

# Critical Flicker Fusion Frequency: Effect of Age, Gender, Sleep and Display Screens

Vishavdeep Kaur<sup>1</sup>, Lily Walia<sup>2</sup>, Randhir Singh<sup>3</sup>

## ABSTRACT

**Introduction:** The rate at which a successive light stimulus appears to be steady and continuous is called as the critical flickering fusion frequency (CFFF). It is expressed in Hz and is referred to as the threshold frequency. It provides the information about CNS activity and arousal as well as measures the discrete sensory events happening in the central nervous system. To perceive the flickering light eye and brain have to work simultaneously and have to act together. The CFFF was measured using critical flicker fusion apparatus. The study aimed to measure critical flicker fusion frequency and to measure the effect of age, gender, sleep and display screens on critical flicker fusion frequency

**Material and methods:** The study was done in the department of Physiology, Maharishi Markandeshwar Medical College and hospital, Solan, HP after taking institutional ethical committee clearance. A total of 1000 apparently healthy subjects were recruited from the institute which included the students, faculty, non teaching staff and nursing staff. Critical flicker fusion frequency was measured using Flicker Fusion apparatus (FF-705): Medicaid Ambala. The critical flicker fusion frequency threshold was noted after explaining the procedure in their native language and obtaining consent. The data collected was analyzed statically.

**Results:** We found a significant difference in the values of CFFF between the younger age group and among the older age group. CFFF and age are indirectly proportional to each other with increase in age there is decrease in the value of CFFF. The value of CFFF was found to be higher in individuals with a normal sleep pattern and duration compared to those having less sleeping hours. Inadequate sleep also has been shown to decrease the motor functioning, decreased learning ability, poor productivity and shortened memory. CFFF was higher in individuals playing games compared to those who were using display screens normally, in addition to it those individuals who were playing instructive games had a higher CFFF than those playing quest games.

**Conclusion:** In this study we measured the critical flicker fusion and the factors that have a role in increasing or decreasing the CFFF threshold. A simple and non invasive procedure helps in finding the harmful effects of various factors like age gender sleep disturbances or over usage of display screens on retina and central nervous system.

**Keywords:** CFFF, Sleep Deprivation, Games, Gender, Age, Display Screens

referred to as the threshold frequency. It provides the information about CNS activity and arousal as well as measures the discrete sensory events happening in the central nervous system.<sup>1</sup> To perceive the flickering light eye and brain have to work simultaneously and have to act together. For the visual processing and functioning the activities in retina and brain are synchronized. The visual system perceives flickering light as continuous steady light if the flickering frequency is high enough. Since CFF is a relatively non invasive, quick and easy to perform it is widely used to study physiology of vision and human behavior. There are many factors that influence CFFF which includes work with visual display screens, shifts in work, sleep deprivation, intake of stimulants like caffeine, alcohol and various medications. Other factors which have effect are age, intelligence and gender. Though there might be many factors influencing in our study we focused on age, gender, usage of display screens and sleep deprivation. In today's world more time is spent on computer/mobile screens causing sight and visual fatigue.<sup>2,3</sup> The underlying possible physiological basis 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.<sup>4</sup> 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

<sup>1</sup>Associate Professor, Department of Physiology, Maharishi Markandeshwar Medical College and Hospital, Solan, Haryana,

<sup>2</sup>Professor, Department of Physiology, MMMSR, Mullana, Ambala, Haryana <sup>3</sup>Assistant Professor, Department of Physiology, Maharishi Markandeshwar Medical College and Hospital, Solan, Haryana, India

**Corresponding author:** Mr Randhir Singh, Assistant Professor, Department of Physiology, MMMCH Solan HP, India

**How to cite this article:** Vishavdeep Kaur, Lily Walia, Randhir Singh. Critical flicker fusion frequency: effect of age, gender, sleep and display screens. International Journal of Contemporary Medical Research 2020;7(6):F9-F12.

**DOI:** <http://dx.doi.org/10.21276/ijcmr.2020.7.6.20>



## INTRODUCTION

The rate at which a successive light stimulus appears to be steady and continuous is called as the critical flickering fusion frequency (CFFF). It is expressed in Hz and is

CFF obtained by behavioral or psychophysical techniques, and is hence not the limiting factor in determining the CFF. This led to the conclusion that temporal resolution of the flickering stimulus is often limited by the brain rather than the eye.<sup>5</sup> CFF has been used as a diagnostic tool in various nervous system disorders like Alzheimer's disease, multiple sclerosis and schizophrenia. It has also been used to assess the postoperative outcome in various ophthalmic surgeries and also to diagnose and staging minimal hepatic encephalopathy. In medical profession the faculty teaching and non teaching along with the students face challenges with the work related stress and also disturbances in the sleep. The usage of display screens has further exaggerated the effects caused on the retina and central nervous system.<sup>6</sup> Our study was aimed to find the effects using an easy and non invasive method i.e. critical flicker fusion frequency.

## MATERIAL AND METHODS

The study was done in the department of Physiology, Maharishi Markandeshwar Medical College and hospital, Solan, HP after taking institutional ethical committee clearance. A total of 1000 apparently healthy subjects were recruited from the institute which included the students, faculty, non teaching staff and nursing staff. The procedure was explained in their native language and consent was taken. The subject with past or present history of retinal or neurological disease or brain injury were excluded from the study. The demonstration was done in a dark room in groups of 10 individuals each at a fixed time daily. A random individual from each group was chosen as the subject for the demonstration. Critical flicker fusion frequency was measured using Flicker Fusion apparatus (FF-705): Medicaid Ambala. The apparatus was placed at a distance of 1 m after placing the chin at the stand; its height

was adjusted such that it was at the same level of that of the subject's eye. The subject was then dark adapted for 15 min. Other students were briefed about the demonstration setup by a faculty during this time. Demonstration of concept of CFF was explained thoroughly. The knobs were adjusted to adjust the flickering frequency and the intensity to the lower most level on the apparatus. The subject was then asked to close the right eye with the palm and look at the LED with the left eye. The frequency was increased, and bell was rung by the subject when the light source appeared steady. The frequency displayed by the LED was noted down. The subject was now asked to open the right eye and look at the LED with the other eye closed. The intensity of the light source was increased, and an alarm bell was rung by the subject when the flickering of light reappeared. The result displayed on LED was noted. The individuals were provided with as many rest periods as required by them in between the testing. The data was collected and analyzed statistically.

## RESULTS

Table 1 shows the CFFFR values in different age groups. The CFFFR threshold values showed an inverse relation with the age. Table 2 shows the comparison of CFFFR threshold values among males and females wherein though difference was not much but still males had a slightly higher threshold of CFFFR compared to females. Table 3 shows comparison of individuals with a normal sleep pattern and individual with disturbed sleep. The result was significant and the CFFFR threshold was found to be higher in people with a normal sleep. Table 4 shows the comparison of individuals using display screens for normal usage and for playing games. The result was significantly higher in individuals who were using display screens to play instructive type of games.

Age in Years	CFFFR threshold values in Hz
18 - 21 years	49.95
22 - 26 years	47.77
27 - 31 years	44.23
32 - 35 years	42.78
36 - 39 years	39.63
40 - 43 years	37.64
44 - 45 years	35.42

**Table-1:** CFFFR threshold values in different age groups

Parameter	Males	Females	P value
CFFFR threshold values in Hz	40.8	38.4	0.165732

**Table-2:** Comparison of CFFFR threshold values in Males and Females

Parameter	Normal sleep hours	Disturbed sleep hours	P value
CFFFR threshold values in Hz	29.43±3.42	25.82±3.22	0.001

**Table-3:** Critical fusion frequency among normal sleep and disturbed sleep group.

Parameter studied	Instructive games	Quest games	General usage of display screen	P value
CFFFR threshold values in Hz	50.39 ±0.1725	49.54±0.2436	37.29± 0.1892	0.0054

**Table-4:** Comparison of CFFFR threshold values in different types of games

## DISCUSSION

Critical flicker fusion is a part is an important phenomenon which we face in our daily routine life in form of many lighting technologies and screen displays. The underlying phenomenon remains same i.e. they display several times in a second very brief flashes of light. It is related to the vision persistence of an individual. The CFF majorly depends upon the size and luminance of stimulus. Flicker fusion occurs at about a frequency of 60Hz. In our study we found that there was a statistically significant increase in the CFFFR in the individuals who were using display screens more frequently for playing games compared to those who used the screens for other uses than the games. This increase shows an increase in the visual sensitivity. Studies have shown that playing games decreases the reaction time, enhances the visual attention as well as acts as a motivation source. But in addition to it harmful effects are also reported which includes mental stress, addiction, mental and visual fatigue. Among the individuals who were using screens for playing games, CFFF was found to be higher in those who were playing instructive games rather than the quest types of games. This may be because more mental resources are recruited for the visual attention and also they require more visual sensitivity. These types of games require more concentration, visual attention and cognition skills. A higher value of CFFF results from the fast reactions and prolonged attention. The changes in CFFF results from the improvements in the sensitivity for the motion direction which causes plasticity in the visual areas these changes are retained for years and are thus long lasting. The magnocellular ganglion cells of the visual system correspond well with the heterochromatic flicker fusion thresholds of the humans and also shows phasic activity. These cells also causes activation of apparent specific movements which reacts to high temporal frequencies. In subjects playing games perceptual learning is the key mechanism for increasing the CFFF values and the underlying mechanism for perceptual learning is plasticity. This process is augmented by the neurotransmitters such as acetylcholine, catecholamine, norepinephrine and dopamine which are widely released during task specific manners.<sup>7,8</sup>

In our study we also tried to explore how age and gender effects. CFFFR. We found a significant difference in the values of CFFFR between the younger age group and among the older age group. CFFFR and age are indirectly proportional to each other with increase in age there is decrease in the value of CFFFR. This can be because of age related changes and degeneration of cerebrum and optic nerve. On the other hand though the difference in the values of CFFF among males and females was non-significant the value of CFFF was slightly higher in the males compared to females.<sup>9</sup>

The other parameter that has an effect on the CFFF is the duration of sleep. In our study we found that the value of CFFF decreases significantly with increased loss of sleep. The loss of sleep can be contributed to night shifts, long

duration of studies, peer pressure, extra usage of smart phones or display screens which all resulted in delay of onset of sleep or disturbed sleep. Sleep deprivation further causes delay or compromised quality of working during the day hours hence effecting both the physical as well as psychological well being of an individual.<sup>10,11</sup> Inadequate sleep has been shown to decrease the motor functioning, decreased learning ability, poor productivity and shortened memory. CFFF being an indicator of alertness and mental fatigue was used in our study to measure the cortical arousal or central nervous system activity. Sleep deprivation has an impact on consolidation and encoding of memories as well as affects cognitive functioning of an individual.<sup>12-14</sup> It can be concluded that the disturbance in sleep leads to a decrease in CFFF as it disturbs the functions like learning memory and concentration. Disturbed sleep causes delays in information processing and normal CNS activities.

## REFERENCES

1. Chiranjeevi kumar Endukuru, K.N. Maruthy, T.S. Deepthi. A Study of Critical Flickering Fusion Frequency Rate in Media Players. 2015;2: 499-502.
2. Aaron R. Seitz et al. Perceptual Learning of Motion leads to faster flickering perception. PLoS ONE December 2006 | Issue 1 | e28.
3. Aaron R. Seitz et al. Visual experience can substantially alter critical flicker. Hum Psychopharmacol Clin Exp 2005; 20: 55-60.
4. Seong Taekjeon et al. The Effect of Video Game Training on the Vision of Adults with Bilateral Deprivation Amblyopia. Seeing and Perceiving (2012) DOI:10.1163/18784763-00002391
5. Clarence E.Rash et al. Awareness of causes and symptoms of Flicker vertigo can limit 111 effects. Human factors and aviation medicine March – April 2004 Vol.51 No.2
6. Chih-Long Lin et al. The Effect of Display Type and Video Game Type on Visual Fatigue and Mental Workload. Proceedings of the 2010 International Conference on Industrial Engineering and Operations Management Dhaka, Bangladesh, January 9 – 10, 2010.
7. Ramamoorthy S, Mohandas S and Premasembulingam M. Prevalence of excessive daytime sleepiness among medical students. World journal of pharamaaceutical research.2014;3:1819-1826.
8. Nonato DR, Viegas CA, Abreue Silva AA and Tavares P. Daytime sleepiness and academic Performance in medical students. Arq Neuropsiquiatr. 2002;60:6-11.
9. Misiak, Henryk et al. Age and sex differences in critical flicker frequency. Journal of Experimental Psychology, 1947;37:318-332.
10. Ahrberg K, Dresler M, Niedermaier S, Steiger A, Genzel L. The interaction between sleep quality and academic performance. Journal of Psychiatric Research 2012;41: 1618-1622.
11. Azad MC, Fraser K, Rumana N, Abdullah AF, Shahana N, Hanly PJ, Turin TC. Sleep disturbances among medical students: a global perspective. J Clin Sleep Med 2015;11:69-74.

12. Rasekhi S, Ashouri FP, Pirouzan A. Effects of Sleep Quality on the Academic Performance of Undergraduate Medical Students. *Health Scope*. 2016; 5:e31641.
13. Schulz H, Frenz JW, Kurfurst GU. Cognitive deficits in patients with daytime sleepiness. *Acta Neurologica Belgica* 1997;97:108-112.
14. Schneider C, Fulda S, and Schulz H. Daytime variation in performance and tiredness/sleepiness ratings in patients with insomnia, narcolepsy, sleep apnea and normal controls. *J. Sleep Res.* 2004;13:373–383.

**Source of Support:** Nil; **Conflict of Interest:** None

**Submitted:** 08-05-2020; **Accepted:** 06-06-2020; **Published:** 23-06-2020