Effect of Long Term Physical Exercise Training on Auditory and Visual Reaction Time

Shashi Kant Verma

ABSTRACT

The present work was planned to determine long term physical exercise has any beneficial effect on central neural processing, by studying its effect on reaction time. In present study 20 male and 20 female, young medical students practiced exercise (15 min sessions) for 3 months on alternate day basis. Outcome assessments of auditory reaction time (ART) and visual reaction time (VRT) were performed at baseline and after the 3 month of exercise training. In both male & female, there was a statistically significant (P<.001) decrease in ART and VRT. Also ART and VRT values were more in females than in males both before and after physical exercise training. This probably attributed to the differences in processing strategy in males and females. This decrease in ART and VRT after exercise practices may be due to physiologically relaxed state but increased mental alertness, improved concentration, and/or increased CRH & cortisol secretion in response to a challenge. . This is of applied value in situations requiring faster reactivity regarding serious safety concern such as in day today driving to avoid road traffic accidents, in sports for recommendation of safety limits, machine operations and in specialized surgery. So we suggest that the physical exercise is a lifestyle factor that might lead to increased physical and mental health and performance that can be used as an effective means of training people involving such tasks.

Key words: Physical exercise, Reaction time, Central neural processing

INTRODUCTION

Simple reaction time is defined as "the interval between the onset of the stimulus and the response under the condition that the subject has been instructed to respond as rapidly as possible"[1].

Reaction time (RT) is an indirect index of the processing ability of central nervous system and a simple means of determining sensory motor association and performance [2]. RT involves central neural mechanisms and its study is of considerable physiological interest. In 1983 Spirduso proposed RT as a measure of the overall integrity of central nervous system [3]. Also there is evidence that cardiovascular fitness exerts a positive influence in the psychomotor domain. RT has been used as primary index of psychomotor performance.4 RT is sensitive and reproducible test and its measurement can be done with simple apparatus and set up. It has also been suggested that RT can be used as a simple and objective method to determine the cognitive and motor performance effects of various exercise trainings [4].

Over the past several decades there has been an increasing interest in the influence of exercise on motor performance. A number of studies have reported improvement in performance in terms of reaction time (RT) with physical training5-7 while some research showed no effect on RT.8-10 So, we planned to see the effect of long term exercise training on reaction time. Additionally, we try to make a hypothesis on neurophysiological mechanism be-

Author Affilation: Assistant Professor, Dept of Physiology, RMCH, Bareilly, U.P.

Reprint request: Shashi Kant Verma, Assistant Professor, Dept of PhysiologyRMCH, Bareilly, U.P. E-mail: skdonn@gmail.com.

(Received on 07.03.2011, Accepted on 09.04.2011)

hind the changes in RT after long term exercise.

MATERIALS AND METHODS

The present study was conducted in Department of Physiology, RMCH, Bareilly on forty (40), 1st year MBBS students. Detailed information was collected on pre-designed proforma. Complete general, anthropometric and systemic examinations were carried out. Subjects with previous regular athletic activity or yogic training/ meditation were excluded from study. After briefing about the study protocol, consent was obtained. These two groups of male (n=20) and female (n=20) students performed physical exercise on bicycle ergometer till target heart rate between 100-150 beats/minute (moderate exercise) was obtained. This exercise was done for 3 months on alternate day basis in peaceful, lighted and well - ventilated hall between 7.00 AM to 8.00 AM at room temperature. Clothing was minimal and very loose. The ART and VRT were recorded initially at the onset of the study (Baseline reading) and again after 3 months of physical exercise training.

An electronic instrument (Fig. 1 and Fig. 2) was used to measure reaction time both auditory and visual, whose sensitivity was to take readings from 0

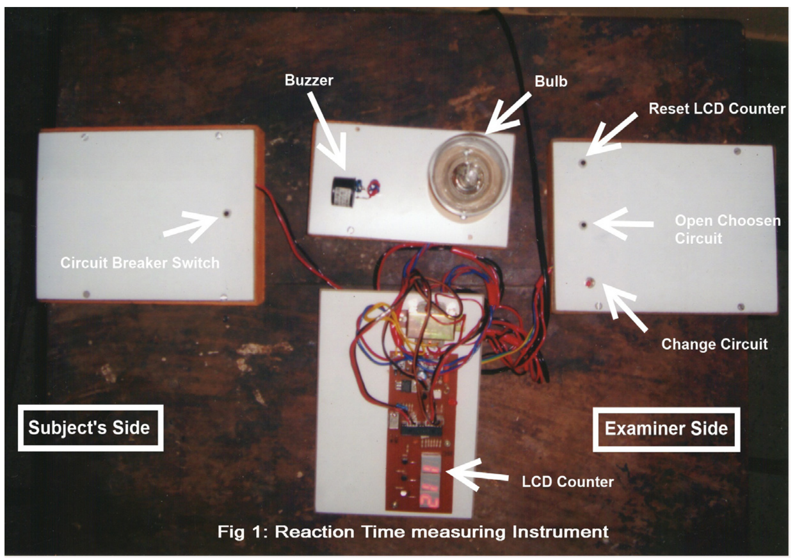

Fig. 1. Reaction time measuring instrument

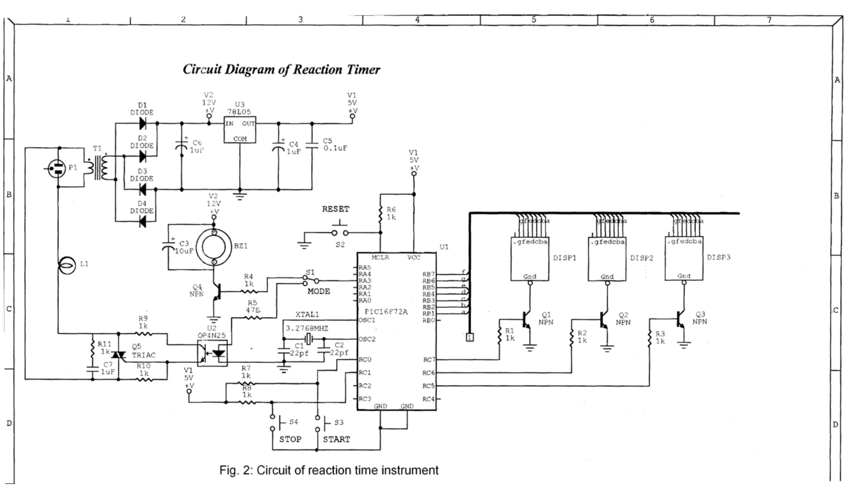

Fig. 2. Circuit of reaction time instrument

to 999 milliseconds (ms). This instrument consisted of 4 boards. One board was on the examiner's side (which subjects cannot see) in which there were 3 switches: first switch was to change the circuit between auditory or visual signal productions, second switch was to open the circuit as opted by first switch and third switch was to reset the LCD counter. Second board had the LCD for counting the reaction time (0 to 999 ms).The third board had a buzzer and a bulb. The second and third boards were placed in between the subject and the examiner. The fourth board on the subject's side had a switch to break the circuit after receiving the stimulus either auditory or visual. All the switches used in instrument were micro-switches that were very sensitive to touch.

No warning signal was given and to avoid the effect of lateralized stimulus, visual and auditory signals were given from the front of the subjects who were instructed to use their dominant hand while responding to signal.

Table 1. Anthropometric data of the volunteers

	Male (Mean ± SD)	Female (Mean ± SD)
Age (Yrs)	22.9 ± 1.141	21.5 ± 1.732
Height (cm)	179.0 ± 5.254	156.05 ± 2.999
Weight (kg)	58.6 ± 3.720	48.55 ± 3.649

SD = Standard Deviation, Yrs = Years, cm = Centimeter and kg = Kilogram.

Recording of Auditory Reaction Time

Subjects were blindfolded and instructed to cut off the circuit by pressing the switch as soon as they hear the buzzer. The observer selects the auditory circuit by the switch provided and switches on this circuit at varying time intervals to avoid guess work by subject. As soon as subject hears the sound, he cut off the circuit by pressing the switch. The subsequent time taken was recorded as auditory reaction time (ART) of that particular subject. Three such readings of each subject were taken and the mean was calculated.

Recording of visual reaction time

The above procedure was repeated by choosing the visual circuit instead of auditory circuit, where the subject is instructed to use ear plug and responds by pressing the switch as soon as he visualizes the lighted bulb (40 watt). The subsequent time taken is the visual reaction time (VRT) of that particular subject. Three such readings of each subject were taken and the mean was calculated.

Data collection and analysis

The baseline readings were taken at start of the study and then compared with that of final readings at the end of 3 month training in both male and female groups. The paired t-test was used for statistical analysis, a P-value of <0.05 was considered statistically significant. RT analysis excluded erroneous key presses.

Table 2. Comparison of auditory reaction time in males and females before and after the 3 months of exercise practice

	Before Ex practice (ms)	After 3 months of Ex practice (ms)	Significance
Male (Mean ± SD) (n=20)	148.10 ± 25.538	122.90 ± 13.799	HS
Female (Mean ± SD) (n=20)	160.25 ± 28.325	134.30 ± 17.391	HS

SD = Standard Deviation, Ex = Exercise, ms = millisecond and HS = Highly significant (P<.001).

RESULTS

All the students were unmarried and Hindu. 60% (24) students were vegetarian, and the remaining 40% (16) gave history of taking non-vegetarian diet occasionally. Anthropometric data of subjects are summarized in Table 1.

None of the subject gave any history of yogic training or physical exercise of any kind. Also no history of any addiction (alcohol, guthka or cigarette smoking) is found.

Paired 't' test was used to analyze the data. For statistical analysis, the software SPSS version 17.0 was used. The confidence interval of 95% was set for all comparisons and a P valve of less than 0.05 was accepted as indicating significant difference between the compared values. Data are expressed by using mean and standard deviation.

Before Exercise training, in males ART was 148.10 ± 25.538 ms and after performing three months training, ART decreased to 122.90 ± 13.799 ms, the decrease being statistically highly significant (P<0.001). (Table 2)

Table 3. Comparison of visual reaction time in males and females before and after the 3 months of Exercise practice

	Before Ex practice (ms)	After 3 months of Ex practice (ms)	Significance
Male (Mean ± SD) (n=20)	167.55 ± 26.916	137.00 ± 18.186	HS
Female (Mean ± SD) (n=20)	177.95 ± 24.831	149.80 ± 14.898	HS

SD = Standard Deviation, Ex = Exercise, ms = millisecond and HS = Highly significant (P<.001).

Before Exercise training, in females ART was 160.25 ± 28.325 ms and after performing three months training, ART decreased to 134.30 ± 17.391 ms, the decrease being statistically highly significant ($P<0.001$). (Table 2)

Before Exercise training, in males VRT was 167.55 ± 26.916 ms and after performing three months training, VRT decreased to 137.00 ± 18.186 ms, the decrease being statistically highly significant ($P<0.001$). (Table 3)

Before Exercise training, in females VRT was 177.95 ± 24.831 ms and after performing three months training, VRT decreased to 149.80 ± 14.898 ms, the decrease being statistically highly significant ($P<0.001$). (Table 3)

DISCUSSION

Effect of exercise on processing ability of central nervous system in terms of reaction time is debatable as some studies shown no effect8-10 while other reported a decrease5-7 in it.

The finding of our study revealed that RT for auditory & visual reaction stimuli was found to be faster in subjects having exercise training as compared to pre-training RT status.

In our study we have also found that ART and VRT was more in females than in males, which is in conformity with previous studies11-13. This probably attributed to the differences in processing strategy in males and females [14]. Also the auditory reaction time was faster than the visual reaction time both in males and females that is in line with previous studies [13].

This faster RT in aerobic exercises is due to improved concentration, alertness, better muscular coordination and improved performance in the speed and accuracy task [15, 16[. These factors leads to reduce tension and develops alertness and better coordination of mind with body, which seems to be responsible for better performance of the individual [15, 17]. Aerobic exercise training affects various organ systems including Cardiovascular, respiratory, CNS & skeletal muscles etc. These trainings leads to an increase in cardiac stroke output associated with more complete emptying of heart during systole. There is also a reduction in the ventilation minute volume at high rates of work, on account of an improved muscle blood flow and an increase in intracellular enzymes[15]. There is increased vagal tone in athletes, with greater muscle tension and behavioral features which distinguish the trained from the untrained and favours establishment of new motor performance[16, 17].

Exercise training bring out an increase in stores of creatine phosphate as well as glycogen. Creatine kinase activity is increased and so is the activity of mitochondrial enzymes leading to enhanced respiratory capacity of skeletal muscles18. This causes sparing of glycogen and increased capacity to oxidise fatty acid, thus improved work time, delayed fatigue, increasing oxidation of ketones and increased removal[15, 19]. Thus, these beneficial effects in aerobic exercisers are responsible for their faster reaction time performance.

Some studies had shown no significant change in reaction time after long term aerobic and resistance training[8, 9, 10, 20, 21]. However this inconsistency may due to differing in subject selection, mode of exercise (strength/ endurance), the timing of RT measurement (Immediate after exercise or during exercise) or sensitivity of RT instrument.

A decrease in RT is known to improve the sensorimotor performances. Thus RT could be used either for screening the large population for physical fitness [22], in sports physiology [23, 24], as a therapeutic intervention in certain type of medical conditions like depression [25], cardiovascular diseases and diabetes [26], to train mentally retarded children and older sports persons who have prolonged RT [27], as an index of cortical arousal [28] or to assess cognitive impairment after an accident [29].

Exercise training leads to increased CRH (corticotropin releasing hormone) [30] and cortisol secretion in response to a challenge as compared to the control subjects [31] but the baseline levels during rest are reduced [32]. So when a challenge is presented in form of pressing the key as soon as possible in response to light or buzzer there is increased CRH and cortisol secretion. While testing RT, the individual being tested is in a state of stress/ challenge as he has to press the key in the shortest possible time in response to an auditory /visual signal. To do so the nerve impulse has to be processed faster in the auditory/visual neuronal pathways and its association fibers to frontal cortex. The reaction time also depends on the quick activity of skeletal muscle. Both these factors depend on the blood flow to the particular organ i.e. central nervous system and skeletal muscle. Exercise has been shown to increase cerebral [33, 34] and skeletal muscle blood flow18 by increasing cortisol level in blood during stress [31].

So we want to hypothesize that this dual action of exercise both on CNS as well as skeletal muscle are the possible mechanisms that lead to markedly decrease reaction time as compared to control subjects. Further studies are required to substantiate this.

CONCLUSIONS

This shortening of RT after regular exercise training is of applied value in situations requiring faster reactivity regarding serious safety concern such as in day today driving to avoid road traffic accidents, sports, for recommendation of safety limits, machine operations and in specialized surgery. So we suggest that regular physical activity should be promoted and access to sports facilities should be facilitated especially in people involving such tasks.

ACKNOWLEDGEMENT

The authors thank Dr Mrs Sharda Gupta, Professor and Head, Department of physiology, RMCH, Bareilly and other faculty members for their support.

REFERENCES

1. Teichner WR. Recent studies in Simple Reaction Time. *Psychol Bull* 1954; 51: 128-149.
2. Dash M, Telles S. Yoga training and motor speed based on a finger tapping task. *Indian J Physiol Pharmacol* 1999; 43(4): 458-462.
3. Spiruso WW. Exercise and aging brain. *Research Quarterly for Exercise and Sport* 1983; 54: 208-218.
4. Hillman CH, Weiss EP, Hagberg JM, Hatfield BD. The relationship of age and cardiovascular fitness to cognitive and motor processes. *Psychophysiology* 2002; 39: 303–312.
5. Pesce A, Tessitore A, Casella R, Pirritano M, Capranica L. Focusing of visual attention at rest and during physical exercise in soccer players. *Journal of Sports Sciences* 2007; 25(11): 1259-1270.
6. Lemmink KA, Visscher C. Effect of intermittent exercise on multiple chioce reaction times of soccer players. *Perceptual and Motor Skills* 2005; 100: 85-95.
7. McMorris T, Delves S, Sproule J, Lauder M, Hale B. Effect of incremental exercise on initiation and movement times in a choice response, whole body psychomotor task. *Br J Sports Med* 2005; 39: 537–541.
8. Nakamoto H, Mori S. Sport-specific decision-making in a go/no go reaction task: difference among nonathletes and baseball and basketball players. *Perceptual and Motor Skills* 2008; 106(1): 163-171.
9. Davranche K, Audiffren M, Denjean A. A distributional analysis of the effect of physical exercise on a choice reaction time task. *Journal of Sports Sciences* 2006; 24(3): 323-330.
10. Welford AT. Choice reaction time: Basic concepts. In A. T. Welford (Ed.), Reaction Times. New York; Academic Press, 1980; 73-128.
11. Bahramali H, Gordon E, Lagopoulos J, Lim CL, Li W, Leslie J, Wright J. Effects of age on late components of the ERP and reaction time. *Experimental Aging Research* 1999; 25(1): 69-80.

12. Dane S, Erzurumluoglu A. Sex and handedness differences in eye-hand visual reaction times in handball players. *International Journal of Neuroscience* 2003; 113(7): 923-929.
13. Misra N, Mahajan K, Maini BK. Comparative study of visual and auditory reaction time of hands and feet in Males and females. *Indian J Physiol Pharmacol* 1985; 29(4): 213-218.
14. Adam JJ, Paas FG, Buekers MJ, Wuyts IJ, Spijkers WA, Wallmeyer P. Gender differences in choice reaction time: evidence for differential strategies. *Ergonomics* 1999; 42(2): 327-335.
15. Cotes JE, Meade F. Physical training in relation to the energy expenditure of walking and to factors controlling respiration during exercise. *Ergonomics* 1959; 2: 195.
16. Grim BY, L Hannertz. Recruitment order of motor units on voluntary contractions changes induced by propioceptive afferent activity. *J Neurol Neurosurg Psychiatry* 1965; 31: 563-73.
17. Joki E, Lexington KY, Anand RL. Advances in exercise physiology. *Record Physiology* 1974; 9(18): 21-22.
18. Bijlani RL. *Physiology of exercise* In: Understanding medical physiology, 3rd ed. New Delhi; Jaypee Brothers Medical Publishers Ltd, 2004; 644 & 637.
19. Winder WW, Baldwin KM, Holloszy JO. Enyme involved in ketone utilisation in different types of muscle: adaptation to exercise. *Eur J Biochem* 1974; 47(3): 461-467.
20. Panton L B, Graves J E, Pollock M L, Hagberg J M, and Chen W: Effect of aerobic and resistance training on fractionated reaction time and speed of movement. *J Gerontol* 1990; 45(1): M26-31.
21. Simonen RL, Videman T, Battie MC, Gibbons LE. The effect of lifelong exercise on psychomotor reaction time: a study of 38 pairs of male zygotic twins. *Med Sci Sports Exerc* 1998; 30(9): 1445-50.
22. Borker AS, Pednekar JR. Effect of pranayam on visual and auditory reaction time. *Indian J Physiol Pharmacol* 2003; 47(2): 229-230.
23. Gharote ML. Effect of yogic training on physical fitness. *Yoga Mimamsa* 1973; 15(4): 31-35.
24. Bhanot JL, Sindhi LS. Reaction time in Indian hockey players with reference to three level of participation. *J sports med* 1979; 19: 199-204.
25. Bieliauskasab LA, Lambertyc GJ. Simple reaction time and depression in the elderly. *Aging, Neuropsychology, and Cognition* 1995; 2(2): 128-131.
26. Richerson SJ, Robinson CJ, Shum J. A comparative study of reaction times between type II diabetics and non-diabetics. *Biomed Eng Online* 2005; 4: 12.
27. Un N, Erbahceci F. The evaluation of reaction time on mentally retarded children. *Pediatr Rehabil* 2001; 4: 17–20.
28. Malathi A, Parulkar VG. Effect of yogasanas on the visual and auditory reaction time. *Indian J Physiol Pharmacol* 1989; 33(2): 110-112.
29. Warden DL, Bleiberg J, Cameron KL, Ecklund J, Walter J, Sparling MB, Reeves D, Reynolds KY, Arciero R. Persistent prolongation of simple reaction time in sports concussion. *Neurology* 2001; 57(3): 524–26.
30. Inder WJ, Hellemans J, Swanney MP, Prickett TC, Donald RA. Prolonged exercise increases peripheral plasma ACTH, CRH, and AVP in male athletes. *J Appl Physiol* 1998; 85(3): 835-41.
31. Harte JL, Eifert GH, Smith R. Effects of running and meditation on beta-endorphin, corticotropin-releasing hormone and cortisol in plasma and on mood. *Biological Psychology* 1995; 40(3): 251-265.
32. Duclos M, Corcuff JB, Pehourcq F, Tabarin A. Decreased pituitary sensitivity to glucocorticoids in endurance-trained men. *European Journal of Endocrinology* 2001; 144: 363-68.
33. Dustman RE, Emmerson RY, Ruhling RO, Shearer DE, Steinhaus LA, Johnson SC, Bonekat HW, Shigeoka JW. Age and fitness effects on EEG, ERPs, visual sensitivity, and cognition. *Neurobiology of Aging* 1990; 11: 193–200.
34. Rogers RL, Meyer JS, Mortel KF. After reaching retirement age physical sustains cerebral perfusion and cognition. *Journal of the American Geriatric Society* 1990; 38: 123–128.