Original Research Article

International Physiology
Volume 7 Number 1 January - April 2019
DOI: https://dx.doi.org/10.21088/ip.2347.1506.7119.3

Comparative Study of Event Related Potential in Athletes and Healthy Adults

Priti Kamble[1], Shafique A Mundewadi[2], Charushila Atul Rukadikar[3],

Author Affiliation

[1]Medical Officer, BMC, Mumbai, India [2]Associate Professor, Department of Physiology, Dr Vaishampayan Memorial Govt Medical College, Solapur, Maharashtra 413003, India. [3]Assistant Professor, Department of Physiology, Zydus Medical College and Hospital, Dahod, Gujarat 389151, India.

Corresponding Author

Charushila Atul Rukadikar, Assistant Professor, Department of Physiology, Zydus Medical College and Hospital, Dahod, Gujarat 389151, India.

E-mail: charuj11@yahoo.com

Received on: 28.11.2018

Accepted on: 14.12.2018

Abstract

Background: Cognitive Evoked Potential components are depend on mental attention of subject which are related with cognition, memory. *Aims and Objectives:* The purpose of study is comparison of properties of event related potential in athletes and cricket players. *Material and Methods:* Total 60 athletes (15-25 years), from district sports academy, who are regularly practicing from more than 3 years having physical activity 5-7 hrs per week. We have taken 60 healthy age match volunteer controls having physical activity less than 5 hrs per week. Both control & athletes don't have any abnormality of auditory, neurological problem. Evoked potential, P300 response was recorded using standard auditory oddball paradigm by Rmsemg Ep II machine. All participants received 3-minute conventional, eyes-closed, awake, rehearsal by placing headphone over ears after 5-minute habituation to experimental environment. 2 tones were used as stimulus, frequent low pitch tone & rare high pitch tone. Subjects were instructed to ignore common low pitch tones and raise finger of dominant hand each time when rare high pitch tone occurred. P300 response was recorded from vertex (Cz) in response to stimuli. The mean value of latency, amplitude was further analyzed using anovatest to establish whether statistical differences existed between controls and athletes for ERP. *Results:* ERP (P300) latency was significantly less and amplitude was significantly more in athletes in athletes as compared to controls having p value >0.001 (highly significant).

Keywords: Event Related Potential; P300; electroencephalogram (EEG).

How to cite this article:

Priti Kamble, Shafique A Mundewadi, Charushila Atul Rukadikar. Comparative Study of Event Related Potential in Athletes and Healthy Adults. International Physiology. 2019;7(1):15-22.

Introduction

Different human & animal studies have reported the beneficial influence of exercise on cognitive & brain functions so exercise is drawing increasing research attention as a possible lifestyle factor for improving neurocognitive functions & preventing or delaying dementia [1]. Exercise has the capacity to induce hippocampus synaptic plasticity, prominently enhancing synaptic efficacy [2,3] & expression of molecules implicated in learning & memory. The electroencephalogram (EEG) means recording of electrical activity of the brain by placing electrode on the scalp [4].

Cognitive Evoked Potential components are depend on mental attention of subject. Such "event-related" potentials or "endogenous" potentials are related in same manner to the cognitive aspects of distinguishing an infrequently occurring target stimulus from other stimuli occurring more frequently[5]. For clinical purposes, attention has been directed particularly at the so-called P3

component of the ERP, which is also designated the P300 component because of its positive polarity and latency of approximately 300–400 ms after onset of an auditory target stimulus. Components of ERP's are visually identified as N1, P2, N2 and P3 (P300).

An event-related potential (ERP) is a series of peaks and troughs which appears in the EEG in response to occurrence of a discrete event, such as presentation of a stimulus (visual, auditory etc.), psychological reaction to a stimulus.An endogenous ERP which has been extensively studied is the P300 (P3) wave. It is seen in response to rare, meaningful stimuli (often called "oddball" stimuli) [6]. Its peak has a typical latency of 300-1000 msec from stimulus onset. This latency varies with stimulus processing time, which is often determined by stimulus complexity. The size or amplitude of P300 at a given recording site is inversely proportional to the rareness of presentation; in practice, probabilities 3 or < 3 are typically used.

The physiological basis of the cortical ERP lies in fields of potential generated by interacting neurons [7]. Field potentials are largely dendritic in origin, resulting from the summed extracellular currents generated by electromotive forces (EMFs) in the dendrites of synchronously active cortical neurons, primarily pyramidal cells.

As these potential related with cognition, memory, and these and influenced by exercise, we have compared properties of event related potential like P300 (amplitude and latency) in athletes and normal person in present study

Material and Method

The present study was carried out in the sports physiology laboratory ofdepartment of physiology, Dr. Vaishampayan Medical College, Solapur in athletes and their age matched controls.

Table 1: sample size

No.	Group	No.of subjects	Age group (yr)
I	Athletes	60	15-25
II	Normal healthy controls	60	15-25

Before undertaking the event related potential study, a detailed case history was obtained and clinical examination was done in each control and athletes. Both groups were matched on age, educational level and sex to minimize general neurocognitive variation [8].

Group I: Controls

The controls were selected from healthy volunteers.

Inclusion criteria for control

1. Subjects between age group of 15 to 25 years
2. Having physical activity less than 5hrs/week

Exclusion criteria for control

1. Subjects below 15years and above 25 years

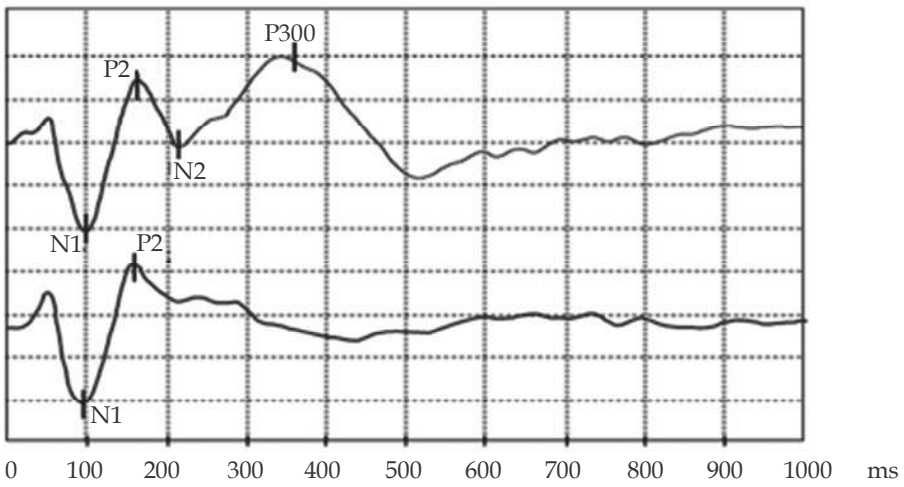

Fig. 1: In first trace, obtained in response to rare stimulus (a 2,000 Hz pure tone with an 80 dB HL intensity), there is presence of peaks N1, P2 passively generated and peaks N2, P300 generated by the mental count of the stimuli.

In the second trace, obtained in response to a frequent stimulus (a 1,000 Hz pure tone with 80 dB HL intensity), there is only peaks N1, P2 which are not associated with the task of counting sound stimuli.

2. Having physical activity more than 5hrs/week
3. Subjects with hearing defects
4. Subjects of neurological or psychiatric disorders
5. Subjects taking any sort of psychotropic, psychoactive or other drugs during course of study

Group II: Athletes

The athletes were selected from football and cricket players who played at district level.

Inclusion criteria for athletes

1. Subjects between age group of 15 to 25 years
2. Duration of training more than 3 years
3. Having physical activity 5-7hrs/week

Exclusion criteria for athletes

1. Subjects below 15 years and above 25 years
2. Duration of training less than 3 years
3. Having physical activity less than 5hrs/week
4. Subjects with hearing defects
5. Subjects of neurological or psychiatric disorders
6. Subjects taking any sort of psychotropic, psychoactive or other drugs during course of study

Recording conditions and procedure

The P300 response was recorded using the standard auditory oddball paradigm by RMSEMG EP II machine. The room was acoustically and electrically shielded. The P300 response was recorded using the standard auditory oddball paradigm. The volunteer was instructed to lie down or seat and relax on bed in a dimly lighted room & instructed to close eyes to avoid any electro–ocular artifacts.

All participants received a 3-minute conventional, eyes-closed, awake, rehearsal by placing headphone over ears after a 5-minute habituation to the experimental environment. Recordings were in accord with the international 10-20 system, with linked ear reference, a 128 Hz sampling rate and impedance below 3 kΩ. Two tones were used as stimulus, frequent low pitch tone and rare high pitch tone which were given through headphone. Subjects were instructed to ignore the common low pitch tones and raise the finger of the dominant hand each time when the rare high pitch tone occurred. P300 response was recorded from vertex (Cz) in response to stimuli present ednaurally. The subject was emphasized on remaining awake & alert during the test.

The input impedance of electrodes (Agcl electrodes) was kept below 5 kΩ. Electrodes were fixed on scalp by paste. Surface electrodes were placed on specific locations on scalp relative to bony landmarks as follows

a. Ground electrode in between eyebrows (FpZ)
b. Reference electrode at mastoid (right & left)
c. Active electrodes over forehead (Fz) & at vertex (Cz).

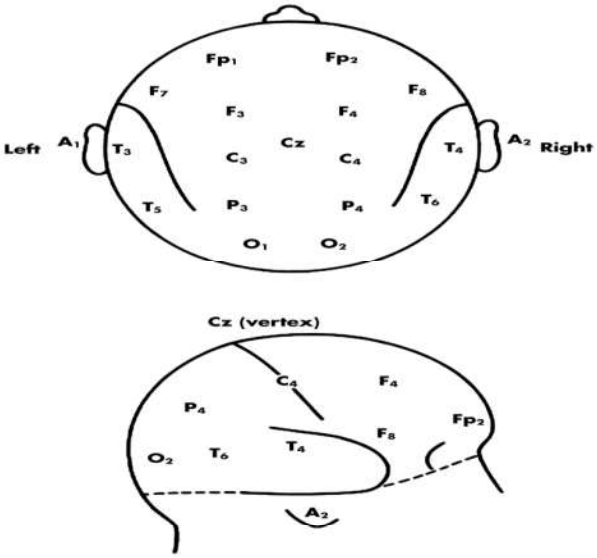

Fig. 2: Surface landmarks on scalp for electrode placement

The stimuli were delivered using oddball paradigm where the rare stimulicomprise 15–20% of total stimuli which appear randomly. The frequent stimuli were of 750 Hz and rare stimuli of 2000 Hz. The stimulus intensity of 60–80 dB is delivered binaurally at the rate of 1 Hz through headphones.

In machine setup low pass filter was kept between 0.3Hz & 1Hz & high pass filter between 20Hz & 100Hz with sweep time of 1s. The frequencies of rare & frequent stimulus were 750Hz & 2KHz respectively. The alternating tone bursts with 100 μsec duration & 80 Db intensity were used randomly. The peak latency of P300 & amplitudes of P300 of rare stimuli were calculated.

Fig. 3: Showing electrode placement for recording ERP

The relevant information gathered from printed data was tabulated using Microsoft excel spreadsheet. Relevant information consisted of latency (msec) and amplitude (μV) of each marked P300 waveform. Procedures were performed on latencies and amplitudes to determine mean and standard deviation of each variable. The mean value of latency and amplitude was further analyzed using unpaired ttest to establish whether statistical differences existed between controls and athletes for ERP.

Result and Observation

The observation tables show comparison of two groups,

Group I – Athletes

Group II- Healthy controls

Table 2: Comparison of ERP latency (msec) in athletes and controls

	Athletes	Control	t test	P value
Mean +SD	307.78 + 31.73	354.68 + 33.15	7.78	< 0.001

Above table 2 shows that ERP latency was significantly less in athletes as compared to controls having p value- >0.001 (highly significant) by unpaired t test (t test = 7.87) .

Table 3: Comparison of ERP amplitude (μV) in athletes and controls

	Athletes	Control	t test	P value
Mean +SD	12.66 + 6.64	5.91 + 3.46	6.99	< 0.001

Above table 3 shows that ERP amplitude wassignificantly more in athletes as compared to controls having p value- >0.01(highly significant) by unpaired t test (t test = 6.99) .

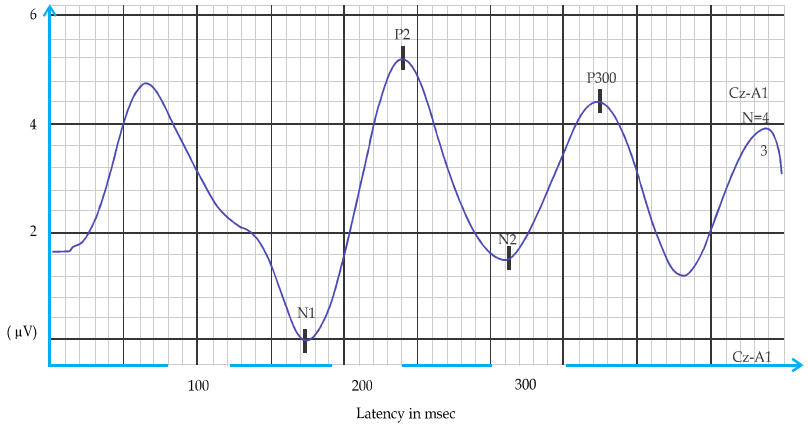

Fig. 4: showing ERP wave in normal healthy control.

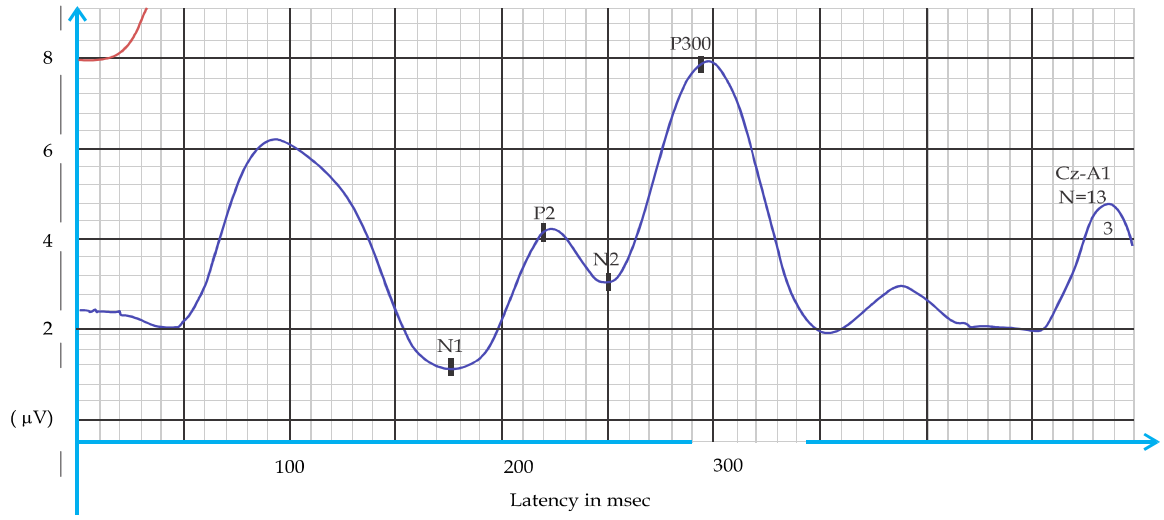

Fig. 5: showing ERP wave in athletes

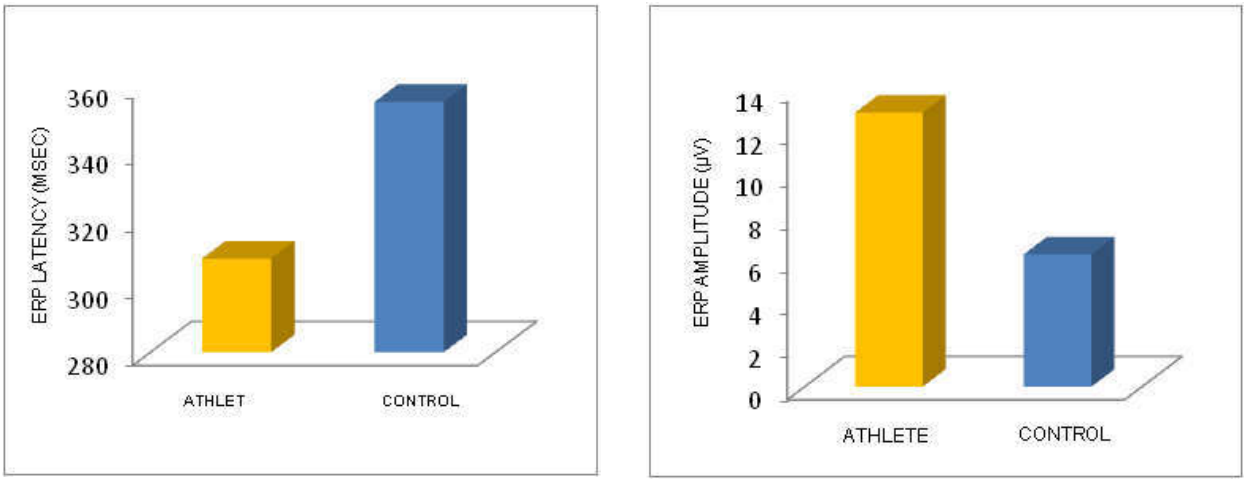

Fig 6: Bar Diagram-Comparison of ERP latency and ERP amplitude (µV) in athlete and control.

Discussion

ERP is a test used to evaluate cognition. ERP is a series of peaks and troughs which appears in EEG in response to psychological reaction to discrete event. P300 wave is a common measurement made during this test. P300 wave is seen in response to rare meaningful stimuli. It is positive wave with latency of 300-1000 msec from stimulus onset. P300 is a sensitive measure of the capacity to allocate attentional resources [9]. P300 amplitude is influenced by meaningfulness of stimulus. The amplitude of P300 is determining the amount of attention needed to encode the stimulus in working memory. The latency of P300 is reflecting speed of cognitive evaluation of stimulus.

Although exercise and physical fitness has been shown to have an influence on cognition in some populations, it is difficult to determine the precise components of the cognitive processes that are affected. High levels of physical fitness for members of younger populations are often brought upon by intense aerobic training that is often synonymous with athletic participation. One non-invasive procedure that can account for the particular mechanisms of cognitive functions and measure the enhancement of cognitive abilities in humans resulting from higher fitness levels and acute bouts of exercise is the Electroencephalogram (EEG). Identifiable peaks in the ERP waveform occur roughly correspond to various stages of the cognitive process; peaks occurring shortly after stimulus presentation are believed to represent more elementary sensory and perceptual processing whereas peaks occurring later in the waveform are thought to detect higher levels of cognitive functioning, such as decision-making and response selection. By systematically varying aspects of a stimulus, the timing and magnitude of ERP peaks

can help researchers draw conclusions about the nature of the cognitive functioning.

This study intends to define the link between the body and the mind by investigating the effects of long-term physical fitness and athletic participation on the human cognitive processes that are involved in stimulus perception and response selection. In this study as shown in Table 1 and 2, it is observed that latency was decreased and amplitude was increased significantly (p value <0.001) in athletes as compared to their age matched healthy controls.

Kramer et al. (2001) argue that frequent aerobic exercise plays a large role in the maintenance of cerebrovascular activity and cardiorespiratory functioning, which can in turn help to sustain cognitive aptitude as humans enter into old age. [10] By examining a sample of elderly individuals ranging in age between 60 and 75, Kramer et al. (2001) found that participants who completed a six month aerobic exercise program exhibited reaction time improvements on numerous executive functioning tasks compared to participants who exercised anaerobically (i.e., participated in a weight training program) for the same length of time. A meta-analysis conducted by Colcombe and Kramer (2003) also found that fitness training had a robust impact on executive control functioning for older populations [11]. This study also suggests that older adults who participated in fitness training for longer periods of time showed increased cognitive benefits when compared to those who participated in fitness programs for limited periods of time. However, not all studies have shown cognitive improvements from participation in long-term exercise programs like Blumenthal, et al. (1991) [12]. Blumenthal and Madden (1988) showed that, although performance on a memory search task did not improve after participation in a twelve week jogging program, memory search performance was in fact related to initial fitness levels of the middle-aged male subjects. This may further add to the idea that long term fitness levels have a larger impact on cognitive performance than relatively short intervals of aerobic training. Although the relationship between fitness and cognition has been extensively studied and for the most part confirmed in elderly populations, research often fails to find effects in younger populations (Chodzjo-Zajko, 1991) [13].

A number of studies have studied the effects of acute bouts of exercise on the P300 component. Nakamura et al. (1999), Hillman et al. (2003) and Magnie et al. (2000) also looked at the effects participants' long-term levels of aerobic fitness had on their performance on the oddball task [14,15,16]. However, there were no statistically significant differences between the aerobically conditioned cyclists and the low fit sedentary control subjects. However, Polich and Lardon (1997) found slightly different results [17]. This study separated participants into a high and low fit group based on the amount and intensity of exercise in which they engage on an average week. Participants were given both an auditory and a visual oddball task, and the results showed that the individuals who engaged in relatively high amount of intense physical activity on a regular basis had higher P300 amplitudes than participants who were relatively sedentary. However, Polich and Lardon (1997) did not find that physical fitness influenced P300 latencies. It is possible that differences in latencies did not arise due to the mean age of the subject pool, which was in the lower thirties. Dustman et al. (1990) also found the mean latency of the P300 to be longer for older men of a low fitness level than older men of a high fitness level and the younger men of all fitness levels. [18] Polich and Lardon (1997) posit that the some of the effects of long-term aerobic exercise on the P300 potential may originate from fundamental changes in the electrophysiological parameters employed in the experiment [17]. This suggestion is supported by Dustman et al. (1990), who found the alpha bands at the Parietal (Pz) and Occipital (Oz) electrode sites of high fit subjects to be more abundant than those in low fit subjects. Students obtained for this study are most likely close to their peak lifetime intellectual capacity; even if there were some cognitive effects of athletic participation, they were not large enough to emerge in statistical testing [18].

There are several different plausible biological mechanisms underlying exercise effects on brain and cognition which are demonstrated on molecular, vascular and cellular changes in brain. Aerobic exercise training in aging animals have shown to increase levels of key neurochemicals that improve plasticity and neuronal survival such as BDNF and IGF-1, serotonin and dopamine. [19,20,21,22]. Other studies have shown that aerobic exercise interventions increase development of new capillaries, presumably to support increased firing[23]. Also hippocampal neurogenesis is involved with exercise training [24].

The present study was conducted to extend the body of research that has examined the relationship between physical activity and human cognition. Physically active individuals demonstrated faster P300 latencies and greater amplitude than

sedentary participants. These results also suggest that exercise training interventions may also be quite effective during young adulthood (Hillman 2006) [25]. This study also incorporated long term exercise which is much less studied yet. Long term exercise showed improvement in P300 amplitude which is lacking in other studies. This study also excluded CNS arousal which can modify attention by doing exercise just before the measurement of ERP (NareshKumar, 2012) [26].

References

1. Hillman CH, Erickson KI, Kramer AF. Be smart, exercise your heart: exercise effects on brain and cognition. Nat. Rev. Neurosci. 2008;9:58–65.
2. Farmer J, Zhao X, Van Praag H, Wodtke K, Gage FH, Christie BR. Effects of voluntary exercise on synaptic plasticity and gene expression in the dentate gyrus of adult male Sprague–Dawley rats in vivo. Neuroscience. 2004;124:71–79.
3. Vaynman S, Zing L, Gomez-Pinilla F. Interplay between BDNF and signal transduction modulators in the regulation of the effects of exercise on synaptic-plasticity. Neuroscience. 2003;122:647–57.
4. Michael J. Amminoff. Electrodiagnosis in clinical neurology, 5th edition, 38-60, 609-622.
5. Dan L. Longo Dennis L. Kasper, J. Larry Jameson, Anthony S. Fauci, Stephen L. Hauser, Joseph Loscalzo, Harrison's Principles of Internal Medicine, 18th edition, Chapter e45.
6. Donchin E, & Coles M. Is the P300 component a manifestation of context updating? Behavioral Brain Sciences, 1988;11:357-74.
7. Lopes da Silva F. Neural mechanisms underlying brain waves: From neuralmembranes to networks, Electroenceph. Clin. Neurophysiol. 1991;79:81-93.
8. Polich J. & Kok A. Cognitive and biological determinants of P300; an integrative review. Biological Psychology. 1995;41:103-146.
9. Johnson Jr R, Barnhardt J, Zhu J. The contribution of executive processes to deceptive responding. Neuropsychologia. 2004;42:878–901.
10. Kramer AF, Hahn S, McAuley E, Cohen NJ, Banish MT, Harrison C, Chason J, Boileau RA, Bardell L, Colcombe A, &Vakil E. Exercise, Aging, and Cognition: Healthy Body, Healthy Mind? In: Fisk, AD.; Rogers, W., editors. Human Factors Interventions for the Health Care of Older Adults. Hillsdale, N.J.: Erlbaum; 2001. https://faculty.biu.ac.il/~vakil/chapters/Kramer-Vakil_chapter_2001_5.pdf
11. Colcombe S, Kramer AF. Fitness effects on the cognitive function of older adults: A meta-analytic study. Psychological Science. 2003;14(2): 125-30.
12. Blumenthal JA, Emery CF, Madden D J, Schniebolk S, Walsh-Riddle M, George LK, McKee DC, Higginbotham MB, Cobb FR & Coleman RE. Longtermeffects of exercise on psychological functioning in older men and women. Journalof Gerontology. 1991;46(6):352-61.
13. Chodzko-Zajko WJ. Physical fitness, cognitive performance, and aging. Medicine and Science in Sports and Exercise, 1991;23(7):868-873.
14. Nakamura Y, Nishimoto K, Akamatu M,Tkahashi M & Maruyama A. The effect of jogging on P300 event related potentials. Electromyography and Clinical Neurophysiology. 1999;39:71-74
15. Magnie MN, Bermon S, Martin F, Madany-Lounis M, Suisse G, Muhammad W, et al. P300, N400, aerobic fitness, and maximal aerobic exercise. Psychophysiology. 2000;37(3):369–77.
16. Hillman CH, Snook EM, Jerome GJ. Acute cardiovascular exercise and executive control function. Int. J. Psychophysiol. 2003;48:307–14.
17. Polich J, Lardon M. P300 and long term physical exercise. Electroencephalogr Clin. Neurophysiol. 1997;103:493–98.
18. Dustman RE, Emmerson RY, Ruhling RO, Shearer DE, Steinhaus LA, Johnson SC, et al. Age and fitness effects on EEG, ERPs, visual sensitivity, and cognition. Neurobiol. Aging. 1990;11:193–200.
19. Neeper S, Gomez-Pinilla F, Chi J, & Cottman C. Exercise and brain neurotrophins. Nature, 1995;373:109.
20. Carro E,Trejo LJ,Busiguina S,& Torres-Alemam I. Circulating insulin- like growth factor 1 mediates the protective effects of physical exercise against brain insults of different etiology and anatomy. Journal of Neuroscience; 2001;21:5678-84.
21. Blomstrand JE, Parrett D, Parry-Billings M. & Newsholme EA. Effect of sustained exercise on plasma amino acid concentrations and on 5-hydroxy-tryptamine metabolism in six different brain regions in the rat. Acta Physiologica Scandinavica. 1989;136:473-81
22. Spirduso WW and Farrar RP. Effects of aerobic training on reactive capacity: An animal model. Journal of Gerontology. 1981;36:654-62.
23. Black JE, Issac KR, Anderson BJ, Alcatara AA & Greenough W T. Learning causes synaptogenesis, whereas motor activity causes angiogenesis, in cerebellar cortex of adult rats. Proceedings of the National Academy of Sciences. 1990; 87: 5568-72.
24. Van Praag H, Kempermann G and Gage FH. Running

increases cell proliferation and neurogenesis in adult mouse dentate gyrus. Nature Neuroscience 1999, 2,266-270.

25. Hillman CH, Kramer AF, Belopolsky AV, et al. A cross-sectional examination of age and physical activity on performance and event-related brain potentials in a task switching paradigm. Int. J. Psychophysiol. 2006;59:30–39.

26. NareshKumar, Manjeet Singh, Sushama Sood, Beena, Sakshi, Prasnta Saha Roy & Joshil Kumar Behera et al. Effect of acute moderate exercise on cognitive P300 in persons having sedentary lifestyles, International Journal of Applied and Basic Medical Reseasrch. 2012;2:67-69