Volume - 13 | Issue - 10 | October - 2024 | PRINT ISSN No. 2277 - 8179 | DOI : 10.36106/ijsr

INTERNATIONAL JOURNAL OF SCIENTIFIC RESEARCH

"COGNITION IN MOTION: ANALYZING THE COGNITIVE IMPLICATIONS OF HIIT VERSUS SEDENTARY LIVING"

General Medicine

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ABSTRACT

Aims And Objectives: To assess the effect of High-intensity interval training on the cognitive functions of young healthy adults. **Methodology:** a cross-sectional study was conducted on 30 healthy adults (15 - participants doing HIIT regularly named as cases here, 15 participants NOT DOING HIIT at all is named control here) in the age group of 18-25 years. Sleep quality scale as used to asses the quality of sleep in both groups. The following tests were used to assess the cognitive functions -1. Stroop test : congruent and incongruent 2. MoCA Test 3. Rey-osterrich complex figure test. **Results:** Control group is showing positive correlation between habitual sleep duration and Stroop test score reaction time, we observed that, as habitual sleep duration increases then stroop test score also increases, however it is not significantly correlated. Control group shows insignificant association (p value > 0.05), when habitual sleep duration is correlated with MoCA score. In control groups, Sleep quality score when correlated with Stroop test reaction time score, MoCA score and Rey Osterich complex figure test score, it showed non- significant association. Cases are evaluated two times, before performing HIIT (Pre - HIIT) and after performing HIIT (Post HIIT). Before HIIT, habitual sleep duration score is correlated with MoCA score which showed insignificant association. After HIIT, when habitual sleep duration score is correlated with MoCA score it showed significant association. **Conclusion:** HIIT shows significant improvement in the cognitive functions.

KEYWORDS

HIIT, Cognitive functions, sleep quality

INTRODUCTION

Exercise offers a wide range of benefits that extend beyond physical health to encompass mental, emotional, and even social well-being. Some prefer brisk walking, running, or cycling types of aerobic exercises while some prefer yoga, stretching kind of anaerobic exercises. High-intensity interval training (HIIT) is a popular and effective exercise method that alternates between short bursts of intense activity and periods of low intensity or rest. Emerging research is showing a positive effect of physical exercise on mental well-being [1].

Despite of extensive benefits of physical exercise most of the population across the globe does not focus on them. HIIT has emerged to be the most feasible for most people and is one of the efficacious strategies to work on. The primary feature of HIIT is that it can be performed in a short period equivalent to longer sessions of aerobic exercise training. Many pieces of evidence demonstrate the positive effect of HIIT on physical health, emotional health, reduces depression, and improves sleep quality. However, little is known about the effect of a sedentary lifestyle on the cognitive power and sleep of an individual.

Many studies show that parts of the brain that control thinking and memory are more developed in people who do regular HIIT'S than the people who don't. DR.Mc Ginnins says "Even more exciting finding is that, engaging in regular physical exercise of moderate intensity over six months or a year is associated with an increase in the volume of selected brain regions. " It has been shown that moderate-intensity workouts increase performance in working memory and cognition Whereas, HIIT improves the speed of processing as well [2].

Aims And Objectives:

1. To assess the effect of High-intensity interval training on the cognitive functions of young healthy adults.

MATERIALS AND METHODS:

After institutional Ethics committee approval, a cross-sectional study was conducted on 30 healthy adults (15 - participants doing HIIT regularly named as cases here, 15 participants NOT DOING HIIT at all is named control here) in the age group of 18-25 years. Written informed consent was obtained from participants who were involved in the study voluntarily.

Inclusion Criteria:

1. Healthy adults of 18 to 25 years age group

Exclusion Criteria:

1. Those who are not giving written informed consent.
2. Those who are taking any medication.
3. Any history of major physical/mental illness.
4. Any history of intramuscular/neurological/ psychological disorder/head trauma.
5. Any history of substance abuse, smoking or alcohol abuse.

Methodology:

The willing participants were briefed regarding the nature of the study and those were asked to come for a single contact session. On the study day, written informed consent was taken from each participant. The study was conducted in a quiet isolated room with adequate light. Subjects were asked to sit in the natural sitting comfortable position. Each subject was tested individually. Subjects were given a case record form in which detailed history was recorded.

The following methods were used in data collection:

A) The following scale was used to assess sleep quality

1. Sleep quality Scale:

This scale was used to assess the quality of sleep. This is a simple, self-reported scale, consisting of 28 items evaluating six domains of sleep quality which are – daytime symptoms, restoration after sleep, problems initiating and maintaining sleep, difficulty waking, and sleep satisfaction.

Scoring: Responses to these 28 questions are expected using a four-point Likert-type scale, respondents need to choose from four items (0= few, 1=sometimes, 2=often, 3=almost always) as applicable to them. Total score ranges from 0 to 84, with higher scores referring to more acute sleep problems [3]. Scale assesses the six domains of the sleep quality which are daytime symptoms, restoration after sleep problems initiating and maintaining sleep difficulty in waking up and sleep satisfaction. ANNEXURE A has been used as the Sleep quality scale [4].

B) High–intensity interval training (HIIT):

This group includes the participants who are indulge into HIIT for more than 2 yrs on daily basis in any forms like Squat, Push-Up, Lunge, Push-Press, Box Jump, Planks etc. Cognitive function test was conducted on participant before the HIIT and after HIIT session which may take 30 min to 40 min., Once the intervention was finished, they were again evaluated with the same cognitive function tests. Both pre HIIT and post HIIT evaluation is done on the same day.

C) Following tests to assess the cognitive functions:

1. Stroop Test:

It is a neuropsychological test extensively used to assess the ability to inhibit cognitive interference that occurs when the processing of a specific stimulus feature impedes the simultaneous processing of a second stimulus attribute, well known as the Stroop effect [5]. We used PsychoPy Demo Software version 1.83.01 which runs a digital demonstration of the Stroop effect. Colors-word task in which subjects were shown names of colors printed in conflicting ink colors (e.g., the word "red" in blue ink) and were asked to name the color of the ink rather than the word. Subjects were instructed to press the laptop keys assigned for a particular color. Instructions are as follows; Keys to press Left, Down, right for color red, green and blue respectively. After the end of the test, Reaction time for the given responses and number of errors made was recorded. This component measures mental flexibility and the ability to inhibit a dominant response as well as provide a measure of the individual's ability to inhibit stimulus bound responses and deal with inference [6]. Stroop test assess the following domains of cognition - the attentional processes, cognitive flexibility, and executive functions.

2. MoCA SCORE:

The Montreal Cognitive Assessment (MoCA) was designed as a rapid screening instrument which estimates even mild cognitive dysfunction. It assesses following cognitive domains – attention and concentration, executive functions, memory, language, visuoconstructional skills, conceptual thinking, calculations and orientation. It carries different tasks, which cumulatively scores maximum of 30 points. A final total score of 26 and above is considered normal [7]. ANNEXURE B has been used as the MoCA test [7].

3. Rey Ostrich Complex Figure Test Score:

This test is commonly used neuropsychological assessment tool. It is widely implemented to assess the visuo - constructional ability and visual memory of neuropsychiatric disorders. Many versions of this test are available, we have used an 18 scoring units version of the rey - ostrich complex figure test. Participants were asked to reproduce a complicated line drawing. Complex diagram is shown to subjects for 2 min. then they were asked recall & redraw it. Drawing is composed of 44 straight lines and circles. Score of 2 points was given for each drawn element remembered correctly: a complete straigtht line or a circle. Score of 76 to 88 points indicates an excellent memory, 60 to 74 points - good memory, 46 to 58 points - an average memory, less than 46 points - poor memory [8]. ANNEXURE C has been used for Rey-ostrich complex figure test [9].

Statistical Analysis:

As per distribution of study data, we used following tests were used for statistical analysis – 1. Descriptive statistics for frequency and percentage, 2. Pearson correlation for the group statistics, 3. Mann - Whitney U test, 4. Wilcoxon signed rank test.

RESULTS:

Table 1: Descriptive statistics (Control group)

Descriptive Statistics (Control group)			
Sleep Group			
		Frequency	Percent
Habitual sleep duration	Group1 4 hrs - 6 hrs	4	26.7
	Group 2 6 hrs - 8 hrs	9	60.0
	Group3 > 8 hrs	2	13.3
	Total	15	100.0

Table 2: correlation between habitual sleep duration and stroop tests score for controls

Correlations test (control group)			
		Habitual Sleep Hr	Stroop test score (Reaction Time)
Habitual Sleep Hr	Pearson Correlation	1	.197
	p value		.482
	N	15	15
Stroop test score (Reaction Time)	Pearson Correlation	.197	1
	p value	.482	
	N	15	15
Correlation between habitual sleep hour and Stroop test score reaction time is positively correlated that as habitual sleep hour increases then stroop test score increases, however, it is not significantly correlated			

Table 3: Correlation between habitual sleep duration and MoCA score for controls

Sleep group * MoCA Score Cross-tabulation Chi Square test						P value	Conclusion
			MoCA Score		Total		
			Mild	N			
Sleep Group	Group1	Count	2	2	4	0.244	Insignificant association (Since P value > 0.05)
		% within Sleep Group	50.0%	50.0 %	100.0%		
		% within MoCA Score	25.0%	28.6 %	26.7%		
	Group2	Count	4	5	9		
		% within Sleep Group	44.4%	55.6 %	100.0%		
		% within MoCA Score	50.0%	71.4 %	60.0%		
	Group3	Count	2	0	2		
		% within Sleep Group	100.0 %	0.0%	100.0%		
		% within MoCA Score	25.0%	0.0%	13.3%		
Total		Count	8	7	15		
		% within Sleep Group	53.3%	46.7 %	100.0%		
		% within MoCA Score	100.0 %	100.0 %	100.0%		

Table 4:

Correlation for Controls					
Sleep Quality Score	Stroop test score Reaction Time	MoCA Score	Rey-Osterich Complex figure test	Percentile	Stroop test score Errors
Pearson Correlation	.067	.276	.078	.080	.750
P value	.812	.319	.782	.777	0.001*
* P value < 0.05 Significance obtained					

Table 5 Correlation between habitual sleep duration and MoCA score in Cases before the HIIT

			(Pre-HIIT) MoCA score		Total	P value	Conclusion
			Mild	N			
Sleep group	Group1	Count	0	2	2	0.403	Insignificant association (Since P value> 0.05)
		% within Sleep group	0.0%	100.0%	100.0%		
	Group2	Count	4	6	10		
		% within Sleep group	40.0%	60.0%	100.0%		
	Group3	Count	1	2	3		
		% within Sleep group	33.3%	66.7%	100.0%		
Total		Count	5	10	15		
		% within Sleep group	33.3%	66.7%	100.0%		

Table 6 Correlation between habitual sleep duration and MoCA score in Cases after the HIIT

(Post HIIT) MOCA group			Total	Total		
			N		P value	Conclusion
Sleep	Grou	Count	2	2	0.002*	significant

 PRINT ISSN No. 2277 - 8179 | DOI : 10.36106/ijsr

group	p1	% within Sleep group	100.0%	100.0%	association (Since P value < 0.05)
	Group2	Count	10	10	
		% within Sleep group	100.0%	100.0%	
	Group3	Count	3	3	
		% within Sleep group	100.0%	100.0%	
Total		Count	15	15	
		% within Sleep group	100.0%	100.0%	

Table 7 Correlation between habitual sleep duration and Stroop test Reaction time in Cases - Pre HIIT and Post HIIT

Correlations				
		Habitual Sleep Hr	(Pre-HIIT) Stroop test score_ Reaction time	(Post HIIT) Stroop test score_ Reaction time
Habitual Sleep Hr	Pearson Correlation	1	-.292	-.110
	Sig. (2-tailed)		.290	.696
	N	15	15	15
(Pre-HIIT) Stroop test score Reaction time	Pearson Correlation	-.292	1	.696**
	Sig. (2-tailed)	.290		.004
	N	15	15	15
(Post HIIT) Stroop test score Reaction time	Pearson Correlation	-.110	.696**	1
	Sig. (2-tailed)	.696	.004	
	N	15	15	15
Correlation between habitual sleep hour and Stroop test score reaction time is negatively correlated meaning that as, habitual sleep hour increases then stroop test score decreases, however it is not significantly correlated				

Table 8 Correlation between habitual Sleep Quality score and Cognitive function tests in Cases in Pre HIIT and Post HIIT

Correlation for Cases	sleep quality score	Pearson Correlation	P value
	HIIT_Daily Hrs	-.197	.481
	(Pre-HIIT)Stroop test score_Reaction time	.097	.731
	(Pre-HIIT)Stroop test score_Errors	-.047	.868
	(Pre-HIIT)MoCA Score	.196	.485
	(Pre-HIIT)Rey Osterich complex figure test	.127	.653
	(Pre-HIIT)PERCENTILE	.400	.139
	(Post HIIT)Stroop test score_Reaction time	.027	.924
	(Post HIIT)Stroop test score_Errors	Cannot be computed due to single observation	
	(Post HIIT)MoCA Score	.222	.427
	(Post HIIT)Rey Osterich complex figure test	.236	.398
	(Post HIIT)Percentile	.187	.505

Table 9 Correlation of cognitive function tests between control group and Pre HIIT group

	Stroop Reaction time	MoCA Score	Rey-osterich complex figure test
Mann- whitney U	82.00	118.500	84.500
Asymptotic sig. (2-sided test)	0.206	0.801	0.242
Observation	Insignificant	Insignificant	Insignificant

Control Vs Pre Hiit

Table 10 Correlation of Stroop test reaction time scores between Pre-HIIT and Post- HIIT group

Paired Samples Test								
	Paired Differences					t	df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
(Pre-HIIT)Stroop test score Reaction time - (Post HIIT)Stroop test score Reaction time	1.22267	1.57481	.40661	.35057	2.09477	3.007	14	.009
There is significant mean difference of Stroop test score among cases. It has observed that the participants stroop test score decreased from pre to post HIIT.								

Pre HIIT vs Post HIIT

Table 11 Correlation of Cognitive function tests between Pre HIIT and Post HIIT group

	Post HIIT MoCA Score Pre HIIT MoCA Score	Post Rey-osterich complex figure test score Pre Rey-osterich complex figure test
Wilcoxon signed rank test Z value	-3.089b	120
Asymptotic sig. (2-sided test)	0.02	0.001
Observation	Significant	Significant

DISCUSSION:

Exercise has numerous effects on physical and mental health. HIIT is most preferred way of exercise, HIIT affects cognitive functions however, not exercising also has effects on cognitive functions. In the present study, we try to evaluate the effects of sedentary lifestyle on the cognitive functions as well as effects of HIIT on various cognitive function tests.

In present study, we have taken 15 participants who are not doing any physical activity and labeled them as Controls. 15 participants who are involved in HIIT are included and labeled them as Cases. The participant's habitual sleep duration was divided into 3 groups: Group 1 - 4 to 6 hrs., Group 2 - 6 to 8 hrs., and Group 3 - 8 to 10 hrs. Table 1 shows, out of the 15 Controls, 4 participants had a habitual sleep duration between 4 to 6 hrs, 9 participants had habitual sleep duration of 6 to 8 hrs and 2 participants had habitual sleep duration of more than 8 hrs.

In Table 2 Control group is showing positive correlation between habitual sleep duration and Stroop test score reaction time, we observed that, as habitual sleep duration increases then stroop test score also increases, however it is not significantly correlated. As stroop test assess the attentional processes, cognitive flexibility, and executive functions, as per our results we can say that, more sleep causes increase in time taken by the individual to complete the tasks in the group who are having sedentary lifestyle. Contrary to our findings You Y et al, report that short sleep was associated with decreased cognitive performance represented by lower accuracy during the incongruent stroop tests[10]. Shilpa khullar et al also quotes in their results that, reaction time was higher in sleep deprived subjects than those getting adequate sleep [11].

In this study, Control group shows insignificant association (p value > 0.05), when habitual sleep duration is correlated with MoCA score (Table 3). As MoCA test assess the attention and concentration, executive functions memory, language, visuoconstructional skills, conceptual thinking, calculations and orientation domains of cognition our results represent no correlation between habitual sleep duration and all these domains. Some research studies found out a significant association like, results of Ayushi Sen et al, found out that people who had insomnia 90.6% exhibited below normal scores and 9.4% of subjects had scored normal in MOCA test [12]. Aggarwal B et al, also found that poor sleep patterns were associated with lower cognitive scores [13].

In control groups, Sleep quality score when correlated with Stroop test reaction time score, MoCA score and Rey Osterich complex figure test score, it showed non- significant association (Table no. 4) with each cognitive function tests but showed very strong association (p value 0.001) with stroop tests errors scores. Rey Osterich complex figure test assess the visuo-constructional ability and visual memory of neuropsychiatric disorder. A research study by Nitin Narayan Rao et al, found that the Rey Osterich Complex Figure Tests score were less in nursing women at the end of the night shift duration due to poor sleep [14].

Cases are evaluated two times, before performing HIIT (Pre - HIIT) and after performing HIIT (Post HIIT). Before HIIT, habitual sleep duration score is correlated with MoCA score which showed insignificant association (Table 5). After HIIT, when habitual sleep duration score is correlated with MoCA score it showed significant association - table 6 (with p value - 0.002). MoCA test reflects attention and concentration, executive functions, memory, language, visuo - constructional skills, conceptual thinking, calculations and orientation. Our results reflects, Post HIIT all these domains showed improvement meaning cognition improved post HIIT (Table 7). Our results are accordant with Said Meraki et al who's results confirm that selectively executive functions are sensitive to HIIT training. Their results showed, Only subjects from the HIIT group enhanced their flexibility performance as measured by the Stroop task and Trail B [15]. Results of Khatuja Bhadur et al shows significant improvement in the cognitive processing time [16]. Grace Mclllvain et al noted a significant influence of exercise on task performance [17]. Results of Manuel de Diego et al are congruous with us, they state that an acute bout of HIIT influence the cognitive functions mainly in executive functions and selective attention [18].

An increasing amount of research suggests that training-induced brain adaptations can help prevent or delay cognitive decline and neurodegenerative diseases. Regular exercise promotes synaptic plasticity, the formation of new blood vessels (angiogenesis), and the growth of new neurons (neurogenesis) [19, 20, 21]. Data from animal studies, along with human research, indicate that several weeks of training can lead to increased expression of neurotrophic factors, such as BDNF, and a growth in hippocampal brain volume [22,23]. While most research focuses on the effects of sustained exercise, these exercise-induced brain changes are consistently associated with enhanced cognitive function.

Habitual sleep duration is correlated with stroop reaction time score pre HIIT and post HIIT (Table 7), Correlation between habitual sleep hour and Stroop test score reaction time is negatively correlated meaning that if habitual sleep hour increases then stroop test score decreases, however it is not significantly correlated.

Table 8 shows, Sleep quality score correlation with Pre HIIT and Post HIIT - Stroop test reaction time score, MoCA score and Rey-Osterich complex figure test score, it is observed as non- significant.

When control group cognitive function tests are correlated with the pre-HIIT score, its found to be non significant (Table 9). Whereas, when Pre-HIIT and Post HIIT cognitive function test scores are correlated it shows significant correlation, means all the cognitive functions had improved in Post HIIT group (Table 10 &11). A research study by Neumir Sales de Lima et al, suggests that an 8-week regimen of either moderate-intensity continuous training (MICT) or high-intensity interval training (HIIT) could serve as an effective non-pharmacological intervention to enhance cognitive function and increase BDNF levels in middle-aged overweight men [24]. The researchers found that HIIT had the greatest impact on information processing compared to other exercise regimens. They attributed this improvement to increased VO2 max, which is directly linked to enhanced cognitive function. Additionally, they noted that HIIT boosts blood flow, elevating BDNF levels, which promotes neuroplasticity and further contributes to cognitive enhancement [25].

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