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Effect of Acute Exercise on Cognitive Control

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Abstract

Aim: To assess effect of acute exercise on attention and memory (Cognitive Control). **Introduction:** Studies have shown that exercise and cognition are positively correlated. Cognitive control encompasses core cognitive process like inhibition, working memory and cognitive flexibility. Key elements like selection, scheduling and coordinated programming process are needed for cognitive control is brought about by target oriented, self-regulatory operations of brain. This study was specifically designed to assess effect of acute exercise on attention and memory (Cognitive Control) in fifty healthy young male subjects in the age group of 17-25 years .**Material and Method:** Participant were instructed on methodology of Stroop colour Word Test, Ray Auditory Verbal Test and Complex figural test. Following instruction on methodology they were given five practice sessions. They were then divided in two group i.e. Group A had resting session on the second day and exercise session on the third day where as Group B had the session in exactly reverse order to that of group A. **Result:** After an acute session of exercise, the reaction time for Stroop colour condition, Stroop word condition and Strop colour word condition were decreased and this was found to statistically significant when compared to resting stage(before exercise) .In case of backward digit span test and RAVLT total score, delayed recall and average recall no significant change was observed. The immediate recall time changed significantly after exercise. **Conclusion:** A single bout of moderate intensity acute exercise has its effect on selective attention subset of cognitive control.

Key words: *Cognitive control, Acute aerobic exercise, Memory, Attention*

Introduction

Several aspects of the cognitive function such as Executive function, Attention, Memory and Visual-spatial skills etc. were found to be enhanced after regular aerobic exercise both in person suffering from psychiatric disorder as well as in healthy subjects [1,2,3,4,5,6,7].

Using investigational tool such as SPECT, PET and fMRI shows that aerobic exercise leads to change in the pattern of perfusion, glucose uptake and neurotransmitter release by areas of the brain tasked with cognitive control [8,9,10].

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Cognitive control encompasses core cognitive process like inhibition, working memory and cognitive flexibility. Key elements like selection, scheduling and coordinated programming process are needed for cognitive control that are brought about by target oriented, self-regulatory operations of brain [11].

Works of Angevaren et al [12]. shows that particularly in adult population the effect of exercise on tasks falling under the canopy of cognitive control is relatively more compared to the other subsets of populations. This is supported by evidence gathered by Colcombe et al. Differential increment in gray and white matter volume in the areas of the brain i.e. prefrontal, parietal and temporal cortex which are known to play role in cognitive control was observed after exercise by them [13, 14].

Most of the studies till date are directed towards elder population and have shown a positive correlation between physical activities and cognition. The recent

upsurge in the studies have somewhat ignored the age group of 17-25 Years. Research on this age group is particularly important in the sense that if this particular age group can be convinced of beneficial effect of exercise even for short duration on their cognitive functions then there are chances that they will imbibe the habit of regular exercise. This may as well act as a primordial prevention of dementia.

Material and Method

The study was specifically designed to assess effect of acute exercise on selective attention and memory (Cognitive Control) in fifty healthy young male subjects in the age group of 17-25 years.

Criteria for selection:

Not suffering from any illness like diabetes mellitus, hypertension, CKD, Psychiatric disorder, Neurological disease or any other illness which is known to impair cognitive performance.

No History of drug abuse including alcoholism.

Not practicing Yoga, Meditation, Biofeed back technique or any other relaxation technique.

No family history of Psychiatric illness.

The study was explained to the subjects and their informed consent was taken according to the ethical principles of Indian Council of Medical Research, New Delhi.

Procedure

The study was modeled as within the subject design; where participant themselves acted as a control. Participant came to the Exercise physiology laboratory in the department of Physiology on three different days (7±6.5).They were instructed to come at the same time on all the three occasions and were also instructed not to indulge in any form physical exercise on the day of their scheduled visit.

Informed written consent was taken from the participant and resting heart rate was recorded after 15 minutes of seated rest using Cardivision Stress Test System, Medicaid India, on the first day of their visit. They were instructed on methodology of Stroop colour Word Test, Ray Auditory Verbal Test and Backward digit span. Following instruction on methodology they were given five practice sessions. Any query about the test was answered. Participants were then divided in two group i.e. Group A had resting session on the second day and exercise session on the third day where as Group B had the session in exactly reverse order to that of group A. This was done to remove any change in the result due to the order of the session.

Exercise Protocol:

The participant exercised for twenty minutes on treadmill (Cardivision Stress Test System, Medicaid India) at 60% of maximum heart rate estimated by the formula i.e. HRmax; 220-Age. Mean HR for this intensity was 120.4 ± 3.0 bpm which equaled to 59.7 ± 0.6 % of HRmax.

Stroop Colour Word Test [15]:

Vitoria version of Stroop Colour Word Test was used. It consists of three 21.5X14 cm cards, each containing six rows of four items (Helvetica, 28 point in rows which are placed one centimeter apart. In Part D (Dots), the subject is instructed to name as quickly as possible the colour of 24 dots printed in blue, green, red, or yellow ink. Each color is used six times, and the four colors are arranged in a pseudorandom order within the array, each color appearing once in each row. Part W (Words) is similar to Part D, except that the dots are replaced by common words, printed in lowercase letters. The subject is required to name the colors in which the stimuli are printed and to disregard their verbal content. Part C (Colors) is similar to Parts D and W, but here the colored stimuli are the color names "blue, green, red, and yellow" printed in lowercase so that the print color never corresponds to the color name. This latter task thus requires the individual to inhibit an automatic reading response and to produce a more effortful color naming response. The time difference between part C and Part W is known as interference effect or Stroop effect.

The Rey Auditory Verbal learning Test (RAVLT) [16]

RAVLT assessed verbal memory and learning. Participants were read a list of 15 common words five times. Immediately after each time, they were asked to recapitulate as many words as possible. After completion of the fifth trial, an interference list was presented following which subject had to spontaneously recall the original words. Finally, participants were required to spontaneously recall the original words after a 20 minute

delay. Scores were calculated as the total number of words recalled (1) across the five trials (total acquisition); (2) after the interference list (recall after interference); (3) on the fifth trial minus after the interference (loss after interference); and (4) after the delay (long delay free recall).

Backwards Digit Span test [17]

In a standard Backwards Digit Span test, the length of the number-string increases by 1 and continues until participants fail two consecutive attempts at reciting strings of a given length—generating a score in relation to the maximum string-length successfully recited . Participants attempted to recite nine number-strings which were 3–11 digits in length, increasing with order.

Statistical Analysis

All data are expressed as mean ± standard deviation (SD).The analysis was performed using SPSS 17. Statistical significance was accepted at $P<0.05$. Comparisons among after exercise and before exercise were performed by two tailed paired t test.

Result

After an acute session of exercise, the reaction time for Stroop colour condition, Stroop word condition and Strop colour word condition were decreased and this was found to be statistically significant when compared to resting stage(before exercise)

In case of backward digit span test and RAVLT total score, delayed recall and average recall no significant change was observed. The immediate recall time changed significantly after exercise.

Table1: Comparison of before–exercise and after-exercise Neuropsychological tests score

Neuropsychological Test	Before-exercise Score(Mean±SD)	After-exercise Score(Mean±SD)	p-Value
RAVLT-Total Score	44.93± 10.07	45.74 ± 10.28	>0.05
RAVLT-Average Score	8.78 ± 2.02	8.15± 2.06	>0.05
RAVLT-Immediate Recall	8.98± 2.86	7.95 ± 2.68	<0.01
RAVLT-Delayed Recall	9.55± 3.27	9.83± 2.23	>0.05
Backward digit span test	4.61(1.54)	4.89(1.08)	>0.05
Stroop color condition(time in second)	18.87±6.9	13.82±2.2	<0.001
Stroop word condition(time in second)	26.68±5.2	19.5.4±2.7	<0.001
Stroop color-word condition(time in second)	38.56±8.3	29.80±3.6	<0.001
Stroop Interference(time in second)	16.82±7.1	12.57±4.2	<0.001

All results are expressed as Mean ± standard deviation, p< 0.05 is considered significant

Discussion

Our finding suggests that a single acute session of moderate intensity aerobic exercise yielded a positive influence on the tasks requiring cognitive control.

In our study, the inhibitory control, a component of cognitive control, was assessed using Stroop's colour word test (SCWT). In SCWT, the colour condition and word condition are congruent task where as colour word condition is an incongruent task requiring sustained and selective attention to the task at hand and inattention to distracting task.

The reaction times were significantly decreased after an acute session of moderate intensity exercise in all the three condition i.e. Stroop colour, Stroop word and Stroop colour word condition when compared to the reaction time score before exercise condition.

Statistically significant change in interference (difference in reaction times for congruent and incongruent condition) .The mean value of interference changed from 16.82±7.1second at before exercise to 12.57±4.2 second in after exercise condition.

Acute moderate intensity continuous aerobic exercise can improve specific cognitive functions, such as short-term memory and selective attention. Before and after each experimental session, cognitive performance was assessed by the Victoria Version of the Stroop test (a selective attention test) by Alves CR et al. They were of opinion that following the exercise session, the time to complete the Stroop «Color word" test was significantly lower when compared with that of the control session. Our findings of change in reaction times in congruent and incongruent task conditions are similar to those of Alves CR et al [18].

Other studies also report similar finding on the Stroop colour word test but they were on either the preadolescent or elderly population [7, 8, 11, 19].

Backward Digit span test is primarily employed as a test for short term memory. Alves CR et al. assessed the effects of an acute high-intensity interval training (HIT) session on short-term memory tasks. The performances Digit Span test was not significantly different and thus their result being congruent with that of our observation, but in their case the mean age group was 53.7 years[18].

Vasques PE et al after their study on elderly depressed patients were of conclusion that the Digit Span Test did not change significantly on comparison between the control and the exercise sessions. The results of the Stroop Color-Word Test improved after physical exercise, indicating a positive effect of exercise on cognition. Their finding is also similar to ours but again there is the difference in the age group.

We observed that RAVLT score didn't change significantly after exercise session in terms of total recall, average recall and delayed recall. The change was significant when immediate recall was considered.

RAVLT as a test for short term memory was included in the study undertaken by Nagamatsu LS et al. They had a similar finding but in their case the study group consisted of elderly adult with mild cognitive impairment.

Conclusion

A single bout of moderate intensity acute exercise has its positive effect on selective attention, a subset of cognitive control.

Conflict of Interest: None

Ethical Clearance: Taken

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