The determinants of sleep quality and its impact on exercise capacity of patients with COPD

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Abstract

Impaired sleep is reportedly common in chronic obstructive pulmonary disease (COPD) and the impact of quality of sleep on Exercise capacity has been documented. However, determinants of sleep quality and the effect of sleep quality on exercise capacity has not been previously investigated among patients with COPD in Nigeria.

Sixty clinically stable patients with COPD were evaluated. Subjective sleep quality was assessed using the Pittsburgh Sleep Quality Index (PSQI) and Health related quality of life (HRQL) assessed using COPD Assessment Test (CAT). Lung function was assessed by spirometry, severity of dyspnea by the Modified Medical Research Council (MMRC) scale, and functional exercise capacity by the Six-Minute Walk Test (6MWT). In all the statistical tests, a p value of <0.05 was considered significant.

The mean age of the study population was 70±8years. Forty-nine patients (81.7%) had poor quality of sleep (PSQI > 5). Patients with good sleep quality walked a mean distance of 344.5±86.4 meters in six minutes while those with poor quality sleep walked a mean distance of 264.3 ±83.8meters in six minutes (p-value 0.006). A bivariate correlation shows that exercise capacity reduces with increasing PSQI score (r= -0.396, p=0.002). Multiple regression analysis showed that only HRQL was an independent predictor of sleep quality in our patients (p= <0.001).

Results from this study suggest that poor sleep quality had a negative effect on exercise capacity. Other determinants of sleep quality were health status, exacerbation frequency, severity of dyspnea and lung function parameters.

Chronic Obstructive Pulmonary Disease (COPD) is a major cause of chronic morbidity and mortality throughout the world. It represents an important public health challenge that is both preventable and treatable.[1] According to a recent report, COPD is characterised by persistent airflow limitation that is usually progressive and is enhanced by chronic inflammatory response in the airways and lungs to noxious particles and gases. Exacerbations and co-morbidities contribute to the overall severity in individual patients.[1]

It is the fourth leading cause of death in the world.[1] At least 65 million people worldwide have severe COPD.[2] It is also an important cause of respiratory morbidity and mortality in Nigeria.[3] COPD is associated with several respiratory and non-respiratory symptoms. Among the non-respiratory symptoms is weight loss, anxiety and sleep disturbances.[1]

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Sleep is a complex reversible state characterised by both behavioural quiescence and diminished responsiveness to external stimuli.[4] Sleep is a universal need of all higher life form, absence of which has serious physiological consequences.[5] Sleep disturbances are particularly prevalent in COPD with associated poor outcomes.[6,7,8] The nature and aetiology of disturbed sleep in COPD has been poorly characterised, and studies on the long-term clinical consequences of sleep disturbance in COPD are limited.[7]

Exercise capacity is an important outcome measure in COPD and an important determinant of health status.[9] Factors contributing to exercise limitation COPD are multiple and complex.[10] Studies have suggested that lung mechanics such as hyperinflation, obstruction and diffusion abnormalities clearly play an important role in dyspnea perception and function exercise capacity in addition to other factors.[11] In addition, pulmonary rehabilitation including exercise training programmes for patients with COPD focus on improvement of exercise capacity which is reflected in the outcome measures.[13]

Methodology

This study is a cross-sectional analytical study. Sixty subjects with diagnosis of COPD according to GOLD guidelines were consecutively recruited for the study. Sample size was calculated using the Fisher formula for estimating a single proportion at a specified precision.[13] Proportion of target population estimated to have a particular characteristic (COPD prevalence) was taken to be 16%.[14] Degree of accuracy was taken as 10%. Although 52 was the calculated sample size, a total of 60 patients were used to improve the power of the study. Inclusion Criteria are Patients with COPD diagnosis as defined by the Global initiative for chronic Obstructive Lung Disease (GOLD) guideline who are clinically stable. Shift workers and patients with medical conditions that may contribute to dyspnea and exercise limitations such as cor-pulmonale, congestive heart failure and arthritis were excluded. Severity of dyspnea was assessed using the modified medical research council (MMRC) dyspnea scale.[15]

Sleep quality

Sleep quality was assessed using the Pittsburgh Sleep Quality Index (PSQI), a 9-question, 19-item self-rating scale designed to measure perceived quality of sleep. It differentiates 'poor' from 'good' sleep by measuring seven domains: subjective sleep quality, sleep latency, sleep duration, sleep efficiency, sleep disturbances, use of sleep medication, and daytime dysfunction over the last month. The seven domains' sub scores, each ranging from 0 to 3, are tallied, yielding a 'global' score that range from 0 to 21 with increasing score meaning worse sleep quality. Good sleep quality is represented by a global PSQI score of ≤5 while poor sleep quality is represented by a global PSQI score of >5.[16]

Health-related quality of life

The health-related quality of life was assessed using the COPD assessment test (CAT). CAT measures the perception of the burden of disease and includes one question on sleep. It consists of eight items, relating to coughing, mucus production, chest tightness, capacity for exercise and activities, confidence, sleep quality and energy levels. Each is presented as a 6-point scale, from 0 (best) to 5 (worst), providing a total score out of 40. The scores have been classified into four categories based on impact of disease on HRQL; Low impact (< 10), Medium impact (10-20), High impact (>20) and Very high impact (>30) (17).

Pulmonary function

Lung function test was assessed according to the American thoracic society guideline(ATS)[18] using a standardised spirometer. Forced Expiratory Volume in 1 second (FEV_1), Forced Vital Capacity (FVC), FEV_1/FVC ratio and their values as a percentage of predicted normal were measured. Subjects were divided into four groups on the basis of the severity of their airway obstruction using the GOLD criteria as follows: $FEV_1 \geq 80\%$ (GOLD grade 1), $FEV_1 <$ 80% but ≥ 50% (GOLD grade 2), $FEV_1 < 50\%$ and ≥30% (GOLD grade 3), $FEV_1 < 30\%$ (GOLD grade 4).[1]

Exercise capacity

This was evaluated using the six-minute walk test (6MWT) according to the guidelines of ATS.[19] A long, flat, straight and enclosed corridor was used to perform the test. The walking course was 30 m in length. The distance that a patient can quickly walk in a period of 6 minutes was measured. A cut off of 350 metres appear to be optimal threshold below which there is increased risk of poor outcome in COPD therefore values <350 metres was regarded as abnormal[20]. The minimum clinically important difference (i.e., improvement) in the distance walked in a 6MWT has been estimated as 54 metres.[21]

Data analysis

Frequency table were used to describe the age distribution, gender, social demographic characteristics and clinical characteristics of the study population. Sleep quality for different age group, gender and severity of dyspnea were compared using chi-square tests. A two-tailed independent t-test was used to evaluate the difference in the lung function tests at different categories of sleep quality. One-way ANOVA was used to compare mean values. Pearson's correlation coefficient was used to determine the strength of the relationship between exercise capacity, HRQL and sleep quality. Multivariate regression analysis was done to determine independent predictors of sleep quality.

Results

Sixty patients were recruited for this study. The mean age of the patients was 70 ±8 years with the age range between 50 and 87 years. Other baseline characteristics are shown in Table 1.

The mean global PSQI for the study subjects was 9.93±4.19 (median 9.5). The mean sub scores for subjective sleep quality, sleep latency, duration, habitual sleep efficiency, sleep disturbances, sleep medications and daytime dysfunction were 1.52±0.85, 1.85±0.86, 2.07±0.82, 1.93±1.06, 1.23±0.43, 0.48±0.83 and 0.83±0.74 respectively. A significant proportion (49; 81.7%) of the study subjects rated their overall sleep quality as poor (global PSQI >5) while 11 patients (18.3%) rated their sleep quality as good (global PSQI≤5).

Association between sleep quality and demographic parameters and exacerbation frequency is shown in Table 2.

Table 1 Baseline characteristics

Baseline characteristics	Number of patients (n=60)	Percentage (%)
Age distribution		
<65	14	23.3
>65	46	76.7
Gender Distribution		
Male	32	83.3
Female	28	46.7
Body mass index		
<18.5	14	23.3
18.5-24.9	33	55.0
25-29.9	11	18.3
≥30	2	3.3
Cigarette smoking		
Current smoker	3	5
Ex-smoker	17	28.3
Never smoker	40	66.7
GOLD stage		
Stage1	7	11.7
Stage 2	18	30
Stage 3	25	41.7
Stage 4	10	16.7
Exacerbation (past year)		
Present	32	53.3
1 episode 23(71.9%)		
≥ 2 episodes 9 (28.9%)		
None	28	46.7
CAT Scores		
Low impact	4	7
Medium impact	31	51
High impact	19	32
Very high impact	6	10

The relationship between sleep quality and lung function parameters is shown in Table 3.

The proportion of COPD patients with poor sleep quality increases with increasing severity of dyspnea (Table 4)

Bivariate correlation between CAT score and PSQI score is shown in Figure 1.

Patients with good sleep quality walked a mean distance of 344.5±86.4 meters in six minutes while those with poor quality sleep walked a mean distance of 264.3 ±83.8meters in six minutes with difference a of 80meters (p-value 0.006). Bivariate correlation between exercise capacity and PSQI is shown in Figure 2.

Stepwise Multiple Regression Analysis Showing the Relative Contribution of Each Variable to Predict Quality of sleep as a dependent outcome (Table 5).

Discussion

COPD negatively affects sleep and sleep impairment has been found to be a common complaint among patients with COPD.[8] More than 80% of the patients in this study rated their overall sleep quality as poor (PSQI >5), which is consistent with reports from similar studies.[22,23] Sleep disturbances in COPD are multifactorial and include demographic factors, such as age and obesity, pharmacotherapy, night-time disease-specific symptoms, nocturnal hypoxemia, presence of comorbid sleep disorders such as obstructive sleep apnoea, anxiety, depression as well as other medical conditions.[7]

Table 2 Sleep quality with demographic parameters and exacerbation frequency

Socio-demog.	Good	Poor	Total	X^2	p-value
Age groups					
50–59	3(37.5)	5(62.5)	8 (100.0)		
60–69	2(16.7)	10(83.3)	12 (100.0)		
70–79	5(16.1)	26(83.9)	31 (100.0)		
>80	1(11.1)	8(88.9)	9 (100.0)	2.399	0.494
Gender					
Male	5(15.6)	27(84.4)	32 (100.0)		
Female	6(21.4)	22(78.6)	28 (100.0)	0.336	0.562
BMI (Kg/M2)					
<18.5	1(7.1)	13(92.9)	14 (100.0)		
18 -24.9	7 (21.2)	26 (78.8)	33 (100.0)		
25–29.9	3 (27.3)	8 (72.7)	11 (100.0)		
≥30	0 (0.0)	2 (100.0)	2 (100.0)	2.390	0.496
Frequency					
1	3(13.0)	20(87.0)	23(100.0)		
≥2	0(0.0)	9(100.0)	9(100.0)		
None	8(28.6)	20(71.4)	28(100.0)	8.817	0.03

One way ANOVA test. MMRC= Modified Research Council. CAT= COPD Assessment Test

Table 3 Sleep quality and lung function parameters

Lung function tests	Sleep quality			
	Good	Poor	t	p-value
FEV_1 *	1.21 ±0.39	0.89 ±0.40	2.912	0.005
FEV_1%*	66.4% ±22.2%	45.7% ±18.7%	3.586	0.001
FVC*	2.20 ±0.51	1.68 ±0.61	2.728	0.008
FVC%*	90.9% ±20.5%	.0% ±18.7%	4.226	< 0.001
FEV/FVC%*	57.5% ±10.4%	54.7% ±10.1%	0.821	0.415

*Two-tailed Independent t-tests, *Post bronchodilation. FEV_1= forced expiratory volume in one second. FEV_1%= FEV1 as percent predicted. FVC= forced vital capacity. FVC%= FVC as percent predicted. L= Litres*

The present study found that demographic attributes of the patients such as age and BMI had minimal impact on the sleep pattern of our patients. However, this study demonstrated that sleep quality worsens in patients with more frequent exacerbations in the previous year and this association was statistically significant. Omachi et al also found that sleep quality predicted incidence of exacerbation.[6] Frequency of the exacerbations is closely related to pulmonary and extrapulmonary manifestations of COPD such as depression, reflux, low FEV1 and oxygen saturation,[24] which are potential contributors to poor sleep.

The current study showed that patients with good sleep quality have significantly higher mean lung function parameters compared with those with poor PSQI. Similarly, a study by Nimrod et al found a significant correlation between global PSQI score and FEV1% predicted.[25] Zohal et al also reported that COPD patients with more severe disease had poorer sleep quality with FEV1 and PSQI score showing negative correlation.[22] Poor sleep in a study, contributed to verbal memory decline which may lead to poor adherence to medication and deterioration of disease.[26] Poor sleep quality is also associated with poor immune function leading to frequent exacerbations and lung function deterioration.[27]

Sleep quality worsens with increasing severity of dyspnea in our study population. Nunes et al also found that dyspnea was the best predictor of total sleep time and sleep efficiency in a study.[28] Dyspnea is a major symptom of COPD and patients with severe dyspnea are likely to be breathless at

Table 4 Sleep quality and dyspnea severity

MMRC scale	Good	Poor	Total	Mean±SD	p-value
0	4 (36.4)	7 (63.6)	11 (100.0)	7.09±3.5	
1	4 (25.0)	12 (75.0)	16 (100.0)	8.81±3.6	
2	3 (13.0)	20 (87.0)	23 (100.0)	10.22±4.0	
3	0 (0.0)	7 (100.0)	7 (100.0)	13.57±3.2	
4	0 (0.0)	3 (100.0)	3 (100.0)	15.67±0.6	0.01

Fishers chi-square test X2 =5.538, p-value 0.236. One Way ANOVA for mean values of PSQI
MMRC scale
0 (Not troubled with breathlessness except with strenuous exercise)
1 (Troubled by shortness of breath when hurrying or walking up a slight hill)
2 (Breathlessness slows walking pace)
3 (Stops for breath after walking100m)
4 (Breathless to leave the house)

Table 5 Multivariate regression analysis for predictors of PSQI

Variables	z-score	S.E	partial r	R2	p-value
CAT score	0.899	0.082	0.63	0.403	<0.001
Exercise capacity (6MWD)	0.082	0.006	0.080	0.006	0.551
FEV1%	0.187	0.030	0.164	0.027	0.219

Figure 1 Bivariate correlation between global PSQI and CAT in COPD patients

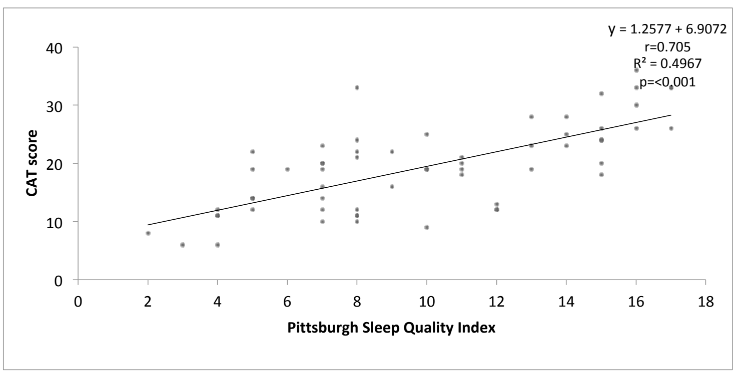
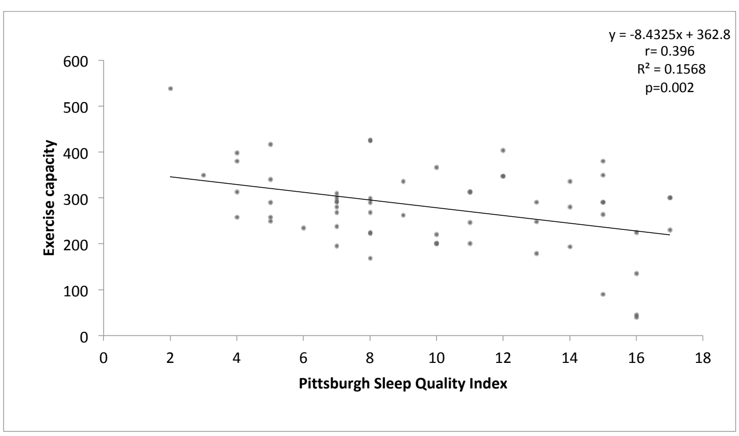


Figure 2 Sleep quality and exercise capacity



night leading to disturbed sleep. In addition, chronic dyspnea can lead to depressive episodes leading to impaired sleep and poor quality of life although this relationship was not assessed in our study.[29,30]

Increasingly, it is being recognised that HRQL is an important outcome of medical care. We demonstrated that HRQL in our patients is poor. In the literature, determinants of HRQL are multiple. However, it is only recently that associations between sleep quality and HRQL have been explored. In this study, HRQL was found to be negatively affected by sleep quality. This finding is consistent with an earlier related study.[23] The relationship between sleep quality and HRQL is bidirectional and complex. Sleep quality has been related to deterioration of lung function, severity of dyspnea, psychological disorders such as anxiety and depression, emergence of cardiovascular disease, fatigue and exercise capacity, all of which are associated with poor health status.[7, 30, 31]

Exercise capacity is an important outcome measure in COPD. The 6MWD test which is a simple, easy to perform and well tolerated test of physical activities has gained importance in the assessment of functional exercise capacity in patients with COPD.[32] In this study, we demonstrated that patients with poor quality sleep walked a clinically significant lower distance in six minutes compared with distance walked by good sleepers. The current study also shows that there is a strong negative correlation between sleep quality and exercise capacity. A study by Chen et al of patients with stable COPD reported that subjects with poor sleep had shorter 6MWD, worse quality of life and more depression or anxiety symptoms.[33] Exercise capacity in patient with COPD is related to severity of dyspnea which is a contributory factor to poor sleep. In COPD, peripheral airway obstruction progressively traps air during expiration, resulting in hyperinflation particularly during exercise. This results in dyspnea and limitation of exercise capacity.[1]

Furthermore, poor exercise capacity may also be related to daytime fatigue which may be a consequence of impaired sleep and dyspnea. Reishtein reported that dyspnea correlated with both fatigue and sleep difficulty.[34] In another study by Kapella, dyspnea, depressed mood and sleep quality were strongly correlated with subjective fatigue. He also found that fatigue is an important problem that affects performance of daily activities in people with COPD.[35]

Moreover, exercise capacity provides prognostic information in COPD. Spruit et al reported that the best predictive thresholds of the 6MWD were 334 meters for increased risk of death and 357 meters for exacerbation-related hospitalisation.[36] In our study, patients with impaired sleep walked distances which were below these thresholds. This observation could also account for relationship between poor sleep quality and increased exacerbation risk as well exercise tolerance in our patients.

There are other contributing factors to exercise limitation such as complexity of the disease process, BMI, depression, activity patterns, muscle dysfunction as well as cardiovascular disease. As a result, exercise capacity is a reliable prognostic indicator in the COPD population and as such, a good prognostic index in patients with COPD.[11]

Although, FEV1% post bronchodilatation which is the basis of GOLD COPD severity staging, exercise capacity and HRQL were significantly associated with sleep quality, only HRQL remained an independent predictor of sleep quality. Other studies also found that HRQL was an independent predictor of sleep quality.[23,25]

Conclusion

Sleep quality is generally poor in patients with COPD and it negatively impacts their functional exercise capacity. The determinants of sleep quality are severity of dyspnea and COPD, frequency of exacerbation, exercise capacity and health status. HRQL was an independent predictor of sleep quality in this study population.

Author declaration

Competing interests: none. Any ethical considerations involving humans or animals: none. Was informed consent required? Consent was obtained, along with opportunities for individuals to opt out of the study if they so desired. An Ethics and Research Committee Clearance Certificate was also obtained. Copies lodged with the publisher.

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