ORIGINAL ARTICLE

Reaction Time Based Cognitive Functions and Associated Recovery Heart Rate in Medical Student

Chaudhary S[1], Shah GJ[2]

ABSTRACT

Introduction: Physical activity is an indicator of physical function that preserve or promotes cerebral blood flow which in turn is associating with better functioning cognitive function. Cognitive functions can be assessed using reaction time. It is the ability to quick motor response to definite stimulus, while the time that elapses between the sensory stimulation and the motor activity. **Aims:** To assess the cognitive function of medical students using visual & auditory reaction times in different fitness groups and to correlate values of reaction times to recovery heart rate **Methods:** In this cross-sectional study, 57 consenting healthy medical students age 17-30 years, underwent 3-Minutes Step Test to assess their physical fitness along with Auditory reaction time and Visual reaction time to assess their cognitive function. Based on Recovery heart rate which was calculated after 3-Minute step test. Students were categorized into four groups that is good, satisfactory, poor and very poor their Auditory reaction time and Visual reaction time T were measured for these groups. **Results**: Results showed Auditory reaction time and Visual reaction time was statistically significant when all groups of physically fitness were compared (p-0.014). When pairs of groups were compared significant differences of Auditory reaction time was found good fitness level Vs very poor fitness level in Auditory reaction time (p-0.008) and significant difference of Visual reaction time was found between good fitness level Vs satisfactory fitness level in Visual reaction time (p-0.028). Comparison of many other pairs of fitness groups found to be non-significant. **Conclusion:** Good fitness level has higher cognition which can be achieved by doing physical activity to improve the fitness level.

Keywords: Auditory reaction time, Recovery heart rate, Visual reaction time

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INTRODUCTION

Cognitive functions can be assessed using reaction time, memory measures and executive function. Reaction speed is the ability to quick motor response to definite stimulus, while the time elapses between the sensory stimulation and the motor activity.[1] It is an index of the processing capability of central nervous system and thereby simple means of determining sensory motor performance.[2] Exercise increases blood flow to the brain which improves exchange of nutrients like glucose, oxygen etc to the structure which influence cognitive function.[3] Regular exercise elicits beneficial changes in brain structures and improvement in cognitive performance.[4] Improving reaction time helps in making decisions and increasing attention.[2] The objectives of our study were to assess the cognitive function of medical students using visual and auditory reaction times in different fitness groups and to correlate the values of reaction times and recovery heart rate.

METHODS

The study was conducted on healthy MBBS male and female medical students in the Nepalgunj Medical College. It was cross sectional study which includes sample size fifty-seven (57) and duration of the study was 6 month (January to June 2021). The purposive sampling method was applied to select the subjects. Fifty-seven medical students fulfilling inclusion and exclusion criteria of the study were enrolled in the study. In the inclusion criteria healthy young adults (MBBS students) were taken whose age was in between 17 to 30 years. And the students with musculoskeletal disorder, cardiovascular disorders, respiratory disorders, endocrine disorders or any other disorders affecting autonomic nervous system along with history of alcohol abuse, use of neurotoxic drugs and students on regular medication were excluded. Subjects who did not have any clinical history were considered as apparently healthy. Their health status was assessed through questionnaires, which assessed their medical history, physical health status along with their cardio-respiratory variables.

Details of Recording Procedure

Recording Procedure of 3-Minute Step Test

The test was conducted using a bench having height 13" inches. The test was done after 10 minutes rest in resting position. The subjects performed stepping cycle of four-step cadence (up-up-down-down) for three minutes. In our study, the physical fitness level given by Young Men's Christian Association was modified into 4 groups based on the recovery heart rate after the sub-maximal exercise. The modified fitness level assigned were:

Fitness level 1 = Good

Fitness level 2 = Satisfactory

Fitness level 3 = Poor

Fitness level 4 = Very Poor

Fitness level assigned for the present study groups	Fitness category assigned by YMCA	Recovery Heart Rate (BPM) for 18-25 yrs of age (male)
Good fitness level	Excellent	50 – 76
	Good	79 – 84
Satisfactory fitness level	Above Average	88-93
	Average	95 – 100
Poor fitness level	Below average	102 – 107
Very poor fitness level	Poor	111 – 119
	Very poor	124 – 157

Table I: Modification of category of physical fitness level and scores given by Young Men's Christian Association that was used for the present study for male subjects[10]

Fitness level assigned for the present study groups	Fitness category assigned by YMCA	Recovery Heart Rate (BPM) for 18-25 yrs of age (female)
Good fitness level	Excellent	52 – 81
	Good	85 – 93
Satisfactory fitness level	Above Average	96 – 102
	Average	104 – 110
Poor fitness level	Below average	113 – 120
Very poor fitness level	Poor	122 – 131
	Very poor	135 – 169

Table II: Modification of category of fitness level and scores given by Young Men's Christian Association that have been used for the present study for female subjects[10]

Physical Fitness Variables

Recovery heart rate (beat/ min) were recorded

Recording Procedure of Cognitive function

The subjects had to proceed for the recording of auditory reaction time (ART) and visual reaction (VRT) timeto assess Cognitive function. The subject had been instructed before performing tests about their procedure and short description.

Recording procedure of Visual Reaction Time

The subjects were instructed to press the stop key as soon as they perceived the visual signal. Keep the two-way switch on "light" side and then, give the stimulus by one switch; start rotating kymograph which records time. The stimulus was given by one sustain and the recording was obtained on a graph attached to the rotating kymograph at a speed of 640mm/sec. When the subject responded to the visual signal by releasing the switch, there was a deflection in the writing lever. And then, the VRT was calculated from the obtained distance and speed of the moving kymograph.

For Recording of Auditory Reaction Time

The subjects were instructed to press the stop key as soon as they perceived the sound signal. It was produced by tapping the morse keys by the instructor. As soon as the subject heard the sound, they had to discontinue by pressing the morse key. The recording was obtained on a graph pasted on a moving kymograph at a speed of 640 mm/s. As in the VRT recording, the downward and upward deflections of the recording was seen. The ART was obtained in similar manner. All tests were done for three times for maintaining reliability of the test.

Cognitive Function Variables

Visual and auditory reaction times (ms) were recorded.

Calculation of ART and VRT

VRT was calculated from the obtained distance and speed of the moving kymograph; VRT= distance / speed.

ART was also calculated using formula VRT; ART= distance/ speed.

Equipment used

For the measurement of cognitive recording variables

For recording auditory and visual reaction times, an electric circuit make and break was made with battery of 6 volt, a bulb of 3 volt, two pairs of morse key (1844, made in USA) and magnetic induction was connected in the series circuit as shown in the (Figure:1) with the help of wires. The recording was obtained in a graph which was set in a kymograph.

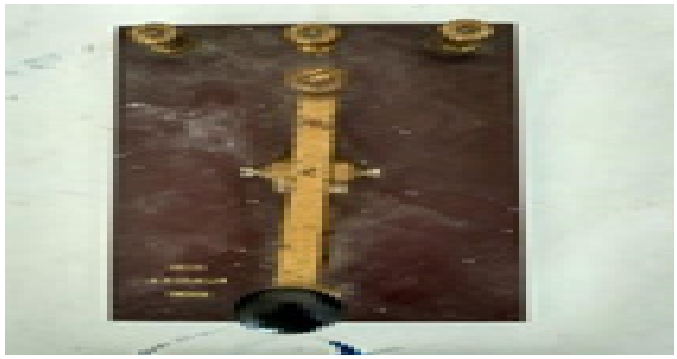

Figure 1: Morse

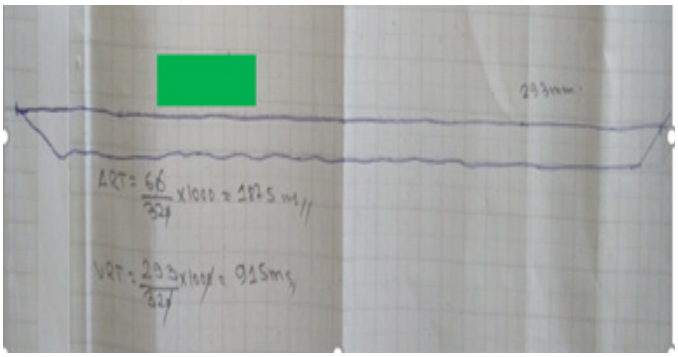

Figure 2: Record of visual reaction time

Statistical analysis

Based on distribution of observations the statistical test was applied. By using statistical software SPSS version 21.0 data were statistically analyzed. The data were expressed as mean ± SD for normally distributed data and median (interquartile range) for non-normally distributed data. Normally distributed data were analyzed using parametric one-way ANOVA followed by Post-hoc Bonferroni tests. The Spearman correlation was applied to find out the correlation between recovery heart rate (RHR) and cognitive function variables. The correlation is expressed in terms of correlation-coefficient rho and level of significance (p). The p<0.05 will be considered statistically significant.

RESULTS

1. Physical fitness variables

All students were grouped into four fitness groups based on the recovery HR measured/ calculated during their physical fitness test. The Young Men's Christian Association guidelines with some modification was used to categorize students into four physical fitness groups; good, satisfactory, poor and very poor fitness (33%) (table III). Maximum percentage of students (33%) had very poor fitness level followed by 30% of them having satisfactory fitness level. The proportion of male and female in each fitness groups were almost similar (table III).

Physical fitness levels	Recovery HR Mean ± SD (n=57)	Number of medical students (%)	Male	Female
Good	87.33 ± 4.24	9 (16%)	4	5
Satisfactory	98.00 ± 6.55	17 (30%)	9	8
Poor	110.92 ± 5.98	12 (21%)	7	5
Very poor	128.42 ± 10.78	19 (33%)	9	10
Total		57 (100%)	29	28

Table III: Physical fitness levels of medical students on the basis of recovery heart rate

2. Comparison of cognitive function variables among four fitness groups

The good fitness group showed significantly low ART as compared to very poor fitness group. There were no significant differences among other groups. For VRT, the good fitness group showed significantly low VRT as compared to the satisfactory fitness group. There were no significant differences among other groups.

Variables	Groups Mean ± SD						
	Good fitness level (n=9)	Satisfactory fitness level (n=17)	Poor fitness level (n=12)	Very poor fitness level (n=19)	Overall p-values	p5	p1
ART (ms)	144.9 ± 38.3	178.3 ± 36.30	181.8 ± 40.3	201.5 ± 47.2	0.014	0.008	0.333
VRT (ms)	508.33± 75.18	658.35± 132.06	561.17± 60.71	638.47± 156.29	0.014	0.070	0.028

Table IV: Comparison of ART and VRT among four fitness levels

ART= auditory reaction time, VRT= Visual reaction time, p<0.05 was considered statistically significant, where, p1= good fitness level Vs satisfactory fitness level, p5= good fitness level Vs very poor fitness level. The comparison among other groups were not statistically significant.

The recovery HR showed significant positive correlation with ART and VRT (table V)

Variables	Recovery heart rate (bpm)	
	Rho	p-value
ART (ms)	0.434	0.001
VRT (ms)	0.275	0.038

Table V: Association of Recovery heart rate with cognitive function variables in healthy young medical students

ART= Auditory reaction time, VRT= Visual reaction time, ms= millisecond, p<0.05 was considered statistically significant

DISCUSSION

This study was conducted to investigate the cognitive function assessed by auditory reaction time and visual reaction time. Our results showed significant differences among four fitness groups which were categorized on the basis of recovery heart rate. The good fitness group had better cognitive performance than poor fitness group which was supported by the study conducted by Garg et al.[5] They determined the effect of aerobic exercise on auditory and visual reaction time. They found both ART and VRT better in aerobic exercisers as compared to non-exercisers irrespective of age and gender which favors our study. Also, Manoux SA et al[6] conducted a study to analyze, the effects of exercise on auditory reaction time. It showed that acute-exercise decreased reaction time which proved to be improvement in reaction time abilities which showed similar results to the study we performed.

Another study conducted by Chaddock et al[7] showed greater hippocampal cerebral blood flow in children with higher level of aerobic fitness. This high blood flow results in increased volume of hippocampal area which enhances the cognitive function of an individual as hippocampal area is associated with cognitive performance which exists in favor our study. A similar study was conducted by Voss et al[8] on bridging animal and human models on exercise induced brain plasticity. They found that aerobic exercise stimulates cascade of neuroplastic mechanism within the hippocampus that were often paralleled by functional improvements. The efficiency of aerobic energy was improved by increasing maximal oxygen uptake from the circulation to the tissues which in turn enhanced velocity of nerve impulse conduction and cardiorespiratory endurance which comes in accordance to the study we performed. A study was conducted by Loretta et al[9] on adults (70-79 yrs) to study the association between the physical fitness and measures of cognitive function in healthy older adults and it was found that physically active adults had higher cognitive performance scores than the physically less active individual. The following statement was supported by our study. In our study we found positive correlation of recovery HR with ART and VRT which reflected that good fitness group had shorter reaction time with improved cognitive performance which parallels with the finding of the study performed by Hannal et al.[4]

Strength of study

Homogenous group of healthy young medical students were included in the study. The methods were performed properly during the study period. All the obtained data were collected between 8:15 AM to 11 AM of the day to avoid variation due to circadian rhythm. Cognitive function assessment of both visual and auditory reaction times was done. Very few studies have been conducted dividing physical fitness into four categories.

LIMITATIONS

We categorized into four groups so, some groups included a smaller number of subjects and the sample size was relatively small so, we couldn't include more numbers of subjects.

Future Directions

The study can be conducted on larger sample size including both male and female as separate groups and in different age groups.

CONCLUSION

The students with good fitness have shorter reaction time with compared to the other groups which showed that they had better cognition. Further, both auditory reaction time and visual reaction time were found to be positively associated with recovery heart rate, that is, an increase in either auditory or visual reaction time was also followed by an increase in recovery heart rate.

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