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ORIGINAL ARTICLE

Sleep Science

Effect of different types of exercise on sleep deprivation and functional capacity in middle aged patients after coronary artery bypass grafting

Hady Atef *
Zeinab Helmy
Abeer Farghaly

Cairo University, Physical Therapy for Internal Medicine - Cairo - Egypt.

ABSTRACT

Introduction: There are still many gaps in research concerning the effect of different physical training modalities on sleep quality in the population underwent coronary artery bypass graft (CABG) surgeries. **Objective:** The purpose of this study was to compare the effect of different exercise types on sleep quality and functional capacity after CABG. **Material and Methods:** 80 Participants aged 45-65 years were randomized to two groups: aerobic group (AG), and combined aerobic and resistance group (ARG). Training lasted ten consecutive weeks with 30 uninterrupted sessions. The actigraph together with Pittsburg Sleep Quality Index (PSQI) were used in sleep quality assessment. Six-minute walk test (6MWT) was used in assessment of functional capacity. The actigraph (Actiwatch Minimitter Company, Incorporated (INC) - Sunriver, OR, USA) was placed on the non-dominant wrist and activities were monitored continuously while being recorded at one-minute intervals. The participants kept the device for a period of 96 hours, filled PSQI, and did 6MWT before the first and last training sessions. **Results:** There was significant decrease in the mean value of sleep latency, fragmentation index, light sleep duration and sleep quality scores ($p<0.01$); and significant increase in total sleep duration, deep sleep duration, number of points on the actigraphy, sleep efficiency and functional capacity in both (AG) and (ARG) ($p<0.01$), that difference was more significant in the aerobic group (AG) ($p<0.01$). **Conclusions:** Both modes of exercise (aerobic alone and combined aerobic and resistance exercises) can improve sleep quality and functional capacity, but isolated aerobic exercise can do that more significantly.

Keywords: Sleep Deprivation; Exercise; Coronary Artery Bypass; Actigraphy.

***Corresponding author:**
Hady Atef
E-mail: hady612@hotmail.com

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INTRODUCTION

Poor sleep quality (SQ) is common among patients after coronary artery bypass graft surgery (CABG)[1].The results of a systematic review showed that more than 50% of patients experienced sleep problems through hospitalization and 6 months after heart surgery[2]. Factors that influence sleep disturbance during hospitalization and 6 months after discharge includes physical and environmental factors (e.g. pain, cardiac function, and noise) affecting the SQ of the patients [3]. Poor SQ interferes with the cardiac patients' quality of life.[4] And because of the ongoing obesity epidemic, previous estimates of sleep-disordered breathing prevalence require updating. We estimated the prevalence of sleep-disordered breathing in the United States for the periods of 1988-1994 and 2007-2010 using data from the Wisconsin Sleep Cohort Study, an ongoing community-based study that was established in 1988 with participants randomly selected from an employed population of Wisconsin adults. A total of 1,520 participants who were 30-70 years of age had baseline polysomnography studies to assess the presence of sleep-disordered breathing. Participants were invited for repeat studies at 4-year intervals. The prevalence of sleep-disordered breathing was modeled as a function of age, sex, and body mass index, and estimates were extrapolated to US body mass index distributions estimated using data from the National Health and Nutrition Examination Survey. The current prevalence estimates of moderate to severe sleep-disordered breathing (apnea-hypopnea index, measured as events/hour, ≥15

The exact reason of the changes in sleep happened after CABG is non-specific[5] including cognitive dysfunction, sleep disorder, delirium, and anxiety, are the important consequences of coronary artery bypass graft surgery (CABG, and as said before it is multifactorial. With more attention to the negative consequences of these changes, chronic sleep deprivation almost affect detrimentally all the body systems, and specially cardiovascular system.[6] Such as insomnia, obstructive sleep apnea (OSAAccordingly, sleep promotion strategies may be in need to be included among the interventions used to promote the cardiovascular health.[7]

A bidirectional interactions exist between sleep and exercise, both influence each other through multiple physiological and psychological pathways.[4] And because of the ongoing obesity epidemic, previous estimates of sleep-disordered breathing prevalence require updating. We estimated the prevalence of sleep-disordered breathing in the United States for the periods of 1988-1994 and 2007-2010 using data from the Wisconsin Sleep Cohort Study, an ongoing community-based study that was established in 1988 with participants randomly selected from an employed population of Wisconsin adults. A total of 1,520 participants who were 30-70 years of age had baseline polysomnography studies to assess the presence of sleep-disordered breathing. Participants were invited for repeat studies at 4-year intervals. The prevalence of sleep-disordered breathing was modeled as a function of age, sex, and body mass index, and estimates were extrapolated to US body mass index distributions estimated using data from the National Health and Nutrition Examination Survey. The current prevalence estimates of moderate to severe sleep-disordered breathing (apnea-hypopnea index, measured as events/hour, ≥15Physical activity can generally aid sleep although this link may be subject to multiple moderating factors such as sex, age, fitness level, sleep quality and the characteristics of the exercise (intensity, duration, time of day, environment).[8] That spotlights on the necessity to improve knowledge in fundamental physiology in order to understand the benefits of exercise on the quantity and quality of sleep in healthy subjects and patients.[9]

Pittsburgh Sleep Quality Index (PSQI) is a widely used valid, internally consistent, and homogenous self-reported measure of sleep quality that is used among different population.[10] And Actigraph is a watch-like devise that is widely used to measure sleep , and can be worn on the hip, shoulders, or wrist[11,12]

Some researchers reported that actigraph provided similar accuracies for sleep/wake determination in subjects as lab based measurements[13] and so does PSQI.[14] Others, claimed that actigraph does not provide valid or accurate measures of sleep due to poor wake detection[15] and PSQI is also a non-comprehensive questionnaire.[16] to test psychometric properties, and to analyze associations with psychological, sociodemographic, and behavioral factors. \n\nMETHODS\ nA German community sample comprising 9284 adult residents (aged 18–80 years Recently, findings suggested that best practice is to include both actigraph as an objective method and PSQI as a subjective one when examining sleep quality in adults.[17,18]

Our hypothesis here was that the two proposed forms of exercise (aerobic and combined aerobic and resisted exercises) would affect sleep quality and functional capacity as well in the same positive way.

MATERIAL AND METHODS

The investigation conforms with the principles outlined in the Declaration of Helsinki" (Br Med J 1964; ii: 177). Approval of **Research Ethical committee of faculty of physical therapy, Cairo University was taken for this study on 3/12/2017 under number: P.T.REC/012/001805** and a written informed consent for patient information and images to be published was provided by the patients. This randomized controlled trial include a completed CONSORT flow chart[19] and conducted in accordance with CONSORT guidelines.

I-Patients:

After the sign of the written consent forms, eighty patients (n=80) who have underwent CABG surgery since 6-8 weeks were included in this two-parallel arm study. They aged from 45-65. They were recruited during a time period of 6 months from the cardiac surgery department at the National heart institute in Cairo, Egypt and randomization was performed using the sealed envelope approach, to two groups with allocation ratio of 1:1. The two groups are aerobic group (AG) and combined aerobic and resistance group (ARG).

Inclusion criteria

Patients who had underwent CABG surgery since 6-8 weeks, their ages ranges from 45 and 65years old ,medically stable, did CABG-only treatment (not combined with valve replacement surgery) , current complaint of poor SQ (score > 2 of the SQ scale) and with body mass index ≤ 35 kg/m^2 (to lessen the risk of obstructive sleep apnea) were only included in the study.

Exclusion criteria

Any patient was known to have any unstable medical condition; history of chronic insomnia for at least one year before surgery, indicated for receiving treatments for depression and/or anxiety or sleep medications, or with any known musculoskeletal or neurological conditions that might interfere with the execution or the assessment of the exercise, was excluded from the study.

II- Instrumentation

A-Evaluation methods:

The *Pittsburgh Sleep Quality Index (PSQI)* is a subjective self-report questionnaire that assesses sleep quality over a 1-month time interval in different populations.[14]

Actigraphy

Actigraphy is a valid objective tool to assist in determining sleep patterns in wide range of people ranging from normal, healthy to patients suspected of certain sleep disorders, and from infant to adults populations.[20]

Six minute walk test (6MWT)

The 6 Minute Walk Test is a valid sub-maximal exercise test used in assessment of aerobic capacity for patients with different cardiopulmonary disorders. Changes in functional capacity can be determined by the distance covered over a time of 6 minutes.[21]AIMS AND OBJECTIVES: Walking speed is an important performance variable, but information on the minimal clinically important difference (MCID

Rate of perceived exertion (RPE)

The RPE scale is a subjective method used in the measurement of the intensity of exercise, also known as Borg/ modified Borg scale. The modified Borg RPE scale is a valid numerical scale that ranges from six to twenty, where 6 means "no exertion at all" or "very very light" as written and 20 means "maximal exertion" or "very very hard" as stated in the scale. Individuals describe their level of exertion during physical activity through choosing a number from this scale.[22]

B-Treatment options

Aerobic exercise

*Intensity***:** 13-15 on modified BORG scale (somewhat hard to hard),*Time***:** The exercise program consisted of 5 minutes warm-up, 30 minutes of moderate aerobic exercises and 10 minutes cool-down, respectively, *Frequency***:** 3sessions/week , and *Duration***:** 10 weeks.[15]

Resistance exercise:

*Intensity***:** 30% then progress to 50-60% of one repetition maximum (1RM) ,*Time***:** The exercise program consisted of 5 minutes warm-up, 30 minutes of nine exercises were selected in the following circuit order: 1) Leg Press 45º; 2) Bench Press; 3) Extensor Bench; 4) Handle Front; 5) Flexor Bench-Sitting; 6) Upright Row; 7) Plantar Flexion; 8) Seated Row, and 9) Abdominals, and 10 minutes cool-down, respectively ,*Frequency***:** 3sessions/week , and *Duration***:** 10 weeks.[23]

III-Procedures

A-Assessment procedure:

All patients were assessed before the first and last sessions via 6MWT to assess their functional capacity, 1RM to assess the resistance exercise intensity used, PSQI questionnaire and wrist actigraph (Actiwatch Minimitter Company, INC – Sunriver, OR, USA) to assess their sleep quality. Actigraph was placed on the non-dominant wrist and activities were monitored continuously and recorded at one minute intervals during wakefulness and sleep. The times of wakefulness and sleep were determined individually by means of a diary kept by the volunteers, together with the times calculated by the actigraph monitor. The participants kept the device for a period of 96 hours before the first and the last training session. The device was removed only at bath time and replaced to the wrist immediately after. The information was collected by the device and recorded by a validated algorithm (Minimitter Company - USA®) and transferred to closed technology software installed in a computer. After analysis of the exams, the data were plotted on a spreadsheet for statistical treatment.

B-Intervention procedures

After the initial evaluation and the execution of the above procedures, the participants were randomized to two groups: aerobic group (AG), and combined aerobic and resistance group (ARG). Training lasted ten consecutive weeks with sessions held three times a week on alternate days for a total of 30 uninterrupted sessions. All sessions were held in the morning[24]

AG group trained on a treadmill. Each session started and ended with five minutes of warm-up and ten minutes of cool-down, respectively. The subjects performed 20 minutes of continuous aerobic exercise from the 1st to the 4th week, with progression to 30 minutes of continuous aerobic exercise from the 5th to the 10th week.[25] During exercise, heart rate (HR) values were measured continuously on the treadmill screen.

ARG subjects did the same as AG group, in addition to completing one circuit (1st to 4th week) and was progressed to 2 circuits (5th to 10th week) with intensity of 30% then progressed to 50 to 60% RM. The rest between stations (types of equipment) is one minute, with each station consisting of a series of 15 repetitions for the upper limbs and 20 repetitions for the trunk and lower limbs.[26] At the end of each station, HR and perceived effort according to the modified Borg scale were recorded.

Statistical Analysis:

The data were collected from patients and classified into paired and independent "t" test values. Data will be statistically described in terms of mean ± standard deviation (± SD). For the current study we define the lowest worthwhile difference in the change in sleep parameters and functional capacity between groups equivalent to a risk reduction of ~8%. Thus, in order to be able to detect the smallest worthwhile difference with an effect size of d=0.6 we need 31 participants in each group with alpha=0.05 and power of 95%. In order to account for loss to follow-up we recruited up to 40 participants in each group.

RESULTS

I- Patients clinical and demographic characteristics:

Eighty patients (n=80) with CABG were included in the study, 40 received aerobic exercise training program (AG) and another 40 received combined aerobic and resistance exercise training program (ARG). Their mean ± SD values for age, weight, height (in meter), BMI, resting heart rate (in beat/min), and duration post-CABG (6-8) weeks were calculated and there was non-significant difference between both groups (p>0.05). (Table 1).

Table 1. Patients demographic characteristics (Mean± Standard Deviation).

Variable	The AG group (n=40)	The ARG group (n=40)	T value	Pvalue	
Age (year)	54.17±6.52	53.65±4.79	0.31	0.76**	NS
Weight (kg)	90.7±6.36	90.04±5.38	0.38	0.71 **	NS
Height (meter)	1.69±0.03	1.67±0.02	1.81	0.08 **	NS
Body mass index (kg/m^2)	31.92±2.58	32.22±2.3	-0.41-	0.68 **	NS
Duration of CABG (weeks)	6.96±0.83	7±0.85	-0.18	0.86 **	NS

☼= Level of significance at P<0.05. * = significant ** =NS: non-significant.

II- Sleep measurements

In spite that there was significant decrease in the mean value of *Sleep Latency, fragmentation index, light sleep duration and sleep quality scores (3=very bad, 2=bad, 1=good and 0=very good)* (P <0.01) and significant increase in *total sleep duration, deep sleep duration, number of points gained on the actigraphy, and sleep efficiency* in both the aerobic group (AG) and combined aerobic and resisted group (ARG) (P <0.01), that difference was more significant in the aerobic exercise training group (AG) (P <0.01) (Figures 1 and 2).

III- Functional capacity

Despite there was significant increase in the *Functional capacity* mean value in in both groups, (P <0.01) that difference was more significant in the aerobic exercise training group (AG) (P=0.02), (Figure 2).

DISCUSSION

In this study we aimed to find an adjusted exercise protocol as a behavioural intervention to alleviate sleep deprivation that may happen after CABG surgery and improve functional capacity as well.

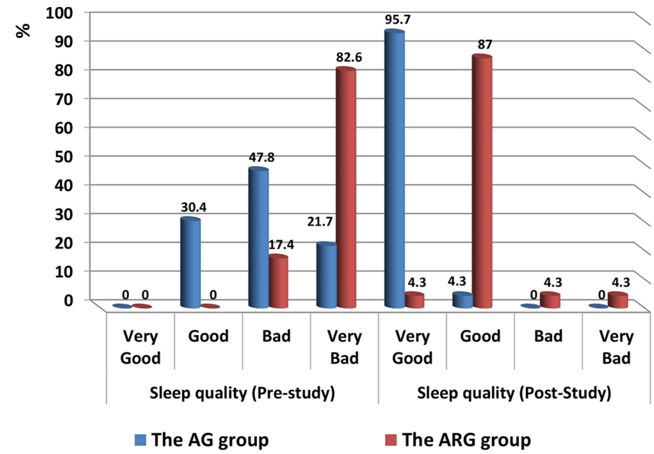

Figure 1. Percent distribution of sleep quality in both groups (pre and post-study). **AG:** aerobic exercise training group, **ARG:** the combined exercise training group.

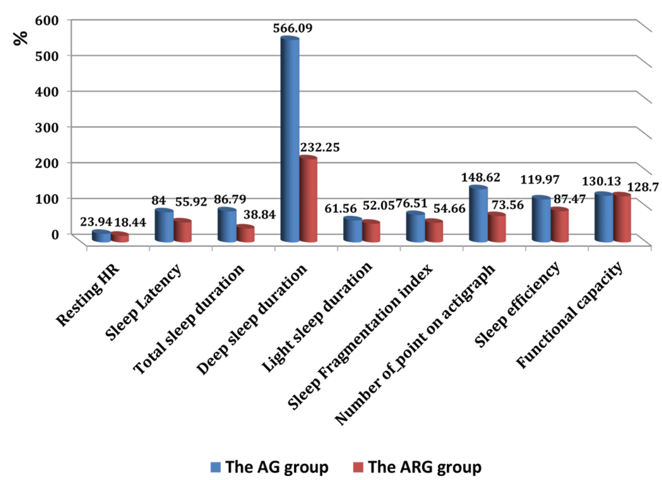

Figure 2. Percentage of change (%) of the evaluated variables in both groups. **AG:** aerobic exercise training group, **ARG:** the combined exercise training group.

Eighty patients were included in this study; as they were randomly assigned into two groups, **Group (A)** was aerobic group (AG); it included 40 patients who did isolated aerobic exercises. While, **Group (B)** was the aerobic and resisted group (ARG); it included 40 patients who did combined aerobic and resisted exercises. Both training interventions lasted ten consecutive weeks with 30 uninterrupted sessions (3sessions/week).

The sleep parameters were measured via PSQI questionnaire and actigraph at equivalent time-points at the beginning and at the end of the study for both groups, and functional capacity was measured by 6MWT.

This study demonstrated that two and half month regimen of regular exercise improved all aspects of sleep quality and functional capacity in both groups, but more significantly in aerobic group.

The current work reflects that exercise in general is a proper behavioural intervention to improve sleep quality and functional capacity after CABG. This result comes in agreement with many systematic reviews like those conducted by Ashcraft KA et al[27]**,** Chennaoui et al[28]**,** and Cable et al[29] who confirmed the positive benefits of exercise on sleep quality and functional capacity.

Meta-analysis conducted by Yang et al.[30] investigated how regular exercise impacts sleep quality in middle-aged and older adults with sleep complaints. Results indicated moderate effects in the favourable direction for regular exercise on sleep quality, and determined the acute and chronic effects of resistance exercise on sleep quantity and quality. Chronic resistance exercise improves all aspects of sleep, with the greatest benefit for sleep quality.[31] That was also flowing with our findings as well.

In our study, sleep parameters and functional capacity were improved in both groups, but more improvement was noticed with the aerobic group. These results come in parallel with de Vries JD[8], who did a two-parallel arm study on 97 subjects to investigate to what extent a low-intensity exercise intervention is effective in improving sleep quality, self-efficacy, and physical fitness. Results underlined the value of low-intensity exercise for subjects with high levels of study-related problems.

However, that was contradicting to Bonardi et al[15] who examined the effect of different types of exercises on sleep quality on ninety women who were randomized to three groups: aerobic group (AG), combined aerobic and resistance group (ARG), and control untrained group (CG). Training lasted for same period like our study, but actigraph only was used in the assessment purposes. They reported that both groups (AG and ARG) got the same benefits of exercise on sleep quality without significant difference between aerobic exercises alone and combined aerobic and resisted exercises.

Literature postulated many theories about the mechanism of exercise on sleep quality improvement, these postulations include: Thermogenic effect, anxiety reduction, increase in serotonin and subsequent antidepressant effects, immunologic alternations, and improvement in quality of life[1,5,9,10,13,23,24,25,26], and many other explanations for improvement of functional capacity with exercise including: cardiac remodeling, cardiac growth and vascular remodeling due to cellular and molecular adaptations in response to exercise.[32]

Limitations:

This study has several limitations. First, the sex differences in outcomes are representative of perioperative practice in Cairo. Similar research needs to be conducted in other settings to confirm the generalizability of our findings. Second, our data sources lacked some relevant detailed information such as smoking history. The inability to measure, and thereby adjust for, differences in such characteristics could have explained, in part, the differences in improvement rates observed in this study. Third, sample size was quite small and that was because many patients refused to share in the study when they knew that they may do resistance exercises after CABG, claiming that it is very risky exercise, and that highlight the importance of a dedicated research towards patient education about the value and safety of cardiac rehabilitation methods used after cardiac surgeries.

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APPENDICES:

1. CABG: coronary artery bypass grafting
2. AG: aerobic group
3. ARG: combined aerobic and resistance group
4. PSQI: Pittsburg sleep quality index
5. 6MWT: six minute walk test
6. INC: incorporated
7. USA: united states of America
8. SQ: sleep quality
9. CVD: cardiovascular disease
10. N: number
11. RPE: rate of perceived exertion
12. 1RM: one repetition maximum
13. SD: standard deviation
14. EXT: exercise training