In many recent studies, moderate intensity aerobic exercise has been shown to improve mental performance. Majority of the studies have focused on the chronic effects of exercise, while studies on the acute effects of exercise on cognition have started to draw growing attention of the researchers. The main objective of the present study was to establish the fact that Queen's College step test (QCT), a short duration step test exercise is a useful tool for improving mental performance of young adult population. Ten healthy young male adults participated for the present study. They performed following cognitive tasks i.e. simple reaction time (SRT) for measuring speed of processing, stroop task for selective attention, during before exercise, immediate after exercise and 30 minutes after exercise. The performance times were recorded and carotid pulse was also measured immediately after the exercise. The finding of the study states that there was a significant decrease in SRT, and stroop task performance time immediately after exercise, 30 minutes after exercise.

**Key Words:** Queen’s College step test, Cognition, Simple reaction time, Stroop task, Young adult
exercise compared to before exercise condition. QCT was found as an effective exercise tool in terms of its simplicity of performance, and less time consuming for improving the speed of processing and selective attention in young adults.

INTRODUCTION

It has already been established that physical exercise has a beneficial effect on mental performance [1, 2, 3]. This effect of exercise has been studied in a wide range of population including pre-school age to older adults considering various disease conditions, gender differences etc. Within this broad spectrum there is vast variability regarding the selection of physical exercise, duration of performance, type of cognitive test performed and type of measurement techniques applied [1]. Like improvement in cardio-respiratory fitness, physical exercise is also associated with the improved mental performance [4]. Exercise has been implicated in many different tests of brain function. It has been observed that by performing a moderate intensity aerobic exercise (defined by 70-80% of maximal heart rate) there is an improvement in working memory [5]. The majority of studies have focused on the chronic effects of exercise, while studies on acute effect of exercise on cognition have started to gain growing attention [6]. Yanagisawa [7] observed among a group of young Japanese adults that there were improved cognitive flexibility on the Stroop task performance established by increased activity level at the dorsolateral and prefrontal area of cortex. It has been shown that an aerobic activity with a frequency of performance of 45 minutes per week is positively associated with cognition, academic achievement, behavioral psychological functioning. Very recently it has been reported that, an exercise session consisting of 5 minute warm up, 20 minute of moderate intensity exercise performance and a 5 minute cool down, is also associated with improved cognition [8]. On the contrary, there are other studies reported that low to moderate intensity exercise does not alter executive functioning [9], moreover when the work load becomes heavy the reaction time in executive condition becomes slow due to lower availability of HbO₂ at various regions of brain [10]. This lack of consensus calls for further research regarding the effects of acute exercise on cognition.

Exercise has many positive benefits among elderly such as, an improved self image, enhanced social skills, and alleviated symptoms of depression and Alzheimer’s disease [1, 11]. Long-term physical exercise may prevent decline of cognitive function in elderly populations and aging adults. It has been found that an aerobic training programme of three months produce benefits primarily on executive functions among older individuals [12]. Taylor et al.[13] in his review article vividly described the beneficial effects of exercise considering both clinical and non-clin-
ical populations, by emphasizing on major beneficial effects such as alleviation of symptoms associated with mild to moderate depression, improves self-concept and confidence in children and adolescence, reduces symptoms of anxiety, alters some aspects of stress response and coronary-prone (Type A) behavior etc. On the whole, exercise is gaining increased research attention as a possible lifestyle factor for improving neuro-cognitive functions.

Besides the old adult population, studies [14, 15] are conducted on pre-adolescent children aged between 7-12 yrs and found that aerobic fitness was related to better cognitive performance. Van der Niet et al. [15] specifically studied the associations between daily physical activity and executive functioning among 80 school going children (36 boys and 44 girls) aged between 8-12 years and concluded that children’s physical activity is associated with their better planning ability.

Very few studies have looked at the effects of acute cardiovascular exercise on cognitive functions in young adults. Young adults are mostly college going and involved in vigorous mental activity. Moreover, it has been observed that during adolescence and throughout young adulthood neural plasticity is at its peak. Ploughman has described by reviewing the findings of the previous researchers that exercise may capitalize on this critical period by stimulating the brain and promoting learning, memory and higher thinking [4]. At the same time most of the young adults find difficulty in managing a separate time schedule for instrumented and sophisticated session of gymnasium just to give the upper hand to their studies. As a best alternative we can suggest them some simple form of exercise which can be conducted anytime and anywhere. With this rationale we have used Queens’ college step test (QCT) as short duration exercise tool to find out:

1) Effect of short duration exercise on cognitive performance with special reference to speed of processing and attention.

2) Persistence of the effect of short duration exercise on cognitive performance, if any.

3) Is there any relation existing between the measures of physical performance and cognitive performance?

MATERIALS AND METHODS

Ten (10) Indian undergraduate male students (Age- 23.50±2.90 years; Height-175.70±3.77 cm; Weight-73.30 ± 11.71 kg; Resting Heart rate-72.20 ± 5.27 beats/min; Heart Rate Reserve- 124±7.10 beats/min; Age predicted maximum heart rate- 197±2.87 beats/min; Predicted VO₂ max- 46±2.56ml/kg/min) with no history of cardio-respiratory disease and musculoskeletal disorder participated for the present study.
The study protocol was approved by Institutional ethical committee of Defence Institute of Physiology and Allied Sciences and was in accordance with the declaration of Helsinki protocol. All the participants received participant information sheets and consent forms before their participation in the main experiments and were priori informed. The ink signed consent forms were acquired from them after explaining the details experimental procedure and possible outcome of the study.

All the participants were checked for the colour blindness by using Ishihara 1-17 colour plates in order to perform stroop test, as it is associated with recognition of colour. Finally all the participants were detected with normal colour vision.

Before the day of participation, participants were strictly instructed to have a standard diet and proper sleep of at least 8 hours. They were also refrained from taking any performance enhancing drug, alcohol, and smoking. At the very next day they participated in the main experiment. All the participants had a light breakfast at least one hour before the commencement of experiment. All the resting parameters were recorded.

The cognitive performances were assessed in the form of executive functions. Two types of executive functions were applied viz., Simple Reaction Time (SRT) and stroop test (ST). SRT was measured to assess the speed of processing and stroop task was applied to assess the selective attention. At the first stage of the experiment, participants performed a simple reaction time test (SRT) session on a computer screen. The participants’ task was to respond as quickly as possible on flashing of green lights by pressing the right button of the mouse in a column of three lights respectively as red, yellow, green from top to bottom. An average value of ten trials was considered for further analysis.

Subsequently participants also performed a modified stroop task 1(ST1), stroop task 2(ST2). In ST1, participants only read the name of the word and in ST2 participants reported the name of the colour in which the words were written. The participants were seated in front of a color monitor at a viewing distance of approximately 70 cm. The participants were instructed to read and respond as quickly as possible without committing any error. We started a stop watch with the participants’ first response and stopped it with his or her last response. Performance time was recorded.

Next in the sequence participants performed Queens College Step Test (QCT). The exercise intensity is categorized under the sub-maximal intensity. The exercise was performed on a stool of 41.3 cm (16.25 inches) height for a total duration of 3 min at the rate of 24 cycles /min which was set by metronome. The metronome was set at 96 beats/min to allow the participants to make contact with a foot on each beep in an up-up-down-down manner. After completion of the exercise the participants were asked to maintain standing posture and the carotid pulse rate was measured from 5 to 20 seconds of the recovery period. Carotid pulse
was measured by placing index and middle finger on carotid artery at the level of Adam’s apple by taking care not to press too hard (measurements were carried out by the same experimenter who had vast experience in recording pulse rate using such technique). Then predicted VO\(_2\) max was calculated by the following equation: 
\[
\text{VO}_2\text{ max}_{\text{pred}} = 111.33 - (0.42 \times 4 \times 15 \text{ sec pulse rate})
\]
recommended by McArdle et al [16].

Just immediately after exercise the SRT, ST1, ST2 was performed by the participants and the time was recorded in similar manner. Then the participants were instructed to take complete rest for 30 minutes in a thermo-neutral room. The room was made noise attenuated. After 30 minutes of rest the participants again performed SRT, ST1, ST2 and time was recorded. A diagrammatic presentation of detailed experimental procedure has given in figure 1.

**Figure 1. A diagrammatic presentation of detailed experimental procedure**
Resting Heart rate (RHR) of the participants we recorded for 1 minute from carotid pulse by following the standard procedure. Recording of carotid pulse is a reliable manual technique used by previous researchers [17].

Age predicted maximum heart rate of all the participants were calculated by using the formula: (220-age).

Subsequently the heart rate reserve (HRR) of all the participants was calculated by subtracting the RHR from the age predicted max HR (HRR = Age predicted max HR – RHR).

QCT Heart Rate (QCT HR) was recorded immediately after completion of QCT. Used Heart rate (Used HR) is defined as percentage of Heart rate Reserve (HRR) achieved during exercise and the exercise Heart Rate is demonstrated as resting Heart Rate subtracted from the QCT maximum Heart Rate. It was calculated by using the following formula- \[ \frac{(QCT\ HR\ -RHR)\times 100}{HRR} \]

A descriptive statistics of various dependent variables in the form of mean and standard deviation is presented in Table 1 under three different independent experimental conditions i.e., before exercise (BE), immediate after exercise (IAE) and 30 minutes after exercise (AE30). The dependent variables are SRT, and performance time of ST 1 and ST 2.

A one way repeated measure analysis of variance ANOVA was applied as the same group of participants was repeatedly involved in three different experimental conditions. At first overall significance was observed. Followed by the overall significance across three conditions, Bonferroni Post-hoc test was applied to compare the conditions pair wise. A bivariate Pearson’s product moment correlation co-efficient (r) was calculated between the measures of physical performance and cognitive parameters to reveal the degree of association between the physiological workload and cognitive performance. The strength of the correlation was determined under following three categories along with their corresponding r values:

- High correlation: 0.5 to 1.0 or -0.5 to 1.0;
- Medium correlation: 0.3 to 0.5 or -0.3 to 0.5;
- Low correlation: 0.1 to 0.3 or -0.1 to -0.3.

For all the tests statistical significance was verified at P<0.05 level. All statistical tests were performed in Statistical Package for Social Sciences Version 17.0 (SPSS, Chicago, Illinois, USA).

**RESULTS**

The overall trend showed an improvement in SRT as there was a gradual decrease in reaction time from BE to IAE and AE30 (Figure-2). Significant changes in SRT was observed across various conditions \[ F_{(2,18)} = 7.403; P<0.05 \]. Bonferroni test for Post Hoc analysis revealed that changes in SRT was significant (P<0.05) when BE was compared separately with AE30. Whereas the comparison of IAE
with BE and AE30 did not reflect any significant change in SRT (P>0.05). The percentage changes in reaction time showed that there was 31.57% decrease in performance time when the BE condition was compared with the IAE. But when IAE was compared with AE30 condition the percentage of decrease in performance time is 11.53%. The decrease was found to be highest (39.47%) when BE is compared with the AE30 condition (Table 1).

![Figure 2. Changes in simple reaction time](image)

The performance time for ST1 showed a gradual decrease across the conditions depicting that the performance has improved for the respective task (Figure-3). One way repeated measure ANOVA revealed the changes are significant \(F(2,18) = 13.801; P<0.05\). Bonferroni test for Post Hoc analysis revealed that changes in ST1 performance time was significant \(P<0.05\) when BE was compared separately with IAE and AE30. Whereas the comparison of IAE with AE30 did not show any significant change \(P>0.05\) (Table 2). The percentage changes in ST1 depicted that there was 12.27% decrease in performance time when BE was compared with IAE. On the other hand decrease was 5.69% and 17.27% when AE30 was compared respectively with IAE and BE (Table 1).
Figure 3. Changes in stroop task 1 performance time

Table 1

Mean±SD, Percentage change in Simple Reaction Time, Stroop Task 1 performance time and Stroop Task 2 performance time

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Experimental condition</th>
<th>% change</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>BE Mean (±SD)</td>
<td>IAE Mean (±SD)</td>
</tr>
<tr>
<td>Simple reaction Time (Sec)</td>
<td>0.38 (±0.067)</td>
<td>0.26 (±0.039)</td>
</tr>
<tr>
<td>Stroop Task 1 time (Sec)</td>
<td>44 (±6.36)</td>
<td>38.60 (±5.83)</td>
</tr>
<tr>
<td>Stroop Task 2 time (Sec)</td>
<td>101.30 (±14.83)</td>
<td>86.20 (±10.20)</td>
</tr>
</tbody>
</table>
The performance time for ST2 showed a gradual decrease across the conditions which depicted that the performance has improved for the respective task (Figure-4). One way repeated measure ANOVA revealed the changes are significant \( F(2,18) = 7.81; P<0.05 \). Bonferroni test for Post Hoc analysis revealed that changes in ST2 performance time was significant \( P<0.05 \) when BE was compared separately with IAE and AE30. Whereas the comparison of IAE with AE30 did not show any significant change \( P>0.05 \) (Table 2). The percentage changes in ST2 depicted that there was 14.90% decrease in performance time when BE was compared with IAE. On the other hand decrease was 7.07% and 20.92% when AE30 was compared respectively with IAE and BE (Table 1).

**Figure 4. Changes in stroop task 2 performance time**
Table 2
The Effect of QCT on the performance time of simple reaction time, Stroop Task 1 and Stroop Task 2 under three different experimental conditions

<table>
<thead>
<tr>
<th>Dependent variables</th>
<th>Independent variables</th>
<th>P Value</th>
<th>Overall Significance</th>
<th>Post-Hoc. Bonferroni test (pair wise comparison)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simple reaction time (sec)</td>
<td>BE, IAE, AE30</td>
<td>0.005</td>
<td>*</td>
<td>BE-IAE**(NS)<strong>, IAE-AE30</strong>(NS)**, BE-AE30*</td>
</tr>
<tr>
<td>Stroop task 1 performance time (sec)</td>
<td>BE, IAE, AE30</td>
<td>0.000</td>
<td>*</td>
<td>BE-IAE * , IAE-AE30**(NS)**, BE-AE30 *</td>
</tr>
<tr>
<td>Stroop task 2 performance time (sec)</td>
<td>BE, IAE, AE30</td>
<td>0.000</td>
<td>*</td>
<td>BE-IAE**(NS)**, IAE-AE30*, BE-AE30 *</td>
</tr>
</tbody>
</table>

NOTE: * denotes the effect is significance (P<0.05); NS- The effect is not significant (p>0.05)

Table 3 showed the correlation coefficients and their statistical significance between the physiological parameters and SRT at various phases of experiment. The results revealed that majority of the correlations were moderate to high in strength ranging from 0.40 to 0.65. The highest strength of correlation was found among all the physiological parameters and SRT after 30 minutes of exercise. After 30 minutes of exercise the correlations of SRT with QCT HR and VO₂ max_(pred) were found to be highly significant (r= 0.66 (P<0.05) for SRT vs. QCT HR; r= -0.66 (P<0.05) for SRT vs. VO₂ max_(pred)). The correlations of SRT with QCT HR, and USED HR were also found to be moderate in strength but not significant before the exercise. Similarly the correlation of SRT with RHR, HRR, and USED HR also found moderate to high in strength after 30 minutes after exercise.
Table 3
Correlation between physical parameters and Simple reaction test, Stroop task 1 performance time, Stroop task 2 performance time

<table>
<thead>
<tr>
<th>Cognitive parameters</th>
<th>Physical parameters</th>
<th>BE</th>
<th>IAE</th>
<th>AE30</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>RHR</td>
<td>-.047&lt;sup&gt;(NS)&lt;/sup&gt;</td>
<td>.064&lt;sup&gt;(NS)&lt;/sup&gt;</td>
<td>.480&lt;sup&gt;(NS)&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>QCT HR</td>
<td>.408&lt;sup&gt;(NS)&lt;/sup&gt;</td>
<td>.070&lt;sup&gt;(NS)&lt;/sup&gt;</td>
<td>.659*</td>
</tr>
<tr>
<td>Simple reaction time</td>
<td>HRR</td>
<td>-.037&lt;sup&gt;(NS)&lt;/sup&gt;</td>
<td>-.047&lt;sup&gt;(NS)&lt;/sup&gt;</td>
<td>.580&lt;sup&gt;(NS)&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>VO&lt;sub&gt;2max&lt;/sub&gt; (pred)</td>
<td>-.408&lt;sup&gt;(NS)&lt;/sup&gt;</td>
<td>-.070&lt;sup&gt;(NS)&lt;/sup&gt;</td>
<td>-.659*</td>
</tr>
<tr>
<td></td>
<td>USED HR</td>
<td>.468&lt;sup&gt;(NS)&lt;/sup&gt;</td>
<td>.061&lt;sup&gt;(NS)&lt;/sup&gt;</td>
<td>-.471&lt;sup&gt;(NS)&lt;/sup&gt;</td>
</tr>
<tr>
<td>Stroop task 1</td>
<td>RHR</td>
<td>-.222&lt;sup&gt;(NS)&lt;/sup&gt;</td>
<td>-.012&lt;sup&gt;(NS)&lt;/sup&gt;</td>
<td>.386&lt;sup&gt;(NS)&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>QCT HR</td>
<td>-.148&lt;sup&gt;(NS)&lt;/sup&gt;</td>
<td>-.645*</td>
<td>-.340&lt;sup&gt;(NS)&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>HRR</td>
<td>.202&lt;sup&gt;(NS)&lt;/sup&gt;</td>
<td>-.038&lt;sup&gt;(NS)&lt;/sup&gt;</td>
<td>-.397&lt;sup&gt;(NS)&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>VO&lt;sub&gt;2max&lt;/sub&gt; (pred)</td>
<td>.148&lt;sup&gt;(NS)&lt;/sup&gt;</td>
<td>.645*</td>
<td>.340&lt;sup&gt;(NS)&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>USED HR</td>
<td>-.072&lt;sup&gt;(NS)&lt;/sup&gt;</td>
<td>-.573&lt;sup&gt;(NS)&lt;/sup&gt;</td>
<td>-.391&lt;sup&gt;(NS)&lt;/sup&gt;</td>
</tr>
<tr>
<td>Stroop task 2</td>
<td>RHR</td>
<td>-.360&lt;sup&gt;(NS)&lt;/sup&gt;</td>
<td>-.471&lt;sup&gt;(NS)&lt;/sup&gt;</td>
<td>.244&lt;sup&gt;(NS)&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>QCT HR</td>
<td>-.395&lt;sup&gt;(NS)&lt;/sup&gt;</td>
<td>-.068&lt;sup&gt;(NS)&lt;/sup&gt;</td>
<td>-.042&lt;sup&gt;(NS)&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>HRR</td>
<td>.351&lt;sup&gt;(NS)&lt;/sup&gt;</td>
<td>.441&lt;sup&gt;(NS)&lt;/sup&gt;</td>
<td>-.351&lt;sup&gt;(NS)&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>VO&lt;sub&gt;2max&lt;/sub&gt; (pred)</td>
<td>.395&lt;sup&gt;(NS)&lt;/sup&gt;</td>
<td>.068&lt;sup&gt;(NS)&lt;/sup&gt;</td>
<td>.042&lt;sup&gt;(NS)&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>USED HR</td>
<td>-.292&lt;sup&gt;(NS)&lt;/sup&gt;</td>
<td>.059&lt;sup&gt;(NS)&lt;/sup&gt;</td>
<td>.041&lt;sup&gt;(NS)&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

NOTE: * denotes the effect is significance (P<0.05); NS- The effect is not significant (p>0.05)
Correlations among the physiological parameters and ST1 performance time at different phases of experiment presented in Table 3. The results of correlations revealed the entire strength categories viz. low, moderate, high ranging from 0.14 to 0.64. In this case it was found that performance time was highly correlated with QCT HR and VO$_2$max$_{(pred)}$ immediately after exercise [(r=0.64 (P<0.05) for ST1 performance time vs. QCT HR ; r= -0.64(P<0.05)]. After 30 minutes of exercise the correlation of ST1 performance time also found to be moderate in strength with all the physiological parameters, although the values were found to be insignificant.

In Table 3 the correlation among the physiological parameters and ST2 performance time at various stages presented. The results showed that before exercise the majority of the correlations of ST2 performance time are low to moderate in strength with all the physiological parameters. The correlations of ST with RHR and HRR were also found to be moderate in strength but not significant immediate after exercise and after 30 minutes of exercise.

**DISCUSSION**

Measurement of SRT represents the speed of processing of some sensory information which are being perceived primarily by the visual system and giving response by motor activity of the hand. The result of the study showed the significant decrease in reaction time immediately after completion of exercise and after 30 minutes of recovery from exercise compared to the before exercise condition. The finding is consistent with the results of the previous study [18] which measured the total reaction time, incongruent reaction time, and congruent reaction time by using a modified flanker task during the similar phases of experiment. Although the present study is differing from the study of Peiffer et al.[19] in type of exercise performed, (Balke protocol, ACMS protocol) the variation of exercise intensity (Low intensity, 50% of VO$_2$max; High intensity, 75% of VO$_2$max), gender of the participants(female), and age group of the participants (60-75 years). Regardless of this broad range of variability in experimental independent variables in both of the studies, the cognitive performance was found to be improved. In this study the percentage change in reaction time was more (39.47%) when before exercise phase was compared with 30 minutes after exercise than when before exercise is compared with immediately after exercise (31.57%). Hence, the improvement in the SRT can also be achieved by performing QCT and thereafter the facilitating effect can persist after 30 minutes of exercise performed.

The present study used a modified stroop task viz.ST1 & ST2. For both of the task the performance time have improved after the QCT compared to the before
exercise condition. In ST1 the participants read the words and the word processing speed was found to be increased immediately after the exercise and even 30 minutes after the exercise, hence resulted in an improved performance time. In ST2 the participants named the colour in which the words were written and in such a case they had to allocate the selective attention to recognize the colour by inhibiting the earlier processing of the words. This process represents higher executive function, which was found to be facilitated by the performance of QCT. These findings are consistent with the findings of other researchers [5]. The percentage change in ST1 was 17.27% when the before exercise phase was compared with 30 minutes after exercise. The percentage change in ST2 was 20.92% when the before exercise phase was compared with 30 minutes after exercise. Although the persistence of effect of the exercise on enhancement of stroop performance is highly sensitive to the exercise intensities and significant crosstalk is existing in this regard. While most of the studies reporting the stroop performance is facilitated by the moderate exercise intensity, there are other studies showing that low to moderate intensity exercise does not alter executive functioning [9], moreover when the work load becomes heavy the reaction time in executive condition becomes slow [10].

This study has attempted to find the correlation between the physiological parameters and the performances in various domains of cognition to reveal the degree of association between these two entities considering the present context. In majority of the cases a moderate to high correlation was found depicting that changes in physiological parameters were well correlated with the changes in the cognitive performance in the exercise intensity at which the QCT was performed. Physiological parameters like QCT HR, VO$_2$ max$^{\text{pred}}$, was found to be significantly correlated with ST1 performance time at various phases of exercise (Table 3). In other cases the correlation shows the insignificant moderate to high value and it may be due to the effect of the smaller sample size (n=10). The highest correlations were observed after the 30 minutes of the exercise performance and may be explained that the relation between the physiological parameters and SRT maintained at a stronger level of association after 30 minutes. Hence the QCT produced a pronounced effect on the SRT. While the different observations were noticed in case of correlation of physiological parameters with ST1 and ST2. In such a case the higher values of correlation were observed till immediately after the exercise and thereafter the correlations weaken. Hence, it can be concluded that the relation between the physiological parameters and performance for selective attention is maintained at a higher level upto immediately after the exercise. In another word it can be postulated that 3 minutes of QCT performance cannot produce a remarkable effect on higher executive function viz. stroop task till 30 minutes after the exercise. Only a very few researchers have attempted the approach in finding the correlation between the physiological parameters and cognitive performance.
Peiffer et al. [19] studied the correlation between VO$_2$ max and measures of cognitive performances at both high and moderate intensity of exercise and found that at both the intensities VO$_2$ max values are well correlated with the domains of cognitive performances.

Various studies have reported that the cognitive performances has augmented by altering the neuronal activities followed by the exercise performances [7, 9, 20, 21, 22, 23, 24, 25]. It has been observed through the recording of event related potential (ERP) that the changes in the activities of P300 wave form at neuronal level is highly responsible in altering the neuro-cognition with the updated stimulus environment [20]. It has been reported by the several researcher that the amplitude of the P300 is increased and the latency is shortened followed by the performance of a bout of aerobic exercise [21].

CONCLUSION

The present study has found the beneficial effect of Queen’s College Step test (short duration exercise)on the cognitive performance in a small group of young Indian adults. It was also found that the performance of a sub-maximal exercise for duration of 3 minutes can influence the attention and enhance speed of processing. This effect persists upto 30 minutes after the performance of exercise. Further studies are required to establish the beneficial effect of the QCT on the cognitive performance and how long it persists beyond 30 minutes by targeting a larger sample size.

IMPLICATIONS AND CONTRIBUTION

Mental performance is of paramount importance in young adult population. Enhanced mental performance followed by physical exercise may produce twofold beneficial effect. QCT can be performed at ease in anywhere. The findings of the study emphasize that exercise protocol is cost effective and providing both physical and mental benefit.

LIMITATIONS OF THE STUDY

There were number of potential limitations of the present study, which may be
addressed with proper scientific approach in the future attempts. The limitations are as follows:

1) Present study is restricted to only young healthy subjects. It is not applicable for patients and aged people.

2) Present study has drawn the inference on a relatively small sample size (n = 10) considering only the young male adult population. In the future attempts more number of participants may be considered for both genders of different age group.

3) We did not have the scope to measure the changes in cardio-respiratory responses throughout the exercise duration which could be addressed by the use of a gas analysis system in the future attempts.

4) Recording of changes in various brain waves by EEG along with the fNIR imaging during various phases of task performance will provide the valuable information on the effect of exercise in different domains of brain function, which was beyond the scope of the present study.

ACKNOWLEDGEMENT

First of all we want to extend our heartiest thanks to all the participants those who have volunteered the study. We also express our sincere thanks to Director, DIPAS for giving us the permission to conduct the study.

REFERENCES


Address for correspondence:

Madhusudan Pal
Ergonomics Division, Defence Institute of Physiology and Allied Sciences, Defence Research & Development Organization, Lucknow Road, Timarpur, Delhi 110 054, India.
Tel.: +91 11 23883011
Email: madhusudanpal@rediffmail.com