2011; Trockel et al., 2011; Smith & Haythornthwaite, 2004) meditative movement interventions (MMIs) Wu, Kwong, Lan, & Jiang (2015), stimulus control, sleep restriction (Dautovich, McNamara, Williams, Cross, & McCrae, 2010; Fuller, Wong, Hoyos, Krass, & Saini, 2015), acupuncture and massage (Mooventhan & Nivethitha, 2014), stress management, sleep compression and relaxation training are efficacious treatments that can be considered in the treatment of insomnia (Morin, Stone, McDonald, & Jones, 1994). A small, but growing literature has applied yoga, as a promising stress reduction mind-body approach (Felbel, Meerpohl, Monsef, Engert, & Skoetz, 2014; Mustian et al., 2013) for either pain management or insomnia to patients with chronic pain. Hence, this study was planned to explore the potential of yoga as an adjunct to the management of insomnia and chronic pain in coal miners with COPD. We hypothesized that a yoga intervention would help calm the mind resulting in improvement in quality of sleep and reduction in pain. In this study we compared the effects of 12-week integrated yoga program with conventional care in grade II and III COPD patients.

Material and Methods

Ethical clearance and informed consent

To ensure scientific integrity, study protocol was approved by Institutional Ethical Committee and Institutional Review Board of S-VYASA University, Bangalore. All procedures were applied in accordance with Helsinki declaration of 1975, as revised in 2000 (5). The detail procedure of the study was explained to the

participants and their informed consent was obtained in writing before they started intervention.

Participants

The coal miners of Rampur colliery, Odisha, India were recruited as study participants. The study sample consisted of 81 non-smoking male coal miners in the age range 36 to 60 years. Of 279 coal miners screened, 162 failed at least one exclusion criterion; another 36 refused informed consent for the investigation; 81 signed up for the trial, but after 9 further dropouts, final data were only available for 72 participants.

Inclusion criteria

Non smoking male coal miners aged between 35 to 60 years; moderate to severe stable physician-confirmed COPD, satisfying Global Initiative for Obstructive Lung Disease (GOLD) criteria; FEV1/FVC ratio<0.7 and post- bronchodilator FEV1<80% predicted; clinically stable for at least 3 months prior to enrollment, lack of cognitive impairment that interfered with the ability to provide informed consent or to complete the questionnaires.

Exclusion criteria

Recent COPD exacerbation, unstable angina, respiratory tract infection within 1 month of the start of the study, myocardial infarction, angioplasty, heart surgery in the previous three months, Body Mass Index (BMI)>35 kg/m2, no history of hospitalization; previous involvement in yoga rehabilitation programs.

Study design

This study was a randomized, wait list control, single blind clinical trial with two study arms yoga and wait list control. Both the groups were on usual conventional care. The yoga group participants were required to attend six sessions of IAYT per week for 12 weeks. Both groups were asked to attend post intervention assessment at the end of intervention. After this control group were offered the yoga therapy session for the same period.

Randomization

Interested eligible participants were randomized via computer generated random number, to either yoga or a wait list control arm. It was performed using opaque

sealed envelopes with group assignments. The envelopes were opened sequentially in the order of assignment during recruitment.

Blinding and masking

Data collectors were blind to the participant's treatment status. But participants in yoga intervention group could not be blinded to treatment allocation arm due to the nature of the intervention. The team did the scoring of questionnaires and the statistician who performed the randomization and final analysis, were also blinded to the allocation of participant's groups.

Yoga therapy Intervention

The participants received an integrated yoga program designed for COPD, based on SVYASA's 30 years of experience of research, aiming to give a holistic healing through correction of imbalances at physical, mental, emotional and intellectual levels using various components like äsanas, loosening practices, breathing exercises, präëäyäma, meditation, yogic counseling, lectures on yoga philosophy, relaxation techniques and kriyä (Nagarathna & Nagendra, 2012). The detailed program with duration was given in Table 1.

Table 1. List of practices for COPD used in this study

Sl.	Types of practice	Name of the practice	Duration
1	**BREATHING PRACTICES**	**Standing:** Hands in and out breathing, Hands stretch breathing, Ankle stretch breathing **Sitting:** Dog breathing, Rabbit breathing, Tiger breathing, *Sasäìkäsana* breathing (moon pose) **Prone:** *Bhujaìgäsana* breathing, *Śalabhāsana* breathing **Supine:** Straight leg raising breathing	**10 Min.**
2	**LOOSENING PRACTICES**	Forward and backward bending, Side bending, Twisting *Pawanmuk*täsana *kriy*ä, Rocking and Rolling *Surya Namaskära*	**10 Min.**

3	***YOGÄSANAS* (PHYSICAL POSTURES)**	**Standing:** *Ardhakati cakräsana, Pädahastäsana, Ardha cakräsana*; **Sitting:** *Vakräsana, Ardhamatsyendräsana Paścimottānāsana*; **Prone:** *Bhujaìgäsana, Śalabhāsana;* **Supine:** *Saravāìgāsana, Matsyäsana*	**20 Min.**
4	***YOGÄ* CHAIR BREATHING**	a) Instant Relaxation Technique b) Neck muscle relaxation with chair support c) Neck movements in *Vajräsana* *d)Sasäìkäsana* movement e) Relaxation in *Tädäsana* f) Neck movements in *Tädäsana* g) *Ardha cakräsana - Pädahastäsana* h) Quick Relaxation Technique	**10 Min.**
5	***PRÄËÄYÄMA***	*Kapälabhäti,Vibhägiya pränäyäm, Nädiśodhana pränäyäma, Ujjayi pränäyäma, Bhrämari pranayama*	**10 Min.**
6	**MEDITATION**	*Nädänusandhäna* (Alternate day) or Om Mediatation (Alternate day)	**10 Min.**
7	**DEEP RELAXATION TECHNIQUE**	a) Relaxation of lower part of the body b) Relaxation of middle part of	
		the body c) Relaxation of upper part of the body d) Relaxation of whole body with AUM chanting e) Visualization of whole body f) Expansion of awareness g) Chanting of AUM and feeling its resonance all over h) Feeling of lightness and movement of energy.	
8	**YOGIC COUNSELLING/ LECTURES**	Yoga philosophy and health, Basis and applications of yoga, *Pancakoña viveka* (Five layers of existence), Lifestyle modification, Emotion and coping, Diet and exercise, COPD causes, complications and lifestyle factors, Stress reaction and its management.	**10 Min.**
	Total		**90 Min.**
9	***KRIYÄ* (once a week)**	*Jala Neti, Sutra Neti, Vamana Dhouti*	**90 Min.**

Assessments

Pittsburg Sleep Quality Index (PSQI)

PSQI is a psychometrically validated, self-reported, effective instrument used to assess the quality and patterns of sleep in the older adult over the last month (Buysse, Reynolds, Monk, Berman, & Kupfer,1989). Nineteen individual items were recoded to comprise seven sleep components: subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleep medication, and daytime dysfunction, each of which has a range of 0-3 points, whereby 3 reflects the negative extreme on the Likert Scale. The sum of scores for these seven components yields one global PSQI score, ranging between 0-21. A global sum of "5"or greater indicates a "poor" sleeper, having sensitivity of 98.7 and specificity of 84.4 as a marker for sleep disturbances. PSQI has internal consistency (Cronbach's alpha) of 0.80 (Carpenter & Andrykowski, 1998) and test-retest reliability of 0.87 (Backhaus, Junghanns, Broocks, Riemann, & Hohagen, 2002). The global sleep quality score was the primary outcome and the subscale scores of global sleep quality characteristics were secondary end.

Numerical Rating Scale (NRS)

Pain intensity was measured on an 11-point numerical pain rating scale, prepared for the purpose by drawing a horizontal 10 cm line in the center of a white sheet with '0' as nil pain and '10' as worst possible pain (Farrar, Young, LaMoreaux, Werth, & Poole, 2001). Separate sheets were used at each assessment time. Participants were asked to indicate the pain intensity by a dot on the line.

Statistical analysis

Statistical analysis was carried out using SPSS, version 18. Means of the both groups were compared for all variables using Student's t-test. Categorical variables were analyzed using the Chi - square test. Pearson correlation coefficient was performed to assess association between sleep quality and pain. A p-value<0.05 was considered statistical significant.

Results

Eighty one participants with moderate to severe COPD (age 36-60 yrs) were studied. There were no significant differences between groups in baseline characteristics [Table 2]. Of 81 participants, 9 participants (Yoga=5, Control=4) excluded from the analysis for the following reasons: attendance below 60%, ill health, did not turn up for post data. Seventy two completed the 12 week intervention. No adverse event was reported during the study.

Table 2. Demographic and medical characteristic of the study population

Variable		**Yoga**		**Control**		**p–value***
		n	**(%)**	**N**	**(%)**	
Number of participants		36		36		
Stage of COPD	GOLD II – Moderate	19	52.8	21	58.3	0.635
	GOLD III – Severe	17	47.2	15	41.7	
Diagnosis	Asthmatic Bronchitis	9	25	7	19.4	0.356
	Chronic bronchitis	12	41.7	18	50	
	Emphysema	15	22.2	11	30.6	
Stress History	Family	8	22.2	6	16.7	0.913
	Financial	7	19.4	9	25	
	Health	12	33.3	14	38.9	
	Job	6	16.7	5	13.9	
	Nil	3	8.3	2	5.6	

Legend: GOLD - Global Initiative for Obstructive Lung Disease, COPD - Chronic Obstructive Pulmonary Disease, ***** - Chi-square test

Participants in the yoga group demonstrated significantly greater improvements in the primary outcome of global sleep quality ($p<0.001$) and pain ($p=0.003$) at post intervention compared with control participants [Table 3 and Figure 1].

Table 3. Changes in quality of sleep and pain in yoga and control groups before and after 12 weeks.

	YOGA (n=36)			
	PRE		**POST**	
	MEAN ± SD	**95% C.I. (LB to UB)**	**MEAN ± SD**	**95% C.I. (LB to UB)**
Global_PSQI	9.94± 3.97	8.60-11.29	6.56± 3.87	5.25-7.86
SSQ	1.53±0.70	1.29-1.76	1.06±0.79	0.79-1.32
SL	1.69±0.67	1.47-1.92	1.31±0.71	1.07-1.54
SDN	1.47±0.84	1.86-1.76	1.14±0.76	0.88-1.40
HSE	1.44±0.61	1.24-1.65	1.03±0.65	0.81-1.24
SD	1.67±0.68	1.44-1.90	0.92±0.84	0.63-1.20
SM	1.03±0.84	0.74-1.31	0.53±0.61	0.32-0.73
DD	1.11±0.71	0.87-1.35	0.58±0.50	0.41-0.75
NRS	6.11±1.60	5.57-6.65	3.78±2.27	3.01-4.55

	CONTROL (n=36)			
	PRE		POST	
Variables	MEAN ± SD	95% C.I. (LB to UB)	MEAN ± SD	95% C.I. (LB to UB)
Global_PSQI	10.17±3.31	9.05-11.29	9.83±3.90	8.52-11.15
SSQ	1.39±0.55	1.20-1.57	1.44±0.84	1.59-1.73
SL	1.81±0.47	1.65-1.96	1.72±0.61	1.51-1.93
SDN	1.64±0.64	1.42-1.86	1.78±0.72	1.53-2.02
HSE	1.56±0.50	1.39-1.73	1.42±0.65	1.20-1.64
SD	1.78±0.68	1.55-2.01	1.58±0.73	1.34-1.83
SM	0.94±0.75	0.69-1.20	1.03±0.84	0.74-1.31
DD	1.06±0.75	0.80-0.31	0.86±0.64	0.64-1.08
NRS	5.78±1.27	5.35-6.1	5.33±2.08	4.63-6.04

	BETWEEN GROUPS		
Variables	PRE vs PRE	POST vs POST	Group *time inter action
Global_ PSQI	.797	.001	<.001
SSQ	.351	.047	.001
SL	.416	.010	.035
SDN	.348	<.001	.001
HSE	.401	.014	.062
SD	.489	.001	<.001
SM	.660	.005	<.001
DD	.748	.044	.042
NRS	.330	.003	<.001

Legend: *PSQI - Pittsburg Sleep Quality Index, SSQ - Subjective Sleep Quality, SL - Sleep Latency, SD- Sleep Duration, HSE – Habitual Sleep Efficiency, SDS- Sleep Disturbances, SM - Sleep Medication, DD- Daytime Dysfunction, NRS – Numeric Rating Scale*

Figure 1. Comparison of Global PSQI and NRS scores among yoga and control group after a 12 week period

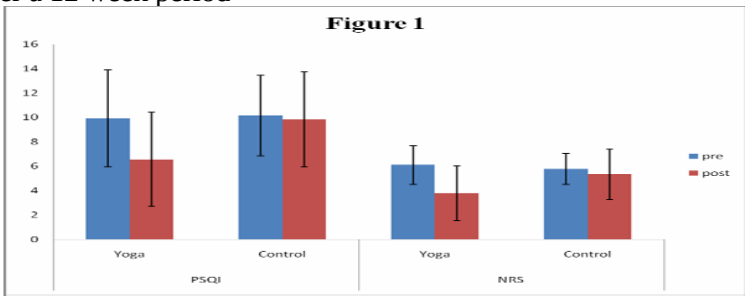
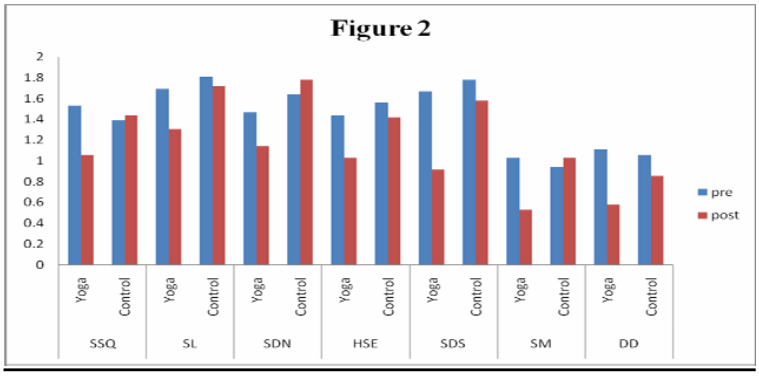


Figure 2. Comparison of scores of seven domains of PSQI among yoga and control group after a 12 week period



Sleep quality as indicated by PSQI global score significantly decreased in yoga group by 34% ($p<0.001$, ES 0.86) and reduction in mean pain score by 38.13% ($p<0.001$, ES 1.15) after the intervention. In contrast, paired sample t-test showed a small but insignificant decrease in PSQI score of 3.34% ($p=0.235$, ES 0.09) and in pain score by 7.79% ($p=0.055$, ES 0.25) in the control group.

In addition, the yoga participants demonstrated significantly greater improvements ($p<.05$) in all the characteristics that define global sleep quality (secondary outcomes) post intervention compared with baseline where as no significant difference was observed in the control group ($p>.05$) [Table 3 and Figure 2]. When the post intervention data of the groups were compared in terms of sleep quality in subcategories, significant difference was found in favor of yoga group ($p<0.05$). Yoga group participants compared to controls had significantly better PSQI global score, subjective sleep quality; shorter sleep latency; longer sleep duration; enhanced percent habitual sleep efficiency; less sleep disturbances and sleep medication use; and superior daytime dysfunction.

Significant group * time interaction ($p<0.001$) was observed in global PSQI score along with all its components as well as in pain scores. This study found a strong negative correlation between PSQI global score and pain ($p<0.001$, $r = 0.757$). Quality of sleep was found to decrease as the level of pain increased.

Discussion

Results of the present study clearly indicated that yoga elicited a significant improvement ($p<0.001$) in sleep quality. The significant fall ($p<0.001$) in pain scores after 12 weeks of integrated yoga in yoga group suggests that regular practice of yoga
progressively develops greater levels of both relaxation and resilience to stress.

Present findings of improved pain following yoga reflect reported significant improvements in a range of subjective factors, including overall sleep quality; sleep efficiency; sleep latency and duration; self- assessed sleep quality after 12 weeks of meditative yoga (Halpern et al., 2014). A recent study on 120 nurses who practiced yoga more than two times every week for 50-60 minutes has shown regular yoga improved sleep quality and reduced work stress after six months (Fang & Li, 2015). It is in agreement with preceding related studies which have shown improvement in sleep quality in varied populations (Chen et al., 2009; Cohen, Warneke, Fouladi, Rodriguez, & Chaoul- Reich, 2004; Garland et al., 2014; Hariprasad et al., 2013; Vitiello, Rybarczyk, Von Korff, & Stepanski, 2009). Our study also confirmed previous findings of reduction in pain following yoga program (Ebnezar, Nagarathna, Yogitha, & Nagendra, 2014; Haldavnekar, Tekur, Nagarathna, & Nagendra, 2014; Mustian, Sprod, Janelsins, Peppone, & Mohile, 2012; Tekur, Nagarathna, Chametcha, Hankey, & Nagendra, 2012). MBSR, a mind-body therapy including body scan, sitting and walking meditation similar to yoga has also shown to reduce pain severity (Banth & Ardebil, 2015). A recent review by Cheung, Park, & Wyman, (2015) involving twelve reports exhibited yoga intervention resulted in reductions in pain in 589 participants with OA-related symptoms.

The multi-factorial IAYT brings about mastery over the local neuromuscular reflexes through internal awareness and controlled physiological responses. The relaxing asanas and pranayama harmonize the physiological system and initiate a relaxation response in the neuro-endocrinal system by which sleep gets deeper and sustained and can help to deal with pain (Vallath, 2010). The improvement in sleep quality in coal miners in this study might be due to relaxation technique, pranayama, and guided meditation, important component of our intervention through enhancement in foster states of relaxation, counteract intrusive thoughts, and decrease body tension by increasing awareness in movement to relax tense muscles and to relieve mental stress (Anderson, Hurley, Staud, & Robinson, 2015). It is clearly in line with behaviours linked to improved sleep, stress reduction (Oken, Chamine, & Wakeland, 2015), muscle relaxation due to breathing exercises (Chien,Chung,Yeh, &Lee, 2015;Sendhilkumar, Gupta, Nagarathna, & Taly, 2013; Vitiello et al., 2009). This has been demonstrated in a previous study which had reported improved sleep latency, sleep duration and significant decrease in the time taken to fall asleep (Manjunath & Telles, 2005).

Stress and pain are intimately related. Stress reducing effect of yoga seems to be a major mechanism of its efficacy in pain management in patients with COPD. Dyspnea is a distressing symptom of COPD associated with pain and CBT is known to relieve dyspnea by cardiac vagal modulation, dynamic hyperinflation, promoting arterial oxygen saturation, myelinated vagus nerve activity, and neuroplasticity (Norweg & Collins, 2013) with stabilizing effect on bronchial hyperresponsiveness and reduced efferent vagal reactivity (Nagarathna & Nagendra, 1985). Yogasanas reduce muscle spasm and pain through deep local rest and repose that follows safe stretches done with awareness where as breathing

exercises, relaxation, and meditation, these three aspects of yoga act to distract the mind from pain. During meditation several subtle level notional corrections may happen making it difficult to pay attention to the pain at the same time. Meditation attenuate the medial system of pain perception including brain regions in insula, as well as the lateral system in the thalamus (Nakata, Sakamoto, & Kakigi, 2014). This appears to cause an uncoupling of the sensory dimension of the pain experience from the affectively evaluative alarm reaction and reduce the experience of suffering via cognitive reappraisal (Kabat-Zinn, 1982) through controlled overtones of hypothalamo-pituitary-adrenal axis during chronic pain (Zheng, Hong, Hayes, & Wiley, 2015).

Good sample size, randomized control design, active supervised intervention and follow up for three months with good compliance are the strengths of this study. The result of this study that has shown marked differences between groups on all variables offers strong evidence for incorporating this module of IAYT for COPD for the management of insomnia and pain in clinical practice.

The study was on a selected group working in a particular coalmine and hence not generalizable. Furthermore, this study did not examine the effects of dyspnea, and its association with pain perception. Objective (polysomnography) sleep metric rather than subjective (PSQI) would attain more conclusive results for effects of yoga.

Directions for future research include three armed randomized clinical trials incorporating appropriate active controls, longitudinal studies and more sufficient fidelity of intervention execution to confirm the results. It also highlights the need for comparing the effectiveness of yoga on different grades of severity of COPD patients. According to the results, it is recommended that patients with COPD be treated for insomnia symptoms with yoga. Studies using objective measures of sleep may throw light on the mechanisms. These results support the need for large-scale randomized controlled trials in diverse patient populations in which insomnia and chronic pain commonly co-occur.

Conclusion

The findings of this study strengthen the fact that integrated yoga is valuable in helping to improve sleep quality and to diminish pain. Further research is required to determine the reliability of these effects and to identify their underlying mechanisms with appropriately sized studies using the conventional, robust randomized trial design.

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