

# THE EFFECT OF SINGLE BOUT OF ACUTE EXERCISE ON WORKING MEMORY PERFORMANCE

Deo SK<sup>1\*</sup>, Agrawal K<sup>2</sup>, Bhattra P<sup>1</sup>, Chaudhary RK<sup>3</sup>

## Affiliation

1. Lecturer, Department of Physiology, Birat Medical College and Teaching Hospital, Morang, Nepal
2. Associate Professor, Department of Physiology, Birat Medical College and Teaching Hospital, Morang, Nepal
3. Lecturer, Department of Anatomy, Birat Medical College and Teaching Hospital, Morang, Nepal

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### \* Corresponding Author

Mr Santosh Kumar Deo  
Lecturer

Department of Physiology

Birat Medical College and Teaching Hospital, Morang, Nepal

Email: [devdsantosh@gmail.com](mailto:devdsantosh@gmail.com)

ORCID: <https://orcid.org/0000-0002-9056-2140>

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## ABSTRACT

### Introduction

Working memory is a kind of short term memory important for reasoning and guiding decision-making and behavioral process.

### Objective

The goal of the present research was to study the outcome of single bout of acute moderate-intensity exercise on working memory.

### Methodology

Twenty two male subjects were asked to perform working memory task by 2n back task in baseline resting, immediately after exercise and after five minute of exercise session. 3 minute step test procedure was used as a moderate intensity exercise intervention.

### Results

The percentage correctness of 2n back task of working memory was found to be 64.36% for baseline resting condition, 78.01 % for immediately after 3-minute step test and 80.70% for 5 minute after the exercise. In both exercise session (i.e. immediately after exercise and after 5 minute of exercise), significant improvement (p value <0.05) in working memory was seen as compared to the baseline resting session while no such significant beneficial improvement was seen when compared between immediately after exercise and after 5 minute of exercise.

### Conclusion

Improvement in working memory after moderate exercise intervention was seen, which is important for learning and memory and decision-making.

## KEYWORDS

Single-bout acute exercise, working Memory, 2n back task.

## INTRODUCTION

Retaining optimum brain well-being and function all over life is a key goal of public health. Extensive research establishes that exercise and fitness are neuroprotective and employ a progressive influence on cognitive function.<sup>1</sup> Cognitive function is the intellectual activity that comprises mental processes like learning and memory, attention, processing speed, executive function and working memory. Working memory includes short-term storage and handling of information, expected essential for an extensive range of complex cognitive events. Working memory is supposed to play an important role in numerous cognitive processes and other characteristics of executive function. Deficits in working memory will extremely impair decision-making process, learning and memory.<sup>2</sup> As a result, working memory has fascinated growing research attention and has become a center of recent research.

The effect of exercise on different realms of cognitive function continue as vigorously explored area in scientific research like cognitive neuroscience, sports science and many other fields.<sup>3</sup> Past analysis shows that long term participation in physical exercise is allied with better attention, cognition and memory; though the outcomes are unreliable when working memory is related to single bout of acute exercise with few studies presenting favorable effects, no effects, or even negative effects. The outcomes differed with form of memory, exercise strength and the extent of exercise.<sup>4</sup> There are different measures available to assess the working memory out of which 2n back task is extensively used in cognitive function research as a gold standard measure. Therefore, the present study makes an effort to replicate the previous studies in our population and laboratory setup and to correlate the effect of acute moderate-intensity single bout exercise on working memory performance using 2n back task.

## METHODOLOGY:

### Participants:

Twenty two medical students of Birat Medical College and Teaching Hospital (mean age = 23.35 ± 1.42 years) were recruited in the study. Informed consent was taken from all the contestants before the experimental protocol. An inclusion criterion was assessed through a detailed history to conform that there was no any potential risk of cardiovascular, respiratory and other health related disorders in the participants to perform a single bout of aerobic acute moderate intensity exercise and working memory task. This study was conducted in Department of Physiology, Birat Medical College and Teaching Hospital from duration of February, 2017 to July, 2017.

### Acute Aerobic Exercise Protocol

The subjects were asked to perform 3 minutes step test on bench of 12-inch height for three minutes in up-up and down-down fashion at the rate of 96 steps per minute.

The test was demonstrated to the subject with alternating stepping rhythm. The rhythm of stepping with the beat was carried as follows: step one foot up on the bench (1<sup>st</sup> beat), step up with the second foot (2<sup>nd</sup> beat), step down with one foot (3<sup>rd</sup> beat), and step down with the other foot (4<sup>th</sup> beat).

The subject was asked to practice the stepping on the metronome rhythm, which was set at 96 beats per minute (4 clicks = one step cycle) for a stepping rate of 24 steps per minute. The subjects stepped up and down on the platform at the given rate for a total of 3 minutes. Immediately after 3 minute of exercise the subject was asked to stop and sit down and remain still.

### Working Memory Task

The n-back test is an uninterrupted performance test that is frequently used as a valuation in cognitive neuroscience to measure working memory and working memory capacity. The subject comes across with a sequence of stimuli, with the task consisting of indication when the current stimulus matches the one from  $n$  steps earlier in the sequence. The stimuli factor  $n$  can be adjusted to make the task less or more challenging. For example, 1n-back one has to remember the position of the item, one turn back likewise 2n-back means that one has to remember the position of the item two turns back, and so on.

In our present study, 2n-back test was performed to assess working memory task using [www.cognitivefun.net](http://www.cognitivefun.net) program. In this task, ten pictures (e.g., car, cake, cat, fish, ball, book heart, shape, pencil, boot, and spoon) appeared on the computer screen randomly and participants were asked to click on the target box when the current picture was a repeat of what they had seen or picked 2 pictures ago. Therefore, the target had to be hit if the same picture was repeated in the third place as shown in figure 1. After end of the task, results with correct percentage were displayed.<sup>5</sup> Each 2n back working memory task was of sixty second duration where around 32 items were displayed.

### This animation shows 2N-back in action

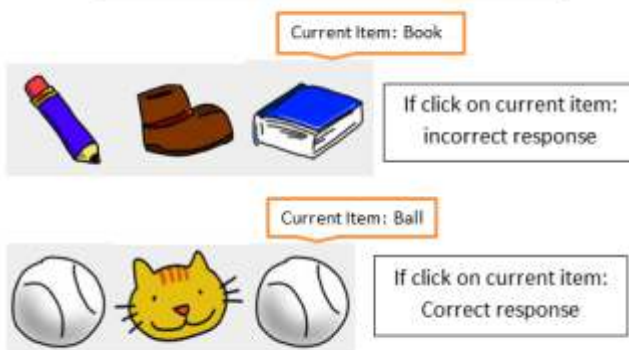


Figure 1

### Experimental Procedure

After obtaining informed written consent, the subject's information regarding history and anthropometric data was recorded in the structured performa. The subject was then instructed for complete bed rest for five minutes to get accustomed to the laboratory environment. After all paperwork, 2n-back task training for assessment of working memory was done for every subject repeatedly for multiple number of times till the maximum percentage of correctness was attained during resting. This was done to exclude the learning effect on working memory performance. It was noted that the subjects understood 2n-back task well.

Now, in the formal experiment, the subject was asked to perform first round of working memory task in baseline resting session. The percentage correctness of the 2n-back test was noted. It was followed with the exercise session by 3 minute step test at the rate of 96 steps per minute and immediately after the exercise session second round of working memory task was performed. Again, the percentage correctness of 2n-back test was recorded. Then at last, the subject was asked to sit idle for 5 minutes and then the next third round of working memory task was performed. Final recording of percentage correctness was noted. All the subjects' heart rates were recorded during baseline resting session, immediately after exercise and 5 minutes after the exercise session.

### Statistical analysis

To compare working memory performance differences between baseline and post-exercise sessions, a paired t-test was used to for testing the significance. The alpha value was set to 0.05 for the difference to be statistically significant. The working memory performance was also correlated with age, gender, BMI or the academic level of the subjects using Spearman's correlation. The statistical analysis was done using Statistical Package for the Social Sciences (SPSS).

## RESULTS

### Exercise Intensity

The baseline resting and exercise session heart rate was 38.12 % and 70.42%, respectively, of the projected maximal heart rate. The differences in percentage of heart rate during baseline resting session and exercise session of the projected maximal heart rate recommends the 3 minute step test to be a moderate-intensity exercise. The heart rate of subject after 5 minute of exercise was found to be returned to that of the baseline resting condition.

### Working Memory Performance:

Figure 2 presents detailed working memory performance based on the three sessions of 2n back task with exercise intervention. To explore the working memory performance difference between baseline and exercise sessions, a paired t-test was used to for the test of significance.



**Figure 2:** Change in percentage correctness of 2n back text in relation to exercise intervention.

The percentage correctness of 2n back task of working memory was found to be 64.36% for baseline resting condition, 78.01 % for immediately after 3-minute step test and 80.70% for 5 minute after the exercise. The both exercise session (i.e. immediately after exercise and after 5 minute of exercise) showed significant improvement

(p value <0.05) in working memory as compared to the baseline resting session while no such significant beneficial improvement was seen when compared between immediately after exercise and after 5 minute of exercise. The working memory performance in our study did not significantly differ in respect to age, gender, BMI or the academic level from which the subjects were enrolled.

## DISCUSSION

This research studied the impacts of single bout of acute moderate exercise on working memory performance. The exercise session was correlated to a baseline session of working memory. It was hypothesized that an association would be present between those parameters, and the current study supported this hypothesis. The core finding of our study was that even a very short period of three minute moderate intensity exercise test is good enough to attain positive impact on working memory. An increasing bulk of literature by Erickson KI et al, Chang YK et al. and Drollette ES et al shows that acute aerobic exercise improves working memory performance and our results are also in agreement with these previous research findings.<sup>6-8</sup> Similarly, a study by Hillman et al revealed that an acute treadmill workout was correlated to improved working memory performance while carrying out a visual attention task by Eriksen flanker test.<sup>9</sup> Also, a study by Sibley et al revealed that acute exercise of moderate-intensity on a treadmill led to enhanced Stroop test performance which is one of the important measure of cognitive function.<sup>10</sup> A similar study by Simazach et al revealed that volleyball training interventions increased the working memory performance measured by Digit span and Visual Memory Span tasks of Wechsler Memory Scale.<sup>11</sup> In our study, we concluded that working memory performance is enhanced with 3 minute of moderate intensity exercise. Through, a series of literature review we could not find satisfactory result on the optimum intensity and duration of exercise which attains a peak level of enhanced working memory performance as it is noted that even increase in the duration and intensity of the exercise more than optimum level would decrease the working memory performance. Therefore, we feel that further study needs to be carried out in this direction.

The exact neurophysiological mechanism that is affected by acute exercise is still unknown but it is estimated that exercise may intensify the courses of neuroplasticity at molecular and cellular level.<sup>12</sup> Thus, further work in future is anticipated to explicate the specific mechanisms by which the exercise affects the human cognition. Few studies argue that the changes in the working memory performance is estimated due to enhanced activities of the brain including bilateral parietal cortices, left hippocampus, and the bilateral cerebellum elicited by acute aerobic exercise.<sup>13</sup> Also, exercise-induced variation in regional cerebral blood flow has also been proposed as a probable mechanism for increased cognition level.<sup>14</sup> Some studies also states that rise in central and peripheral accessibility of neurotrophic elements, energy substrates and signaling molecules are reason behind beneficial memory performance.<sup>15</sup> Some researchers using animal model have revealed that exercise

shows beneficial influence on cognitive function because it brings some changes in brain structure such as hippocampus and cerebral cortex.<sup>16,17</sup>

## CONCLUSION

The current findings support our hypothesis that moderate intensity exercise is related to improve processing task that assessed working memory performance in healthy young adults. It also suggests that acute bouts of exercise may be tremendously useful for those whose cognitive performance is low. Thus it is concluded that even single bout of acute exercise has beneficial effect on working memory and ultimately overall cognitive function. Therefore, acute exercise can be important in decision making, learning and memory process.

## RECOMMENDATIONS

We found that even three minute of acute exercise improves working memory and cognitive function. Therefore, it is recommended to develop moderate exercise as a daily habit to all age groups to boost memory, improve concentration, improve mental health, enhance creativity and retard cognitive decline with age.

## LIMITATIONS OF STUDY

The present research is not devoid of limitations. The overview of our results is constricted by less number of

sample sizes. Further research in future with greater number of sample size might be more reliable to explore the result of acute single bout exercise on working memory. Also, in the experimental procedure, we estimated working memory performance only up to five minutes of exercise, therefore, we could not follow up the time limit up to which the significant beneficial effects of acute exercise exists. Likewise, besides n-back task, even other different measures of working memory capacity like complex span tasks (C span), working memory updating tasks (Updating) and tasks of temporary bindings (Binding) could have been tested simultaneously to increase the reliability of the working memory performance.

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## CONFLICT OF INTEREST

The authors have no conflict of interests.

## FINANCIAL DISCLOSURE

None

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