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Effect Of Circuit Training On Sleep And Cognition In Collegiate With Poor Sleep Quality

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Abstract:
Purpose: *The aim of the study was to investigate the effect of circuit training on sleep and cognition in collegiate with poor sleep quality.*
Methods: *The present study was conducted among 30 subjects having poor sleep quality, who were randomly allocated via lottery method to either a circuit training group or a control group i.e., a treadmill running group. The intervention was given for 3 weeks, with 3 sessions of 30 minutes per week each. Subjects were assessed for poor sleep and cognition at the beginning and end of the 3rd week.*
Result: *3 weeks of circuit training showed significant improvement in sleep and also in working memory and attention.*
Conclusion: *Insufficient sleep is prevailing among college students. Due of their accessibility and minimal danger, non-pharmacological methods are advised. Given the findings of the present study, dynamic circuit training should be recommended as a practical approach in order to improve poor sleep and cognition in collegiate students.*
Keywords: *Circuit Training, Sleep, Poor Sleep Quality.*

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I. Introduction:

The biological process of sleep is essential for a healthy brain and systemic functions, such as metabolism, appetite control, immunity, hormonal balance, and cardiovascular system (1). It is a complex phenomenon of physiological and psychological processes (2), which is governed by two processes: the circadian process C and the homeostatic process S (3). Younger individuals should get seven to nine hours of sleep per night, according to the National Sleep Foundation in order to maintain mental and physical health. Despite the significance of adequate sleep, sleep problems are extremely common among college students (4), and greater than 50% of the collegiate experience insufficient sleep (5). Thus, it can be said that university students are increasingly experiencing a serious problem with inadequate slumber. Additionally, studies on gender variations in sleep quality in young adults have revealed that females report a marginally greater rate of bad sleep than males (6).

College life is frequently defined by alternations in lifestyle and behaviour, such as moving away from home, which fosters greater independence and less parental oversight, as well as more social interactions, and often sometimes the emergence of undesirable habits like smoking and excessive drinking (7,8), high screen time (9) and increased caffeine consumption (10) university students are especially vulnerable to getting little sleep because of these lifestyle and behavioural changes (7) and report major alterations in both quantity and quality of their sleep (11,12,13). In a recent survey of universities, students had a 39.2% incidence of sleeping for less than 6 hours per night (14). Additionally, 55 to 60 percent of college students claim that they have poor sleep quality sleep (12), and over 30 minutes are needed to fall asleep at least once, according to 43% of people (11). Also, poor sleep impairs a wide range of cognitive processes including learning, memory, attention, language, thinking, and decision-making (13, 15,16). According to the National Institute of Health (2015) who obtain poor sleep requires more time to complete tasks, has a slower reaction time, and makes an increased number of mistakes.

Sleep quality can be measured with both objectives like PSG, and subjective instruments like sleep diary and PSQI (17). Of these, the PSQI is the most widely used measure of global sleep quality which covers subjective sleep quality, sleep latency, sleep duration, sleep efficiency, sleep disturbance, daytime dysfunction, and use of sleep medications.

According to AASM, exercise may be a non-pharmacological intervention for bettering sleep quality (18). In a systemic review of 34 studies, 29 studies revealed a beneficial relationship between physical exercise

and sleep duration and quality across all age groups (19). Moreover, studies have shown that physical activity has the biggest effects on working memory, spatial memory, and executive attention (20,21). According to Kelly *et al.,* (2017)(22), Adults over the age of 18 who participated in exercise therapies such as aerobic, resistance, or a combination of the two reported improved sleep quality. Also, a large body of research shows that short-term exercise improves working memory (23,24) and executive function (25,26).

Given these results, we may speculate that combining two exercises i.e., aerobic and resistance in the form of circuit training interspersed into the same session might expand the benefits of physical exercise on sleep and cognition in adults and from the beginning to the finish of the session, this program intermittently stimulates the neuromuscular and cardiovascular systems.

II. Methodology:

Participants:

On the basis of inclusion and exclusion criteria, a total of 30 participants having poor sleep quality were chosen. Software G*power 3.1.9.7 was used to determine the sample size. Sample size was estimated using the changes in sleep quality (global PSQI) in response to combine training used in the previous study by Sousa, 2017. Considering the effect size of 1.03, α prob err 0.05 and power 0.95, 24 participants were deemed to be required to test the study hypothesis. Considering 15% dropouts, the sample size was 28 but we have taken 2 extra participants as a precautionary measure. So, the final sample size considered in the present study was 30 participants (n=15 in each group).13 males and 17 females between the age of 18 and 30 were chosen.

Subjects with poor sleep quality were chosen from Physiotherapy department of SGT University, Gurugram, Haryana. . The study proposal was submitted to an ethical committee for approval, and the study was approved by the SGT University Institutional Ethical Committee (IEC) under the following SGT/FPHY/2022/14.

Study design was a control group experimental study with a pre-test and post-test design. All the subjects in the study underwent a basic assessment for sleep and cognition i.e., PSQI, Simon game, Stroop test, and Reaction time, and then they were randomly assigned into one of two groups: Group A- Experimental Group (n=15) i.e., Circuit Training and Group B- Control Group (n=15) i.e., Treadmill Running. Data was gathered twice during the study: first at the beginning of the study and again at the end of the 3rd week after the intervention.

Outcome Measures:

The Pittsburgh Sleep Quality Index (PSQI), a self-reported tool designed to assess sleep quality and disruptions during a 1-month period was used. According to Spira AP *et al.,* (2012)(27), PSQI is a valid and reliable instrument for measuring sleep quality. The IPAQ-SF was used to measures the number of days and hours spent engaging in PA of moderate to vigorous intensity, walking for at least ten minutes, and sitting down on weekdays over the previous seven days. Moreover, the average reaction time, was evaluated using the ruler drop test. Whereas, working mwmory was measured by Simon game and Attention was measured by Stroop test.

Pittsburg sleep quality index (PSQI):

Sleep quality was assessed using the PSQI. Subjective sleep quality, sleep latency, sleep duration, sleep efficiency (the proportion of sleep time spent in bed), sleep disturbances (nighttime awakening), usage of sleeping medicine, and daytime dysfunction (distress and impaired daytime functioning) are the seven categories included in this instrument. Answers were graded on a scale of 0 to 3 (a total score of 21). Poorer sleep quality is indicated by higher scores. (17) and according to (27) PSQI is a valid and reliable instrument for measuring sleep quality.

International Physical Activity Questionnaire-Short Form (IPAQ-SF):

The IPAQ-SF measures the number of days and hours spent engaging in PA of moderate to vigorous intensity, walking for at least ten minutes, and sitting down on weekdays over the previous seven days. (28) and according to Craig CL et al., (2003) and Lee P.H et al., (2011) (29) IPAQ-SF is a valid and reliable instrument for measuring physical activity.

Ruler Drop Test:

The average reaction time, was evaluated using the ruler drop test, you will need an Assistant and Metre ruler . The person to be tested stands or sits close to the edge of a table, placing their elbow on the surface so that their wrist hangs over the side. The participant's thumb and index finger are not touching when the assessor holds the ruler between them, vertically in the air. The participant's fingers should be in line with the zero mark.When someone is prepared, they should signal it. Release the ruler abruptly and let it fall; the subject

must grab the ruler as soon as they see it start to fall. Observe and mark the point where the person hold the scale. Follow this procedure 3 times and take the average value. According to Del Rossi G *et al.,* (2014) The ruler Drop test is comparable and reliable to assessing the average reaction.

Stroop Color Word Test:

Standard Stroop charts has 3 different conditions. In the first "word test" in which participant had to read the words printed in black (i.e., red, green, blue, and yellow).in the second "colour test" in which the participant needed to name the colour of the rectangles and in the third condition (interference), the participant had to name the colour of the ink in which the words are written. The meaning of each word had to be ignored, since it was incongruent with the colour to the name (e.g., the word "green" written in red) (Grant Aram Killian. Stroop Colour and Word Test. Test Critiques). Count the number of correct answers obtained during that 45 second giving a measure of executive function control, inhibition, automatic reactions, and selective attention. (30,31)

Simon Game:

The SIMON game served as the inspiration for the working memory mobile application. A random pattern of colours and noises were repeated. Another random colour-sound combination was added to the prior sequence as each level was completed. Three times this test was conducted. (32).

Procedure:

The entire method of the study was explained to the subjects before the start of the study, and informed consent was obtained prior to the procedure. On the basis of inclusion, total of 30 participants having poor sleep quality were included, 13 males and 17 females between the age of 18 and 30 were chosen. All the subjects in the study underwent a basic assessment for sleep and cognition i.e., PSQI, Simon game, Stroop test, and Reaction time, and then they were assigned into one of two groups: Group A- Experimental Group (n=15) i.e., Circuit Training. In Circuit-training which consisted of Aerobic training and Resistance Training interspersed into same session was given for 3 consecutive weeks (3 times a week) on alternate days with 24 hours intervals following each session. For evaluating the intensity of walking-related physical exercise, we employed Borg scale values between 11 and 13. A sequence of each session included in this sequence i.e., Walking and seated row for 10 minutes; 2 minutes of Walking and 2 minutes Leg Curls; 2 minutes of Walking and 2 minutes of Bench Press; 2 minutes of Walking and 2 minutes of Abductor Machine; 2 minutes of Walking and 2 minutes of Pushdown; 2 minutes of Walking and 2 minutes of Adductor Machine; 2 minutes of Walking and 2 minutes of Biceps Curls; 2 minutes of Walking and Group B- Control Group (n=15) i.e., Treadmill Running. In treadmill training participants were asked to run on the treadmill for 30 minutes (3 times a week) on alternate days for 3 consecutive weeks. The Borg scale was used to measure the level of physical training intensity for running, with values between 11 and 13 being employed. After completion of 3 weeks of circuit training and treadmill running, the next day participants were analysed for Sleep quality and cognitive tests i.e., PSQI, working memory, attention, reaction time, and their values were noted.

III. Data Analysis:

Data analysis was done by SPSS Software version 26. All of the variable's mean and standard deviation were determined. Tables and graphs were used to display the data's properties. At $p<0.05$, the results were considered statistically significant. Paired t-test was used to analyse intergroup differences in the PSQI questionnaire, Reaction Time, Simon Game, word test, colour test, and colour-word test at baseline and the end of 3rd week.An Independent sample t-test was used analyse and compare the intra-group differences for the variables PSQI Questionnaire, Reaction Time, Simon Game, Word Test, Colour Test, Colour-Word Test.

IV. Result:

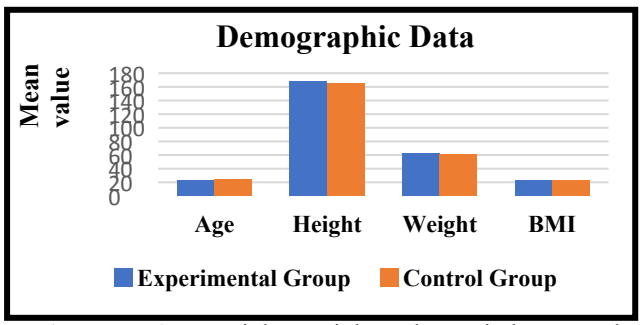
Mean of Age, Height, Weight and BMI in between the Group

This study was done on 30 subjects who were equally divided into two groups, with 15 subjects in each group. The Mean Valueof Age for subjects in Experimental Group and Control Group was 22.40 and 24.60 respectively. The Mean Value of Height for subjects in Experimental Group and Control Group was 167.65 and 164.51 respectively. The Mean Value of Weight for subjects in Experimental Group and Control Group was 61.93 and 61.20 respectively. The Mean Value of BMI for subjects in Experimental Group and Control was 22.09 and 22.58 respectively. (Table 5.1 and Graph 5.1)

Table: 5.1 – Comparison of Mean Age, Height, Weight and BMI in between the Group

	Group	Mean	Std. Deviation

Age	Experimental Group	22.40	2.23
	Control Group	24.60	2.56
Height (cm)	Experimental Group	167.65	9.17
	Control Group	164.51	12.71
Weight(kg)	Experimental Group	61.93	9.72
	Control Group	61.20	11.25
BMI	Experimental Group	22.09	3.51
	Control Group	22.58	3.05



Graph: 5.1 – Mean Age, Height, Weight and BMI in between the group

Changes In Reaction Time And Simon Game And Word Test And PSQI In Experimental Group

Paired T-test was used to analysed within Experimental Group and showed significant differences in Reaction Time (0.002*), Simon Game (0.040*), Word Test (0.005*) and PSQI (0.010*). Graphical representation of mean comparison within Experimental group showed significant differences.

V. Discussion:

Purpose and main findings of the study:

The present study was primarily designed to see the effects of circuit training on sleep and cognition in collegiate with poor sleep quality. Although previous researches have examined the effect of long duration of different types of exercise on sleep and cognition in a different population, however, to the extent that we know, till date no research has been done to examine the effect of 3 weeks of circuit training on sleep and cognition in collegiate students. The primary findings of the study were: (1) females were found to have poor sleep quality with slightly higher prevalence than males. (2) overall sleep quality and its components were improved after 3 weeks of circuit training. (3) circuit training results significant differences in working memory and executive function.

Effect of circuit training on sleep in collegiate with poor sleep quality:

Our study found that overall components that make up good sleep are subjective sleep quality, sleep latency, sleep length , habitual sleep efficiency, sleep distruptions , and daytime dysfunction were improved after 3 weeks of circuit training. The present findings are in accordance with those studies that confirmed a positive effect of exercise on sleep. (33,1,20).

The current research reflected that physical activity in general is a suitable behavioural change to enhance sleep quality. In line with our results, of a previous study (1) that showed continuous advantages of combination training (strength training with aerobic activity) on the quality of sleep in hypertensive older women. The combined training protocol that these researchers used was executed over the course of 10 weeks on alternate days for a total of 30 continuous sessions. The protocol included strength training at 50 to 60% of 1 RM and (one circuit with leg press at 45-degree, bench press, extensor bench, handle front, flexor bench-sitting, upright row, plantar flexion, seated row, and abdominals from 1st to 4th week, with a progression to 2 circuits between 5th and 10th week) as well as aerobic exercises done on the treadmill for 20 minutes, from the 1st to the 4th week, with a progression to 30 minutes from the 5th to the10th week. Additionally, Sousa et al., (2017)(20) have shown that circuit training (resistance training and aerobic training interspersed in the same session for 8 weeks (3 times a week) with 24-hour interval rest between each session. Sequence of each session included the following 10 minutes of walking; seated row; 2 minutes of walking; leg curl; 2 minutes of walking; bench press; 2 minutes of walking; abductor machine; 2 minutes of walking; push-down; 2 minutes of walking; adductor machine; 2 minutes of walking; biceps curl; 2 minutes of walking, may provide benefits on the quality of sleep of elderly. However, some research has found that aerobic or resistance training improves sleep quality in adults. Ezati *et al.,* (2020)(33) found that 8 weeks of intensified aerobic exercise influenced all components of sleep quality in female dormitory students. However, studies investigating the effects of resistance training on sleep of older adults with major depression (34,35), women with fibromyalgia (36), generalized anxiety

training disorder (37) and heart failure (38) have reported significant improvement in subjective sleep quality, SE and Sleep Latency. In addition to this there are few studies (39,40,41) that found no association between sleep and physical activity. Confounding factors may be responsible for the variance in the results (i.e., type of exercise, use of medications, lifestyle factors, disease, and age).

A no of mechanisms has been proposed to explain improved sleep following exercise like theories of energy conservation, thermoregulation and body restoration. As the body attempts to regain homeostasis while we sleep by using the same systems that we use to regulate our body temperature during the day. This results in a reduction in body temperature of about 0.5°C by dilatation of blood vessels and increased blood flow to body's periphery (42). This process acts as a catalyst of sleep initiation. Furthermore, exercise may affect sleep via the cardiac system by increasing the re-entrainment to a shifting light-dark cycle. (39).

Although many studies have already been done on various exercise protocols such as aerobic resistance or combination in different populations (>18 years) but the reason we suspect for the greater effect on sleep in our study in such short duration could be due to the combined exercise protocol interspersed in the same session ie. Aerobic and resistance training via circuit training and that to in younger adults therefore physiological processes might have played a considerable role in showing short duration effects in the present study.

Considering the following results of the studies we can say that combined, aerobic and resistance training was effective in improving sleep quality but we should emphasize that our protocol of 9 sessions showed positive benefits comparable to studies using longer intervention times. Thus, our 3-week circuit training routine may help to improve sleep quality.

Effect of circuit training on cognition in collegiate with poor sleep quality:

According to our findings, 3 weeks of circuit training also brought significant differences in the Simon game which measures working memory, and Stroop word test, Stroop colour test, and Stroop colour-word test which measures executive functions in collegiate with poor sleep quality. These results are congruent with earlier studies that showed that exercise has the biggest impact on spatial memory, (WM), and executive function (21,43).

Working memory is thought to be a fundamental cognitive process that enables the brain to concurrently retain and manipulate information. information. The frontal and parietal networks are active during working memory, and the prefrontal cortex (PFC) is thought to be a key brain region engaged in working memory. The results of previous studies have shown that various forms of exercise enhance working memory. Some of these researches exclusively used aerobic exercise (or resistance exercise or a combination of different kinds of exercise.

In addition to this, our study showed improved performance on the Stroop test. Our findings follow the earlier studies, which claim that aerobic exercise promoted a beneficial effect on the Stroop test performance (44,39) included 67 inactive older individuals in their study and were randomly allocated to a group that underwent resistance training, high-intensity aerobic interval training or moderate continuous aerobic training for 16 weeks, and cognitive functions were assessed with a Stroop test. For the development of older people's executive function, Moderate continuous aerobic training (MCT) and resistance training (RT) were found to be superior to high-intensity aerobic interval training (HIIT), although HIIT was most helpful for the improvement of information processing speed. Moreover, Alves et al,2012 did a study to compare the acute effects of aerobic versus strength exercise on selected executive functions in healthy middle-aged women. The findings of this study were that both aerobic and resistance training for 3 months can improve performance in the Stroop test. Although we suspect improvements in working memory and Stroop test could be due to the enrolled population and use of inventory method i.e., circuit training interspersed in the same session compiled to be the reasons for our results. The underlying protective effect of physical exercise on cognition can be explained by multiple mechanisms. Physical changes that take place in the body as a result of physical exercise are the basis for physiological mechanisms such increased cerebral blood flow, adjustments in neurotransmitter release, structural changes in the CNS, and changed arousal levels. Exercise surges angiogenesis, synaptogenesis, and neurogenesis according to data. At a molecular and cellular level, it has been hypothesised that exercise increases the availability of growth factors like BDNF, insulin-like growth factors-1 (IGF-1), and VEGF. (45)

Our last outcome i.e., the reaction time illustrated the improvements in both the groups (Experimental and control). It is the amount of time that passes between sensory stimulus and the time it takes for a motor response. The reason for improving the reaction time in both groups was the involvement of the peripheral nervous system which played an important role in the exercise. The sympathetic nervous system is stimulated during exercise, which results in a rise in blood pressure and heart rate. Epinephrine was also released in order to enable the body to continue exercising at higher HR and blood pressure levels. Epinephrine reduces total peripheral resistance and induces dilatation in the arteries by attaching to a beta-2 receptor on them. Blood flow to all parts of the body was boosted as a result of these modifications. The brain's ability to think clearly

improved with increased blood flow. Exercise helped the brain to respond to stimuli more quickly, as indicated by the fact that blood pressure increased after acute exercise.

Since participants that were taken in our study had no cognitive impairments; they only had poor sleep quality. We only assess the cognition at baseline and after the 3 weeks of intervention which significantly improved as their sleep quality improved. Therefore, circuit training helped in improving cognition as well.

Gender differences:

Gender differences in poor sleep have been previously reported for the older population (46) but evidence from some recent studies also found gender differences to be present in sleep quality in young adults (47). In general, (6)and (47) revealed that a majority of the study's participants had poor sleep habits, with women experiencing this problem at a somewhat higher rate than men. But after correcting the sociodemographic, lifestyle, and psychological variations, another study found no differences between genders in terms of sleep quality.. (48) Though we have not measured any physiological mechanism behind the gender differences in poor sleep. however, one study suggested that sex hormones could be the reason through which gender disparity in poor sleep is exhibited. Sex hormone impacts sleep via a variety of genetic and non-genetic pathways, and including neurochemical and vascular systems (49).

Limitation of the study

1. The sample size was small, because of the small sample size and timing of measures, it was hard to determine the extent to which circuit training improves sleep and cognition in collegiate students with poor sleep quality.
2. Only short-term effects were evaluated, and we don't know how long such effects will continue.
3. self-rated subjective measures were used to assess sleep quality and physical activity which might lead to potential bias.
4. All the domains of cognition were also not tested in this study.
5. The generalizability of our study has another drawback because we used college students as a sample, which means that the findings might not apply to other populations.

Future Scope of Study

1. A more precise and reliable assessment of overall sleep, including its quality and quantity, may be provided by incorporating objective data from autography or polysomnography.
2. Follow-up needs to be taken in the future in order to find out whether this circuit training has short-term or long-term effects on sleep and cognition.
3. Many studies of long duration have been done on sleep and cognition on various population, since our study has shown the effect of 3 week of circuit training on sleep and cognition in collegiate.so, we can see the effect of our protocol on different populations in future.

VI. Conclusion:

Insufficient sleep is prevailing among college students. Due of their accessibility and minimal danger, non-pharmacological methods are advised. Given the findings of the present study, dynamic circuit training should be recommended as a practical approach in order to improve poor sleep and cognition in collegiate students.

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