

Original Research Article

Baseline physical fitness as a determinant of resting neuro-psychological profile in students undergoing stressful professional course

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ABSTRACT

Background: Several reports indicate that exercise has a positive impact on mental health. However, studies on whether altered physiological status in high fit individuals is reflected in their baseline neuro-psychological profile remains to be ascertained. The aim was to compare the EEG profile and their ability to handle stress in young adult students of high physical fitness with those of low physical fitness.

Methods: To achieve this objective, healthy adult male students (18-22 years age) undergoing stressful professional course were grouped into High fitness group (GI: PFI>80) and Low fitness group (GII:PFI<50) as per their Physical Fitness Index (PFI) scores in Harvard Step Test. Thereafter, their state and trait anxiety scores (STAI) were obtained and resting EEG were recorded for ten minutes.

Results: No significant difference in the STAI scores between these groups (State: 34.8±4.26 vs 37.57±7.89; Trait: 39.1±6.21 vs 40.29±8.77 in GI vs GII) were observed, supported by absence of significant cerebral lateralization in anterior alpha power band in either group (Right vs Left Frontal GI: 5.56±2.10 vs 6.55±2.12 uV²; GII: 5.03±1.14 vs 4.51±1.83 uV²) in addition to lack of right anterior dominance, thereby nullifying the cerebral lateralisation hypothesis as an indicator of anxiety level. However, there was a generalized predominance of alpha power in the anterior (GI vs GII: 6.05±1.82 vs 4.77±1.28 uV²), temporal (GI vs GII: 23.89±11.87 vs 19.10±12.41 uV²) and posterior (GI vs GII: 25.00±2.18 vs 18.37±0.72 uV²) regions in GI mainly in the right hemisphere.

Conclusions: Thus anxiety alone may not be a determinant of mental health in the high fit subjects who may have other dominant characteristics as envisaged by alpha predominance in their EEG profile.

Keywords: Alpha power, Anxiety, Physical fitness, STAI questionnaire

INTRODUCTION

It is a well-known fact that physical fitness of a person is not only a direct measure of his/her cardio-respiratory efficiency but also has a range of beneficial effects on the physical wellness of human being. In addition, reports indicate that it also has a positive impact on mental/psychological health parameters such as reduction of anxiety, coping with situations and general well-being of an individual in terms of various neuro-psychological correlates.^{1,2} Recent reports state that lower

cardiovascular fitness at age 18 is associated with increased risk of serious depression in adulthood.³ In fact, physical exercise, as indexed by cardiovascular fitness, is a factor that strongly affects brain plasticity, such as synapse density, neuronal complexity, and hippocampal neurogenesis.⁴⁻⁷ People have been reported to achieve better psychological status with increase in physical fitness, whereas, susceptibility to depression in later life has recently been related to compromised cardiovascular fitness at a young age.¹⁻³ A recent study showed that voluntary running significantly restores the neural stem

cell pool, hippocampal neurogenesis, and behavioral deficits following a clinically relevant, moderate dose of irradiation.⁸ These experimental studies, juxtaposed with studies reporting modulation of neural activity in brain, after an acute bout of aerobic exercise, underline the importance of physical exercise for cognitive performance. This has been well documented through the Cerebral lateralization hypothesis (CLH) which indicates that frontal EEG asymmetry predicts positive affect (i.e. reduced anxiety) post exercise reflected by a decrease in anterior right relative to left hemisphere activation and is well correlated with a corresponding decrease in State and Trait anxiety scores reflecting a relaxed state of mind post exercise.^{9,1} Some studies support these findings in individuals with high baseline fitness as a result of up to eight weeks of training.¹⁰ However, most studies seem to have tried to find correlation between acute exercise and cortical neuronal activity with only few studies aiming to correlate the base line cardio- pulmonary fitness with the cortical neuronal activity of the subject.

In this backdrop, it seems pertinent to see if long term baseline physical fitness (as a function of BMI or/and activity history) affects stress/anxiety levels of individuals under chronic stress (i.e. young adult students pursuing professional courses) and supports CLH. Therefore, the aim of the study was to compare the anxiety status and EEG profile in young adults of high physical fitness with those of low physical fitness.

METHODS

In this self-controlled prospective experimental study, healthy adult male students (pursuing professional courses) of age group 18-22 years (n=30) were included after due screening. Approval of Institutional Ethics Committee was obtained at the beginning of the study and an informed consent form was signed by each subject before initiating the work. Thereafter, a detailed medical history of all the subjects was taken to meet the inclusion and exclusion criteria. Subjects having History or presence of any medical illness and/or disability/treatment which may affect the results of physical fitness test or psychological disorder/habits of smoking, alcohol consumption etc. were excluded from the study. None of the subjects were taking any drug / medication for the last two weeks prior to study.

Parameters / variables recorded

Physical fitness

It was assessed by the standard Harvard's Step Test (HST) where the subject was asked to step up and down on alternate legs on a 16" high stool at a frequency of 40 steps per minute for five minutes or till complete fatigue, whichever is earlier.¹¹ Thereafter, the heart rate was recorded for 1-1.5, 2-2.5, 3-3.5 minutes of recovery and the values were converted to per minute as 'a', 'b' and 'c'

respectively. The physical fitness index (PFI) was calculated by the formula

$$\text{PFI (\%)} = \text{Duration of exercise in seconds} \times 100 / (a+b+c).$$

EEG

For the recording of EEG, the electrodes were placed bilaterally at frontal, temporal & occipital sites (F3, F4, T1, T2, and O1 and O2) with linked ear references (A1 & A2) and resistance < 5 kΩ following the International 10-20 system of electrode placement.⁹ These electrodes were then connected to Digital EEG machine (Recorder and Medicare System, India) through a junction box which contained EEG acquisition and software for Power Spectral analysis of EEG. After digitalization, the raw signal was submitted to Fast Fourier Transformation (FFT) for computation of power in μV^2 of the EEG waves.

Anxiety scoring

Spielberg's standard self-rating form Y of State-Trait Anxiety Inventory (STAI) Scale (12) was used to calculate the state and trait anxiety scores of each subject. The inventory consists of 20 items for assessing trait anxiety and 20 for state anxiety. All items are rated on a 4-point scale (e.g., from "almost never" to "almost always") with higher scores indicating greater anxiety. The subjects are required to tick the most appropriate feeling in the questionnaire without pondering too long on any question.

Experimental design

The study was conducted under the standard laboratory conditions (temperature 26 ± 2 °C) wherein each subject reported for two consecutive days. All the recordings were conducted 2-3 hours after the last meal in the afternoon. Heart rate and blood pressure were recorded upon arrival of the subject and again after 5 minutes of rest to ensure that the subject is in resting state before commencing the experiment on each day.

Day I

Height and weight of the selected subjects was recorded along with their basal heart rate (HR), followed by their assessment of anxiety status by filling up of STAI questionnaire. The subject then underwent Harvard Step Test following the standard protocol for measurement of PFI. On the basis of the calculated PFI, subjects were put into high fitness (Group I: PFI>80%; n=15) and low fitness (Group II: PFI<50%; n=15) groups.

Day II

After fifteen minutes of supine rest with eyes closed under awake and relaxed conditions, EEG was recorded

for 15 minutes. Basal HR was re-recorded before the subject was released from the study.

Analysis of data

STAI data

The scores for state, trait and total (State+Trait) anxiety was obtained for each subject and averaged (mean ± SD).

Reduction and analysis of EEG waveforms

By visual inspection of EEG records, five artifact free epochs, each of 6 sec, were randomly selected. Fast fourier transformation (FFT) was used to decompose EEG waveform into sine wave components of respective frequencies for estimation of spectral power of various EEG bands i.e. alpha, beta and delta.⁹ The power spectral density (PSD in μv^2) values obtained from the five epochs were averaged for each subject and expressed as Mean±SD. In the present study, the analysis is limited for alpha bands (8-12 Hz) only.

Statistical analysis

Mean±SD of state and trait anxiety scores and total power of alpha waves bilaterally for each recorded brain regions were derived after grouping the data into low fitness (< 55%; Group I) and high fitness (> 80%; Group II).

Mann-Whitney U-Test was done for the comparison between groups for bilateral activity of alpha bands across each cortical regions and anxiety scores (State, Trait and Total). Whereas, for within group comparison at different cortical sites, Kruskal-Wallis test was done. A 'p' value of less than 0.05 was considered as statistically significant.

RESULTS

Physical fitness index

A significant ($p < 0.05$) difference in physical fitness was observed between High Fitness (PFI $85 \pm 11.5\%$) and low fitness (PFI $38 \pm 9.8\%$) groups on the basis of Harvard Step Test (Figure 1).

Anxiety score

The state, trait as well as total anxiety scores calculated from STAI questionnaire were not found to have any significant difference between high and low fitness group subjects (State: 34.8 ± 4.26 vs. 37.57 ± 7.89 ; Trait : 39.1 ± 6.21 vs. 40.29 ± 8.77 in GI vs. GII). The state and trait scores within groups also did not differ significantly (Figure 2).

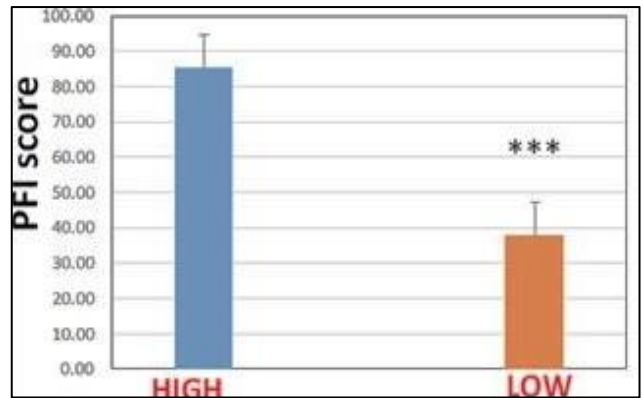


Figure 1: Comparison of physical fitness scores between high and low fit subjects. There was a significant difference observed (*) $p > 0.001$.**

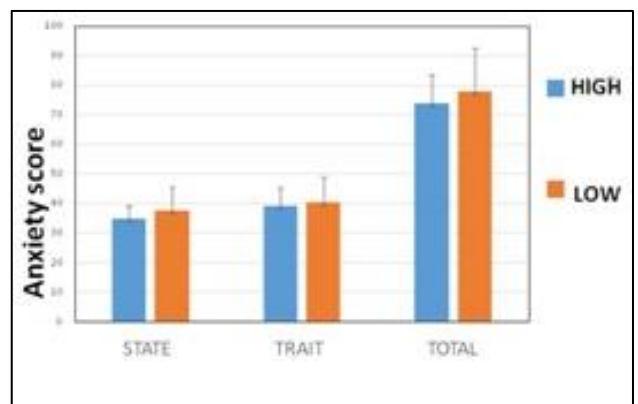


Figure 2: No significant difference within or inter-group in state, trait and total anxiety scores of high and low fitness group subjects was observed.

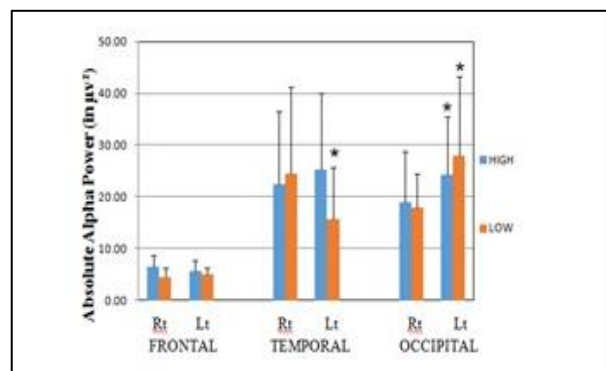


Figure 3: Comparison of alpha power between right and left hemisphere revealed no significant difference at frontal for both high and low fit groups however, right temporal region in low fit group showed significant decrease. In addition, significant increase for both high and low groups was observed at right occipital area $*p > 0.05$.

EEG changes

Total alpha power

In all subjects irrespective of their fitness levels, the alpha power increased from frontal to occipital region. However, High fitness group had higher alpha power in all the recorded sites with marked increased value at temporal and significantly high value at occipital areas as compared to low fitness group (Table 1).

Bilateral comparison

Alpha power in frontal regions (F3 and F4) was comparable with no bilateral asymmetry across fitness levels (Figure 3). However, a significantly decreased alpha power was observed in the right posterior temporal region (T3) of low fitness group, whereas, very high alpha power was recorded from the right occipital region of both High and Low Fitness groups ($p < 0.05$) (Figure 3).

Table 1: Total alpha power across different regions in high and low fitness groups.

Cortical regions	Absolute alpha power (μV^2)	
	High PFI group	Low PFI group
Frontal	6.05±1.82	4.77±1.28
Temporal	23.89±11.87	20.10±12.41
Occipital	25.00±2.18	18.37±0.72*

Total alpha power increased from frontal to occipital region in all subjects irrespective of their fitness level which was always higher for High PFI group. A significant difference was observed between the two groups at occipital region * $p > 0.05$.

DISCUSSION

We observed that in the available literature very few studies have been undertaken to find association between the long term physical fitness of the individual with his/her quantitatively estimated stress levels. It remains to be ascertained whether altered physiological status in high fit individuals is reflected in their baseline neuropsychological profile. Such study may provide a tangible physiological substrate, which can be of importance in shaping the mental and physical health of the chronically stressed students in an era of evidence based medicine. Therefore, we undertook this study with the hypothesis that "Neuropsychological profile of individuals with higher physical fitness might reflect better handling of anxiety" in young students undergoing stressful professional course.

Several earlier reports have clearly indicated that presence of alpha waves (8-12 Hz), not only indicates relaxed state of mind but has a very active role in generation of complex cognitive functions and is a powerful indicator of outcome of perceptual learning or

implicit learning in an individual.^{13,14} As is expected, these perceptual learning ultimately helps an individual to adapt suitably to his complex environment and is bound to be reflected in his/her coping ability or anxiety perception. This led us to look into changes at alpha activity of individuals under stress.

In our study, the resting EEG status of the subjects showed predominantly alpha activity in the posterior sites which was highest at the occipital areas irrespective of fitness level of the subjects. Therefore, regional distribution of alpha followed a similar pattern in both groups. This finding points towards a true resting state of the subjects.¹⁵ However, generally, total alpha power was higher in frontal, temporal and occipital areas of high fitness group subjects (Table 1) indicating a relatively more relaxed state of mind as compared to low fit group. An earlier study not only has documented reflection of cognitive features of physical training in resting brain electrical oscillations but also different resting cortical activity between the two groups of differently fit people i.e. dancers and the people with fast ball sport activity as well as differential cortical response to stimuli on the basis of fitness status.^{16,17} A similar scenario is seen in our subjects too on the basis of their fitness. Besides, right sided posterior alpha dominance in both our subject groups corroborates with the within usual normal limits of alpha pattern.¹⁸

No marked difference in the State and Trait anxiety scores was observed between both groups though their difference in fitness levels were significant, indicating similar psychological profile of the subjects in relation to basic anxiety status. Besides, neither group exhibited hemispherical dominance in frontal alpha activity, which points toward a similar pattern of anxiety level irrespective of their relative fitness as per Cerebral Lateralization hypothesis.⁹ We, in our earlier study have reported Validation of CLH in post exercise cortical changes after an acute bout of aerobic exercise.¹⁵ However, in the present study, it may be suggested that absence of significant difference in the State and Trait anxiety scores between high and low fitness group subjects with absence of significant cerebral lateralization in anterior alpha power band in either group (i.e. right vs. left frontal sites) shows lack of right anterior dominance and therefore, is not following the cerebral lateralization hypothesis.⁹ This suggest that criteria of long term physical fitness as an indicator of anxiety levels or as a basis of greater positive affect in terms of EEG changes in high fit individuals may not hold good.

However, right temporal alpha suppression observed in the low fit group of our study might be explained on the basis of principle of fundamentals of attention (suppression and selection). As has been suggested earlier with this principle that while attending to environmental cues, analytical qualities of the right temporal lobe might lead to alpha suppression on that region as compared to left because attention involves selection of relevant cues

and suppression of the irrelevant ones, while alpha activity generally represents inhibitory processes in the brain.¹⁹ A low fit person, therefore, seem to have higher suppression of right temporal alpha activity even during resting state as compared to fit person which might be due to the demand of greater attention during contextual task in the low fit individuals.

We also found a generalized predominance of alpha power in the anterior and posterior regions in the high fitness persons which was exaggerated on the right hemisphere. Earlier studies also have reported higher alpha activity in fit as compared to unfit adolescents and have suggested role of alpha bands in inhibition and effortful attention depicting a relaxed state of mind thereby helping in better cognition in fitter people.²⁰

Thus it may be concluded that anxiety alone may not be a determinant of mental health in the high fit subjects who may have better attention, perceptual learning, identification of form and shape and visuo-spatial coordinates etc. important external cues vital for improved tackling in a hostile environment in a relatively relaxed state of mind as envisaged / interpreted by alpha predominance at different brain regions in their EEG profile.

It may be said therefore, that students who are physically fit are not necessarily the brightest who can handle anxiety very well. And therefore, under chronic stress, individuals with higher baseline physical fitness do not seem to possess lower levels of anxiety or a correlation with their EEG profile.

Also, in contrast to anxiety alleviating effects of acute aerobic exercise, baseline physical fitness may not be an important criteria in handling anxiety. Therefore, physical fitness may not confer immunity to a person from anxiety, it being a primitive and vital emotion, but might be helpful in modulating other modifiable emotions like anger and situations which demand a better coping ability.

Further studies utilizing parameters for understanding coping and well-being in a larger group is being suggested which might provide better correlation with the neuro-psychological profile, thus helping to understand the mechanism with reference to long term effects of aerobic exercise.

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Ethical approval: The study was approved by the institutional ethics committee

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