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EFFECT OF AEROBIC EXERCISE TRANING ON QUALITY OF SLEEP IN PATIENTS WITH CHRONIC HEART FAILURE

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ABSTRACT

Sleep disturbances, a common compliance of the patients with chronic heart failure (HF) that can reduce quality of life. Because simple and low-cost interventions, such as aerobic exercise, help to improve sleep. Therefore, this study was conducted to determine the effect of aerobic exercises on the quality of sleep in patients with chronic heart failure. A total of thirty male patients with class II and III chronic heart failure associated with obstructive sleep apnea, their LVEF <40% within <6 months participated in this study. They were selected from the outpatient clinic of Qalyub Specialized Hospital, Qalyubia Governorate, Egypt, aged from 50 to 60 years old. They were randomly assigned into two equal groups (n= 15). Group A: received aerobic exercises (EA) for 3 sessions/week in the first two months then 4 sessions/week in the third month on non-consecutive days plus routine physiotherapy and medical treatment program. Group B: received routine physiotherapy and medical treatment programs only. The study outcome variables namely, left ventricle ejection fraction (LVEF), sleep quality, and quality of life were measured before and after treatment program duration. Within group analysis, both groups (A) and (B) showed significant increase in LVEF, however significant reduction in STOP-Bang, Pittsburgh sleep quality index (PSQI), and Minnesota living with heart failure questionnaire (MLHFQ) scores. Between groups analysis, post treatment results revealed significant difference in all study variables in favor of study group (A). It could concluded that, aerobic exercise training might be a very effective rehabilitation approach to improve quality of sleep and life in patients with chronic heart failure associated with obstructive sleep apnea.

Key Words: Aerobic exercises, Chronic heart failure, Obstructive sleep apnea, Quality of sleep, Quality of life.

INTRODUCTION

Heart failure (HF), which affects approximately 23 million people worldwide. Many factors contribute to the development and progression of HF; one of these is obstructive sleep apnea (OSA). The prevalence of OSA is substantially higher in patients who have HF with reduced ejection fraction (HFrEF) or HF with preserved ejection fraction (HFpEF) than in the general population **(Khattak, *et al.*, 2018).**

Obstructive sleep apnea (OSA) can accelerate the progression of heart failure (HF) by increasing pre-load and causing the septum to shift to the left, potentially compromising left ventricle function. Apnea and hypopnea activate the sympathetic nervous system, leading to increased blood pressure, heart rate swings, and endothelial dysfunction **(Pearse and Cowie 2016).**

Obstructive sleep apnea (OSA) is a sleep condition associated with reduced health-related quality of life (HRQoL). This may be related to poor sleep quality due to repeated breathing cessations and fragmented sleep **(Berg *et al.*, 2020).**

Obstructive sleep apnea (OSA) is common in patients with HFpEF, but its causal role is unclear. OSA may contribute to hypertension, ventricular hypertrophy, and HFpEF over time. Intermittent hypoxia stimulates the sympathetic nervous system, renin-angiotensin-aldosterone system, and systemic inflammatory state. HFpEF may develop sleep-disordered breathing and share common comorbidities like obesity and diabetes **(Cistulli, *et al.*, 2023).**

Effective treatment of obstructive sleep apnea (OSA) is an important goal due to its impact on quality of life, and the known cardiovascular and neurocognitive consequences of chronic heart failure. OSA is also associated with an increasing economic and social burden **(Cistulli, *et al.*, 2019).**

Treatment for sleep disturbances includes medication and non-pharmacological interventions. Due to the complications of drug treatments in the treatment of sleep disturbances, it is necessary to seek simple, appropriate, and non-pharmacological approaches to improve the sleep pattern of these individuals. Among the available non-pharmacological interventions, the effect of exercise on the sleep quality of patients with fibromyalgia and kidney transplant, elderly with sleep disturbances has been confirmed **(Pourhabib *et al.*, 2018)**.

Exercise is a strategy to improve OSA and cardiovascular disease (CVD). It reduces the apnea hypopnea index (AHI), improves oxygenation, and improves sleep architecture in patients with OSA. There are several plausible mechanisms by which exercise improves OSA: (1) reduced systemic inflammation, (2) improvements in extracellular fluid distribution with a reduction in rostral edema during sleep, and (3) improved airway tone. Exercise improves OSA independent of weight loss **(Collen *et al.*, 2020).**

Physical training should be considered as adjunct therapy for patients with chronic heart failure. Recent results have been shown that exercise is considered beneficial for these patients in terms of improved mortality and morbidity, quality of life, functional capacity and improved cardiac and vascular function **(Servantes, *et al.*, 2011).**

However, there is limited study on the effect of aerobic exercise training on the quality of sleep in patients with heart failure. Regarding the effectiveness of aerobic exercise training as a simple non-pharmacological intervention and the prevalence of sleep disturbances in patients with heart failure **(Edelmann *et al.*, 2017).** The present study was aimed to investigate the effect of aerobic exercise training on the quality of sleep in patients with chronic heart failure associated with obstructive sleep apnea.

PATIENTS AND METHODS

Study design: A single blinded randomized controlled trial study conducted from September 2023 to May 2024.

Subjects:

Thirty male patients with chronic heart failure associated with obstructive sleep apnea with LVEF <40% within <6 months **(Pourhabib *et al.*, 2018),**were participated in this study. They were selected from the outpatient clinic of Qalyub Specialized Hospital Qalyubia Governorate, Egypt. Their ages ranged from 50 to 60 years old. They were functionally classified as class II and III according to New York Heart Association (NYHA) **(Lodi-Rizzini *et al.*, 2022).** They had the same level of functional capacity assessed by 6-minute walking test, They were randomly subdivided into two groups equal in number (n= 15).

Patients were excluded from this study if they manifested: Uncontrolled atrial fibrillation, uncontrolled diabetes mellitus, myocardial infarction or recurrent angina within <3 months, chronic chest diseases, severe stenotic valvular disease, clinically significant peripheral vascular disease, exercise-induced angina, ST segment changes or exercise induce AV block, chronic renal failure, and any cognitive impairment that interferes with prescribed exercise procedures **(Gupta *et al.*, 2022)**.

Sample size calculation:

A power analysis using the G^* power computer program (Version 3.1) indicated that a total sample of 30 patients (two groups; 15 per group) would be needed to detect large effects (effect size f =0.425 based on a previous study by **Servantes, *et al.*, (2011)** with 80% power using a F test (ANOVA), repeated measures, between groups) between means with alpha at 0.05. **Figure 1** shows the flow chart for the recruitment process.

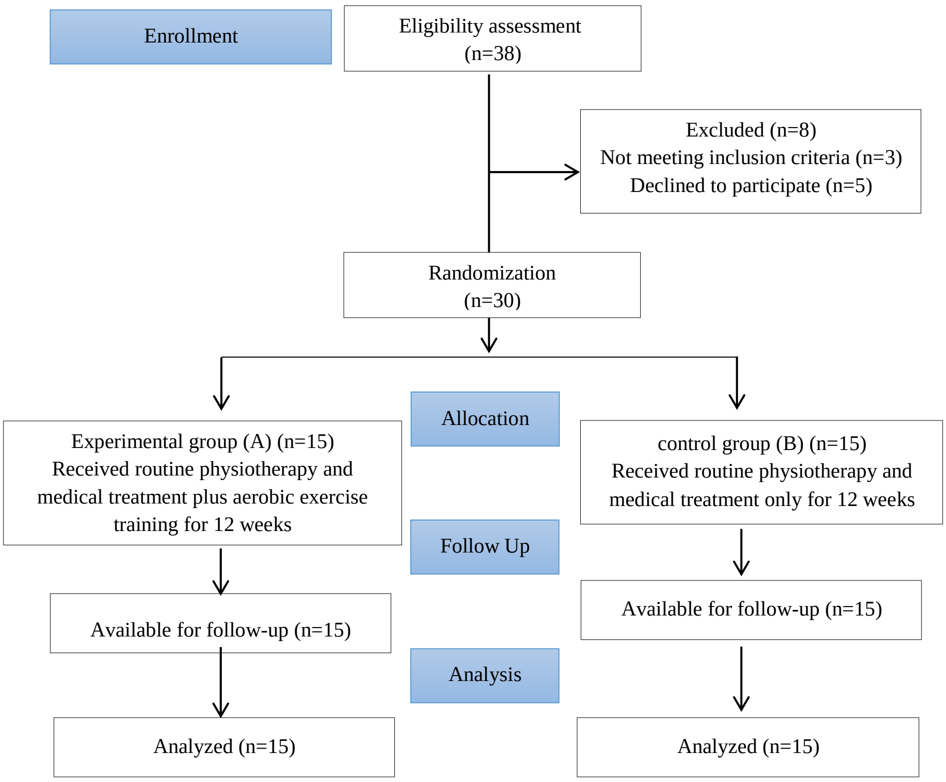

Figure 1: Flow chart of the study.

Procedures:

Assessment procedures:

Before conducting the study, the aim and protocol of this study were described for all participants, who signed the consent form of acceptance for participation. The assessment and analysis were done by one trained researcher.

Assessment for eligibility of subjects:

Detailed medical and clinical histories vital signs, and BMI kg/m^2 were taken for patients and recorded in a recording data sheet. Physical examination was done to include patients in the study according to selected criteria.

Cardiac function: it was assessed using Echocardiography machine to measure left ventricular ejection fraction (LVEF). Patient lied on a table in a dark room so the technician can better see the video monitor, Gel was put on patient's chest to help sound waves pass through the skin. The Technician might ask the patient to move in left lateral decubitus or hold breath briefly to get better pictures, The probe (transducer) was passed across patient's chest. The probe produces sound waves that bounce off the heart and "echo" back to the probe. The sound waves were change into pictures and displayed on a video monitor. The pictures on the video monitor were recorded so doctor can look at them later **(Pourhabib *et al.*, 2018).**

Obstructive sleep apnea: it was assessed by **STOP-Bang questionnaire.** It was an OSA screening tool with high diagnostic accuracy, ease of use, and clear risk stratification. It consisted of four self-reportable items and four demographic items. The questionnaire had been used worldwide due to its high diagnostic accuracy. However, two items, BMI and neck circumference, may be influenced by region-specific body characteristics. Each patient should be instructed to complete all items honestly **(Pivetta *et al.*, 2021).**

Quality of sleep: it was assessed by Pittsburgh sleep quality index (PSQI). It comprises 19 individual items that generate seven component scores, including subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleeping medication, and daytime dysfunction. These component scores are summed to yield a global PSQI score ranging from 0 to 21, with higher scores indicating poorer sleep quality **(Niu *et al.*, 2023).**

Quality of life: using the Minnesota Living with Heart Failure Questionnaire (MLHFQ), which was used to evaluate patients with heart failure, assessing their quality of life. The questionnaire contains 21 items rated on a six-point Likert scale, ranging from 0 to 5. The higher the score, the worse the quality of life. The questionnaire was coded and confidential **(Fox *et al.*, 2021)**.

Treatment procedures:

1. **Aerobic exercise training:** training consisted of walking on a treadmill at 50% to 70% of the heart rate reserve (HRR) 3 days per week (48 hr. interval between sessions) for 12 weeks, under the supervision of a physiotherapist. Sessions lasted 30 to 60 min, being preceded by a short warm-up session on treadmill at approximately 40% HRR and followed by a short recovery and stretching session. The Borg scale was applied every 5 min during walking. Heart rate (HR) was continuously monitored with Polar RS 400 monitors (Polar Electro Oy, Kempele, Finland). Resting systolic and diastolic pressures were measured with a digital sphygmomanometer (Omron, Japan) before and after each session. All patients were weekly followed-up by the team of professionals whose goal was to conduct an informal interview at the beginning of each session, with questions about possible difficulties, expectations and satisfactions in relation to the ET protocol, thereby monitoring their commitment to voluntarily participate in all stages of the study **(Servantes, *et al.*, 2011)**.

Before and after completing exercise for 5 to 10 minutes, they performed warming and cooling (40 minutes per session, in the first month). After completing the 4 weeks, the group performed a light intensity exercise program (using a dumbbell 500 grams in 30 minutes 3 times a week) in addition to a 30-minute aerobic (up to 60 minutes per session in the second and third month). In each session, the exercise program at 3 o'clock in the normal room temperature (18 to 22 degrees Celsius), with clothing (cotton, lightweight and appropriate season) and suitable sports shoes (lightweight, with strap and foot arch protector, participants were advised to feed their diet at least two hours before exercise **(Pooranfar *et al.*, 2014)**.

2. There was no intervention in the control group and this group received only routine physiotherapy and medical treatment prescribed by the cardiologist.

Ethical consent:

A study was conducted in accordance with the declaration of Helsinki (Code of Ethics of the World Medical Association). The study protocol was approved by the Ethical Committee of the Faculty of Physical Therapy, Cairo University, Egypt, by the subjects participation was authorized by a signed written consent form with Legal guardian's acceptance for participation before starting the study procedures.

Statistical analysis:

Statistical analysis was performed using the Statistical Package for the Social Sciences (SPSS), version 25.0 for Windows (IBM Corp., Armonk, NY, USA). The Shapiro–Wilk test was used to assess the normality of data distribution, while Levene's test was applied to evaluate the homogeneity of variances between groups. Unpaired t-test was conducted to compare subject characteristics between groups. A mixed multivariate analysis of variance (MANOVA) was employed to examine both within- and between-group effects on LVEF, STOP-Bang, PSQI, and MLHFQ scores. Post-hoc pairwise comparisons were performed using the Bonferroni correction. A significant level of $p < 0.05$ was adopted for all statistical tests.

RESULTS

Subject characteristics:

Table (1) shows the subject characteristics of group A and B. There was no significant difference between groups in age, weight, height, and BMI ($p > 0.05$).

Table 1. Basic characteristics of participants.

	Group A	Group B	MD	t-value	p-value
	mean ± SD	mean ± SD			
Age (years)	54.60 ± 4.21	54.53 ± 3.58	0.07	0.05	0.96
Weight (kg)	109.07 ± 7.27	106.67 ± 6.27	2.4	0.97	0.34
Height (cm)	173.47 ± 4.18	174.27 ± 3.94	-0.8	-0.54	0.59
BMI (kg/m²)	36.19 ± 1.37	35.13 ± 1.98	1.06	1.71	0.10

SD, Standard deviation; MD, Mean difference p value, Probability value

Effect of treatment on LVEF, STOP-Bang, PSQI and MLHFQ scores:

Mixed MANOVA revealed that there was a significant interaction of treatment and time (F = 9.79, p = 0.001, η^{2-} = 0.53). There was a significant main effect of time (F = 67.13, p = 0.001, η^{2-} = 0.89). There was a significant main effect of treatment (F = 3.62, p = 0.02, η^{2-} = 0.29).

Within group comparison

There was a significant increase in LVEF in both groups post-treatment compared with pre-treatment (p < 0.001). There was a significant decrease in STOP-Bang score, PSQI and MLHFQ scores in both groups post-treatment compared with pre-treatment (p < 0.001). (Table 2).

Between group comparison

There was no significant difference between groups pre-treatment (p > 0.05). Comparison between groups post treatment revealed a significant increase in LVEF (ES = 0.99), and a significant decrease in STOP-Bang score (ES = 1.04), PSQI score (ES = and MLHFQ score (ES = 0.98) of group A compared with that of group B (p < 0.01). (Table 2).

Table 2. Mean LVEF, STOP-Bang, PSQI, and MLHFQ scores pre and post treatment of group A and B:

	Group A	Group B		
	Mean ±SD	**Mean ±SD**	**MD**	**P value**
LVEF (%)				
Pre treatment	**33.20 ± 2.54**	**31.87 ± 2.33**	**1.33**	**0.14**
Post treatment	**35.41 ± 2.75**	**32.89 ± 2.32**	**2.52**	**0.01**
MD	**-2.21**	**-1.02**		
	p = 0.001	***p = 0.001***		
STOP-Bang score				
Pre treatment	**6.27 ± 1.33**	**6.33 ± 1.35**	**-0.06**	**0.89**
Post treatment	**4.60 ± 0.99**	**5.67 ± 1.18**	**-1.07**	**0.01**
MD	**1.67**	**0.66**		
	p = 0.001	***p = 0.001***		
PSQI score				
Pre treatment	***14.33 ± 3.09***	***14.80 ± 3.36***	**-0.47**	**0.93**
Post treatment	***10.67 ± 2.29***	***13.27 ± 3.13***	**-2.6**	**0.02**
MD	***3.66 ±***	***1.53***		
	P =0.001	***P =0.001***		
MLHFQ score				
Pre treatment	**90.67 ± 9.31**	**92.93 ± 8.92**	**-2.26**	**0.50**
Post treatment	**80.27 ± 6.32**	**88.07 ± 8.55**	**-7.8**	**0.008**
MD	**10.40**	**4.87**		
	p = 0.001	***p = 0.003***		

SD, Standard deviation; MD, Mean difference; CI, Confidence interval; p-value, Level of significance; ES, Effect size

DISCUSSION

Heart failure (HF) is a chronic common disease that represents a clinical challenge to health care systems. Nearly 60% of patients with HF had poor sleep quality which was associated with depression, reduced physical and cognitive performance, and increased cost due to the increase of unplanned hospitalization **(Gharaibeh *et al.*, 2022).** Many researchers emphasize the importance of studying sleep quality among patients with HF **(Redeker *et al.*, 2019 ; Coniglio and Mentz 2022).**

Sleep disorder breathing (SDB) is more prevalent in HF patients than in any other population. A previous study showed that ~75% of patients with HF have SDB. It is associated with sleepiness, chronic bronchitis, peripheral edema, and dyspnea **(Ambrosy *et al.*, 2014).**

Regarding the effectiveness of aerobic and resistance exercises as a simple non-pharmacological intervention and the prevalence of sleep disturbances in elderly patients with heart failure **(Edelmann *et al.*, 2017).** The present study was aimed to investigate the effect of aerobic exercises on the quality of sleep in patients with chronic heart failure associated with obstructive sleep apnea.

The present study results showed that there was a significant increase in LVEF. However, there were a significant decrease in STOP-Bang, PSQI and MLHFO scores. The results showed that exercise improves the daily performance of patients with heart failure by improving the overall quality of sleep, sleep time, efficiency, and sleep quality. As these improvements, exercising in the form of aerobics exercise has a very good effect on cognitive and mood of each patient that would improve sleep disturbances and it would increase the cardiac function and health.

Results of **Reid *et al.*, (2010),** showed that physical activity improves the mental quality of sleep. In this study, exercise was effective on the rate of sleep efficiency of the elderly **(Reid *et al.*, 2010)**. Also, the current study results come in agreement with a recent study done by **Abd El-Kader and Al-Jiffri, (2020)** who conceded that aerobic exercise training can be considered as a non-pharmacological modality for modifying sleep quality, psychological wellbeing and immune system among subjects with chronic primary insomnia **(Abd El-Kader and Al-Jiffri 2020)**.

Furthermore, in a study done by **Tseng *et al*. (2020)**, they demonstrated that 12 weeks of moderate aerobic exercise training significantly affects sleep quality and normalizes cardiac autonomic function in middle-aged and older adults with poor sleep quality. Exercise training improves heart rate variability (HRV) by decreasing sympathetic tone and increasing vagal tone; all contribute to the reduction in heart disease **(Tseng *et al.*, 2020)**.

A previous meta-analysis summarized several randomized controlled trials and showed that aerobic exercise training has a moderate, beneficial effect on subjective sleep quality in middle-aged and older adults with sleep complaints **(Yang *et al.*, 2018).**

These finding contradicts the results of **Ranjbaran *et al.* (2015).** The reason for this difference can be related to the research community. Because in the study of **Ranjbaran *et al.* (2015)**, people performed these aerobic exercises one month after coronary artery bypass grafts, and the sleep efficiency of these individuals may have been influenced by mood-induced anesthesia. The results indicated that aerobic exercise was not affected by the duration of sleep latency. The results also showed that cardiac rehabilitation after coronary artery bypass graft does not affect the sleep latency **(Ranjbaran *et al.*, 2015)**.

So, future studies should be performed to detect the effect of different forms of aerobics exercises with different intensities on different age and sexes and durations.

Finally, according to the current study results, it was found that aerobic exercise training was a very good rehabilitation modality for improving quality of sleep among patients with chronic heart failure associated with obstructive sleep apnea.

Strength and limitations:

The limitations of the study are that due to the lack of physical space, the simultaneous presence of male and female patients was not possible. Therefore, it was limited to determine the effectiveness of exercise on sleep quality in women patients with chronic heart failure.

CONCLUSION

In conclusion, the aerobic exercise training program was shown to be an effective intervention for improving quality of sleep among patients with chronic heart failure associated with obstructive sleep apnea.

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Author contribution: Authors contributed equally to the study.

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تأثير التمارين الهوائية على جودة النوم لدى مرضى فشل القلب المزمن المصحوب بانقطاع النفس الانسدادي أثناء النوم

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تُعد اضطرابات النوم من المشكلات الشائعة لدى مرضى فشل القلب المزمن، وقد تؤدي إلى تدهور نوعية حياتهم بشكل كبير. ونظرًا لأن التدخلات البسيطة والمنخفضة التكلفة مثل التمارين الهوائية تساهم في تحسين النوم، فقد هدفت هذه الدراسة إلى تقييم تأثير التمارين الهوائية على جودة النوم لدى هؤلاء المرضى

شارك في الدراسة ثلاثون مريضًا من الذكور، مصابين بفشل القلب المزمن من الدرجة الثانية والثالثة، ويرافقهم انقطاع النفس الانسدادي أثناء النوم، وتقل كفاءة الطرد البطيني الأيسر لديهم.

شملت الدراسة ثلاثين مريضًا من الذكور تتراوح أعمارهم بين 50 و60 عامًا، تم تشخيصهم بفشل القلب المزمن من الدرجة الثانية أو الثالثة، ويعانون من انقطاع النفس الانسدادي أثناء النوم، وتقل كفاءة الطرد البطيني الأيسر لديهم عن 40% خلال أقل من 6 أشهر. تم اختيارهم من العيادة الخارجية بمستشفى قليوب التخصصي بمحافظة القليوبية، مصر، وتم تقسيمهم عشوائيًا إلى مجموعتين متساويتين n=15.

المجموعة الأولى (مجموعة الدراسة): خضعت لبرنامج تمارين هوائية بمعدل ثلاث جلسات أسبوعيًا خلال أول شهرين، ثم أربع جلسات أسبوعيًا في الشهر الثالث في أيام غير متتالية، بالإضافة إلى العلاج الطبيعي الروتيني والعلاج الطبي المعتاد.

المجموعة الثانية (مجموعة الضبط): تلقت العلاج الطبيعي الروتيني والعلاج الطبي المعتاد فقط.

تم تقييم المتغيرات التالية قبل وبعد فترة العلاج: كفاءة الطرد البطيني الأيسر، جودة النوم باستخدام مقياس بيتسبرغ لجودة النوم واستبيان ستوب بانج، وجودة الحياة باستخدام استبيان مينيسوتا لمرضى فشل القلب.

أظهرت نتائج التحليل داخل المجموعتين تحسنًا ذا دلالة إحصائية في LVEF ، وانخفاضًا في درجات PSQI ، و STOP-Bang، و MLHFQ.

وأظهرت التحليلات البعدية بين المجموعتين تفوقًا ملحوظًا لصالح مجموعة الدراسة في جميع المتغيرات بعد فترة العلاج.

تُعد التمارين الهوائية وسيلة فعالة في برامج إعادة التأهيل لتحسين جودة النوم ونوعية الحياة لدى مرضى فشل القلب المزمن المصحوب بانقطاع النفس الانسدادي أثناء النوم.