

PROGRESSIVE INCREASE IN CRITICAL FLICKER FUSION FREQUENCY FOLLOWING YOGA TRAINING

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Abstract: The critical flicker fusion frequency (CFF) is the frequency at which a flickering stimulus is perceived to be steady, with higher values suggesting greater perceptual accuracy. The CFF was measured in two age-matched groups of healthy male volunteers whose ages ranged from 25 to 39 years, with 18 subjects in each group. After baseline assessments one group (yoga group) received yoga training, while the other group (control group) carried on with their routine activities. Yoga practices included asanas, pranayamas, kriyas, meditation, devotional sessions and lectures on the theory of yoga. After 10 days neither group showed a change in CFF. However, at 20 and at 30 days the yoga group showed significant increases in CFF by 11.1% and 14.9%, respectively (two factor ANOVA, Tukey multiple comparison test). The control group showed no change at the day 20 and day 30 followup.

Key words: critical flicker; fusion frequency; visual perception; Yoga.

INTRODUCTION

Meditation has been reported to cause significant changes in perception, attention and cognition (1). The increased sensitivity following meditation has been experimentally proved with different assessment criteria. The Rorschach test was used as a perceptual test and meditators were more sensitive to subtle aspects of colour and shading on the inkblots than they had been before meditation (2). This perceptual sensitivity was not restricted to subtle aspects of the stimuli, as detection of a high frequency flickering stimulus or the critical flicker fusion frequency (CFF) was found to improve (3). The CFF indicates the frequency at which a flickering light is perceived to be steady. Two possible physiological explanations for the "fusion" of a flickering stimulus, involving the peripheral visual pathway are as follows, viz (i) the frequency at which the optic tract discharges may limit the ability to perceive high frequency light stimuli and (ii) ganglion cells of the "on-off" variety, which discharge when illumination comes on and goes off produce a response which is indistinguishable from their discharge under steady illumination, at a frequency of about 35 flashes per second (4). In contrast to these explanations based on properties of the peripheral visual system being responsible for the phenomenon of flicker fusion, electrical recording at various levels of the visual pathway in both animal and human subjects have shown that the eye itself may respond at higher frequencies than the value of the CFF obtained by behavioural or psychophysical techniques, and is hence not the limiting factor in determining the CFF. This lead to the conclusion that temporal resolution of the flickering stimulus is often limited by the brain rather than the eye (5).

In the study cited above (3), 10 days of yoga training increased CFF, whereas a group which did not practice yoga but was retested at the same time showed no change. In attempting to explain this effect of yoga practice, it may be recalled that the effects of yoga in reducing physiological signs of stress, such as a decrease in heart and breath rate, and in oxygen consumption are known (6). This may be relevant because the CFF was found to be lower during specific stressors, such as food and water deprivation (7). The mechanisms for this have not been worked out.

With this background, the present study was conducted with the following aims and objectives:

(1) To assess the effects of yoga training on the critical flicker fusion frequency (CFF), and compare these effects with retest without any intervention (control group) (2). To assess the effects of different durations (i.e. 10, 20 and 30 days of yoga training) on the CFF.

METHOD

Subjects

There were 2 groups of healthy male volunteers, i.e. yoga and control groups, with 18 subjects each. The yoga group was attending a one-month residential yoga training program. The age range was 25 to 39 years, with group average + SD, 33.9 ± 4.5 years.

The non-yoga (control) group was selected to exactly match the yoga group for age. These subjects were working and residing close to the yoga center. Hence both groups stayed in a quiet, rural area. The subjects of both groups also had comparable social and educational backgrounds. All subjects had normal vision without correction and none of them had colour blindness. The latter was measured in view of the fact that the colour of the stimulus has been reported to influence the CFF (8).

Design of the study

Both groups were assessed four times each, under similar conditions. Baseline assessments were made at the start of the study. After this the yoga group received training in yoga, while the control group carried on with their routine activities. Subsequent assessments for both groups were made after 10, 20 and 30 days.

Assessment procedure

Critical flicker fusion frequency was measured with a standard electronic apparatus (9) (Anand Agencies, Pune, India). This apparatus has a red light stimulus, 6 mm in diameter, with a luminous intensity of 50 mcd and flicker frequency which can be adjusted from 12 to 95 Hz. The stimulus was surrounded by a white background with illumination of 150 lux. The subject was seated at ease 50 cm in front of the apparatus (i.e. 80 cm from the stimulus). During the experiment all overhead lights were switched off except for a 40-w bulb fixed behind the subjects. The light: dark ratio was kept as 1 (50:50). The binocular response of all subjects was assessed in two types of trials: [i] ascending: the frequency of flicker was gradually increased, 0.5 Hz per step, from the minimum (12 Hz) till the subjects reported that it was "fused" or steady, this was the fusion threshold, and [ii] descending the frequency of the response was gradually reduced (0.5 Hz per step) from maximum (95 Hz) till the subjects reported that it was flickering, this was the flicker threshold. Each subject was assessed in 20 trials each, i.e. 10 ascending and 10 descending, given alternately. The values obtained in both types of trials were considered together and out of the 20 values obtained for each subject, the value to be used for statistical analysis was selected as follows: when at least 3 successive readings were the same or with not more than 0.5 Hz between them, this value was noted as the critical flicker fusion frequency or CFF (10).

Yoga training

The yoga group received training in physical postures (asanas, 90 minutes), cleansing practices (kriyas, 30 minutes), yoga voluntarily controlled breathing (pranayama, 60 minutes), meditation (60 minutes), devotional sessions (90 minutes) and lectures on the theory of yoga (60 minutes).

Data analysis

The CFF values of the two groups obtained with 4 assessments were compared for significant difference using a two factor ANOVA, where Factor A = yoga versus control group, and Factor B

= the 4 assessments (baseline, day 10, day 20, day 30). The group mean values were compared for significant differences using the Tukey, multiple comparison test.

RESULTS

The two factor ANOVA

Showed a significant difference between yoga and control groups, i.e. Factor A. [F = 27.9, the F value for DF = 1, 120 at the .001 level (two tailed) = 12.8, hence P < .001]. Here the actual DF = 1, 120 were chosen as the nearest values in the probability table]. The difference between the 4 assessments, i.e. baseline, day 10, day 20 and day 30 was also significant, i.e. Factor B [F = 5.3, the F value for DF = 1, 120 at the .005 level (two-tailed) = 5.05. Hence P < .005]. The

Table 1: Group mean values of CFF (\pm SEM) for yoga and control groups at baseline (0 days), and after 10, 20 and 30 days.

	0 days	10 days	20 days	30 days
Yoga group (n = 18)	42.1 \pm 0.76	46.0 \pm 0.90	46.8 \pm 1.0*	8.4 \pm 1.1**
Control group (n = 18)	42.1 \pm 1.0	41.6 \pm 1.0	41.4 \pm 1.0	42.7 \pm 1.3

*P < .05, **P < .001 Tukey test comparison with day 0 value of the respective group.

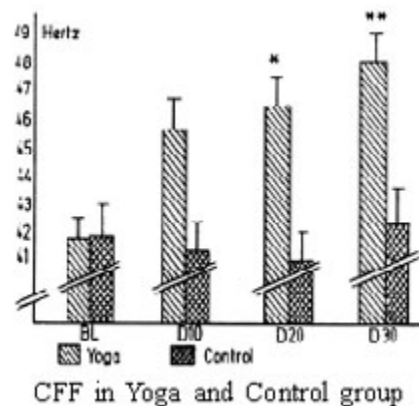


Fig.1: Group mean critical flicker fusion frequency (CFF) values \pm SEM in yoga and control groups (18 subjects) for baseline (BL), days 10 (D 10), 20 (D 20) and 30 (D30). *P < .05, **P < .001; D20 versus BL, D 30 versus BL respectively (Tukey test).

interaction between factors A and B (A' B) was not significant [F = 0.1, P > .51]. The group average CFF values \pm SEM of the four groups at the 4 assessments are provided in Table 1, Fig.1.

The Tukey multiple comparison test

Showed significant differences between the CFF values of the yoga group at days 20 and 30, compared to the baseline reading ($P < .05$, $P < .001$, respectively). The day 10 - baseline comparison for both groups as well as other comparisons for the control group were not significant.

DISCUSSION

The present study showed a significant increase in critical flicker fusion frequency (CFF) of the yoga group after 20 and 30 days compared to the baseline. The CFF values of the control group did not change significantly on repeat assessment.

A previous study (3) had demonstrated a significant increase in CFF values after 10 days of yoga training (similar to the program in the present study). The increase was 5 Hz on an average. In the present study there was a non-significant increase at 10 days. The increase was 3.9 Hz on an average. The difference between the significant effect observed earlier, versus no change (or more accurately the non-significant, lower magnitude increase) in the present study could be related to the difference in age groups of the subjects of the two studies. Subjects of the earlier study were university students between 17 and 22 years of age, whereas the subjects of the present study were between 25 and 39 years, with an average of 33.9 years. It is established that the intra-individual variability of the CFF declines with age (11). This is true for the age difference between the earlier and present studies (average age 20 years versus 33.9 years, respectively). Hence any intervention (e.g. yoga) would be expected to cause smaller magnitude changes (i.e. less intra-individual variability) in the present subjects. The reason for the reduced variability is not clear, both peripheral (retinal) and central (sub-cortical, cortical) factors have been implicated. Hence the present subjects were less amenable to change in the CFF with yoga compared to the earlier group of younger subjects (3).

The absence of change in the control group showed that replications spaced 10 days apart do not increase CFF on retesting. Hence the increase in CFF after 20 and 30 days of yoga training can be attributed to yoga. While the mechanism underlying the change is not known, we may speculate that the increase in CFF may be due to the effects of yoga in reducing physiological signs of stress, such as a decrease in heart and breath rate, and in oxygen consumption (6). As already described (Introduction) this may be relevant because the CFF was found to be lower during specific stressors, such as food and water deprivation (7). Further studies are required to understand the mechanisms and identify whether a specific yoga practice is specially helpful or whether the effect depends on a combination of yoga practices.

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