

## RESEARCH ARTICLE



# Effect of Simplified Kundalini Yoga Meditation on Engineering Students: An EEG Study

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## Abstract

**Objectives:** Meditation influences brain waves. The purpose of the present study was to investigate the effect of Simplified Kundalini Yoga (SKY) meditation on the brain waves of technical college students using the Neurosky mindwave Electroencephalogram (EEG) device. **Methods:** Eighty-six participants were recruited from an engineering college in South India, with ages ranging from 18 to 19 years. They were divided into the yoga group (43 participants) and the sports group (43 participants). During pre-data collection, students of both groups were asked to sit with closed eyes for 20 minutes. During post-data collection, students in the sports group sat with closed eyes for 20 minutes, and yoga group students performed Thuriya meditation for 20 minutes. **Findings:** Pre-test and post-test results showed significant differences within sessions in EEG meditation state and Low Alpha state in both groups. After the intervention, the sports group showed a significant difference at the end of the session, whereas the yoga group showed a significant difference at the beginning of the session. At the baseline, there were significant differences between groups in the High Gamma state and within sessions in the Mid Gamma state. In terms of other variables, there was no significant difference in both groups. **Novelty:** We conclude that the SKY meditation technique can influence the state of mediation, low alpha, high gamma, and mid gamma EEG bands. Sports group have also shown comparable improvements. Hence, meditation and sports activities can be suggested in technical educational institutes for the promotion of positive health.

**Keywords:** SKY Meditation; Engineering; EEG; Neurosky; Mindfulness; Attention

## 1 Introduction

Emerging adulthood is a novel developmental paradigm to study late adolescence to early adulthood, with an emphasis on ages 18 to 25<sup>(1)</sup>. In India during this phase, parents try to establish in their children a strong family orientation through emphasizing respect for elders, establishing hierarchical roles, and supporting interdependent decision-making. This influence is also reflected in career orientation. In recent years, traditional

Indian values have been modified in response to globalization, to reflect Westernized concepts of independence within interdependent familial situations<sup>(2)</sup>.

As an ill effect of the changing lifestyles and societal values, there is an increase in mental health problems among emerging adults. In the USA, adults regularly have feelings of worry, nervousness, or anxiety (11.2%), feelings of depression (4.7%), hypertension (27.1%), and chronic pain (20.6%)<sup>(3)</sup>. Academic factors, environmental factors, and interpersonal relationships appear to be extremely stressful for Indian medical and engineering students<sup>(4)</sup>.

To address these issues, various mind-body interventions were employed. Mindfulness and meditation are beneficial pedagogical methods that produce positive results<sup>(5)</sup>. Low mindfulness is associated with a lack of clarity of values in life, lack of life fulfillment, and impaired engaged living, and these, in turn, lead to depression, stress and anxiety<sup>(6)</sup>. In a study, Simplified Kundalini Yoga has been shown to decrease anxiety, depression and stress<sup>(7)</sup>. Yoga has a positive impact on psycho physiological regulation, resulting in lower levels of stress in college students<sup>(8)</sup>.

People who engage in involuntary mind wandering are more prone to experience symptoms of depression, anxiety, and stress, but intentional mind wandering may protect against these sorts of affective dysfunction<sup>(9)</sup>. Yoga has beneficial effects on brain activity, as evidenced by changes in alpha, beta, and theta brainwaves associated with improvements in insight, memory, and mindset, as well as a reduction in uneasiness or anxiety<sup>(10)</sup>.

Researchers are keen to explore different types of mind-body interventions, and over the years, the world's contemplative traditions have produced a vast array of meditation techniques. One among them is Simplified Kundalini Yoga (SKY) meditation techniques<sup>(11)</sup>. Depression, Stress, and Anxiety were greatly reduced by Simplified Kundalini Yoga<sup>(7,12)</sup>. SKY practices improve academic performance<sup>(13)</sup>, flexibility<sup>(14)</sup> and emotional intelligence<sup>(15)</sup>. However, only a few types of research have been done on Simplified Kundalini Yoga using EEG measures. No EEG research has been done on technical students using SKY Meditation as an intervention. Hence, we aimed to study the effect of SKY meditations on technical students using the EEG technique. This study will help us understand how SKY meditation practices influence the brain waves and thereby elucidating the mechanism of working of SKY practices. This study will therefore address the research gap concerning the use of SKY practices for technical college students.

## 2 Material and methods

### 2.1 Participants

For this study, 86 participants were recruited from an engineering college in South India and their ages ranged from 18 to 19 years. They all belonged to the same academic year. They were divided into two groups; one is a yoga group (43 participants) and another is a sports group (43 participants). Inclusion criteria included participants who showed an interest in participating in the research and participants of both genders were recruited.

### 2.2 Design

We used two groups pre-post designs for this study.

### 2.3 Ethical Consideration

This study was approved by the Institutional Ethics Committee and participants' consent was obtained before conducting the study, after explaining to them all the necessary details about the study.

### 2.4 Assessment Tools

All the psychological variables were assessed using INQUISIT software<sup>(16)</sup>. The recruited students were given a schedule to participate in the assessments. Informed consent was taken from the students to attend the test session, and they were insisted on visiting the Central Computer Lab, where a computer was allotted for each subject and the process of the test was explained to them. The assessments were conducted on 65 systems in the central computer lab. The researcher, along with a faculty member, and a lab technician were available in the lab for all the sessions to assist the participants and clarify their doubts. Participants took around 45 minutes to complete the test. The test comprised a demographic profile and other psychological variables. The Demographic profile contains the roll number, date of birth, earlier experience of yoga practice-having a response range from 0 (no experience) to 3 (above one year experience) and the reason for career selection using the question, "I have chosen engineering due to", which had responses: 1 (My own interest), 2 (Teacher's), 3 (Friends/Seniors), and 4 (parents).

The Revised Adult Attachment Scale (RAAS) was used to evaluate attachment styles. The RAAS is divided into three subscales (close, dependent, anxiety), each of which comprises six items with a response range of 1 to 5, ranging from “Not at all characteristic of me” to “Very characteristic of me.” In a previous study, Cronbach’s alpha for the close, dependent, and anxiety subscales was found to be 0.77, 0.78, and 0.85, respectively<sup>(17)</sup>.

The General Health Questionnaire was used to measure the general health of the participants. It contains twelve items that are answered using a 4-point Likert scale format, ranging from 0 to 3 from left to right for all 12 questions. In our study, we used a 0-0-1-1 scoring scheme. The tool was validated for reliability in a previous study and Cronbach’s alpha was 0.94<sup>(18)</sup>.

The 15-item Mindful Attention Awareness Scale (MAAS) assesses individual differences in the frequency of mindful states over time. MAAS respondents indicate how frequently they have the experience described in each statement using a 6-point Likert scale ranging from 1 (almost always) to 6 (almost never), where high scores reflect more mindfulness. The internal consistency (alpha) was .82<sup>(19)</sup>.

A 13-item short form of the Marlowe-Crowne Social Desirability Scale was used to assess personal attitudes and traits related to presenting one’s responses in a socially desirable way. Participants must decide whether the statement is true or false. In a prior study, the tool was tested for reliability and the test-retest correlation was 0.89<sup>(20,21)</sup>.

EEG was assessed using the Mindwave Mobile EEG headset<sup>(21)</sup>. After psychological variables were assessed, recruited students were given a schedule and insisted to visit the meditation hall according to their scheduled time. The explanation was given to all recruited students about EEG data collection. During pre-data collection both group students were asked to sit in a meditative posture silently for 20 minutes. After the pre-data collection, sports group students underwent a one-and-a-half-day (12 hours) orientation program and the yoga group students underwent 3 days (21 hours) Simplified Kundalini Yoga orientation program. Students of both groups had 30 hours (20 weeks x 1½ hours/week) of follow-up classes after the orientation program. During post data collection sports group students were asked to sit in meditative posture silently for 20 minutes and yoga group students were asked to do Thuriya meditation (Prayer, purification of atmosphere and divine invocation for 5 minutes, meditation for 10 minutes and affirmation and blessings for 5 minutes) totally for 20 minutes.

### 3 Results and Discussion

All raw data from the server computer were collected after completing the tests. Data were extracted from an excel sheet. In addition, all variables’ data were consolidated into a single excel file, and duplicate data were deleted. Then, for the variables that required reverse scores, reverse scores were applied, and descriptive statistics were generated for all variables. The internal consistency, Cronbach’s alpha, was determined for all the variables. We used an alpha of 0.05 to test the significance of all our statistical tests. The statistical software R 4.1.0 was used to analyse the data<sup>(22)</sup>.

The following variables were measured under various domains: Demographic profile, social desirability, General health, the Adult Attachment Scale, which has three sub-domains-Close, Dependent and Anxiety, and the mindful attention and awareness scale (MAAS) and EEG. As a part of the academic curriculum, physical assessments were also done, however, they are not reported in this study.

#### 3.1 Descriptive Statistics

The means and standard deviation of psychological variables are presented in Table 1. The total sample size of the study was 86, but from that, we had to remove 21 participants who didn’t complete the post-test. This led to a final analysable sample size of 65, which includes 31 participants (18 male & 13 female) in the Sports group and 34 participants (28 male & 6 female) in the Yoga group.

We conducted 2 x 3 repeated-measures ANOVA, with yoga and sports (group) as a between-group factor; pre, during and post-meditation period (time) as a within-group factor. We have reported the results of the main effects of group and time, in Table 2. Further post hoc tests were conducted using paired samples t-tests with Bonferroni corrections to control for multiple comparisons. Bonferroni adjusted p value,  $p_{bonf}$  is reported. The raw data and the R analysis script for this study can be downloaded from [https://osf.io/5rpk3/?view\\_only=c96fdf6eb757477abfe96ea84eaf0405](https://osf.io/5rpk3/?view_only=c96fdf6eb757477abfe96ea84eaf0405).

There was a significant difference in the EEG variable ‘meditation state’ within sessions (pre-during-post) in both the groups (yoga and sports) at the baseline (Sports mean:  $M_{pre}=57.68$ ;  $M_{during}=52.35$ ;  $M_{post}=53.9$ , Yoga mean:  $M_{pre}=57.66$ ;  $M_{during}=52.84$ ;  $M_{post}=53.18$ ,  $p=0.001$ ). Post hoc tests showed that difference between pre-during session ( $p_{bonf}=0.001$ ) and pre-post session ( $p_{bonf}=0.037$ ) were statistically significant. After the intervention, similar results were found, in both the groups (Sports mean:  $M_{pre}=53.25$ ;  $M_{during}=49.63$ ;  $M_{post}=48.73$ , Yoga mean:  $M_{pre}=57.88$ ;  $M_{during}=51.82$ ;  $M_{post}=51.79$ ,  $p=0.003$ ). Post hoc tests showed that difference between pre-during session ( $p_{bonf}=0.002$ ) and pre-post session ( $p_{bonf}=0.017$ ) were statistically significant. However, in the post-test results, the sports group showed a significant difference whereas the yoga group showed

**Table 1. Descriptive Statistics**

Variables	Before -Sports			Before -Yoga			After -Sports			After -Yoga		
	N	Mean	SD	N	Mean	SD	N	Mean	SD	N	Mean	SD
Attachment type - Close	27	18.85	5.78	32	19	3.68	-	-	-	-	-	-
Attachment type - Dependent	27	16.59	5.21	32	18.25	3.78	-	-	-	-	-	-
Attachment type - Anxiety	27	16.85	6.24	32	20.03	4.53	-	-	-	-	-	-
General Health	27	10.26	5.31	32	9.69	5.68	-	-	-	-	-	-
Mindfulness - Mean	27	3.62	0.94	32	3.52	0.84	-	-	-	-	-	-
Social Desirability -Total	27	6.81	1.69	32	6.75	2.31	-	-	-	-	-	-
Attention <i>pre</i>	31	48.21	11.86	34	48.83	11.88	31	45.06	15.47	34	46.89	10.69
Attention <i>during</i>	31	49.89	6.96	34	50.06	6.27	31	47.39	14.27	34	47.98	11.28
Attention <i>post</i>	31	47.18	8.13	34	49.59	5.85	31	47.8	14.64	34	45.5	15.49
Meditation <i>pre</i>	31	57.68	13.24	34	57.66	10.38	31	53.25	18.23	34	57.88	12.9
Meditation <i>during</i>	31	52.35	9.19	34	52.84	7.03	31	49.63	14.71	34	51.82	12.84
Meditation <i>post</i>	31	53.9	9.63	34	53.18	6.34	31	48.73	14.59	34	51.79	17.22
Delta <i>pre</i>	31	0.61	0.18	34	0.62	0.2	31	0.68	0.22	34	0.63	0.18
Delta <i>during</i>	31	0.69	0.18	34	0.6	0.18	31	0.68	0.22	34	0.61	0.21
Delta <i>post</i>	31	0.69	0.23	34	0.63	0.23	31	0.65	0.24	34	0.59	0.21
Theta <i>pre</i>	31	0.86	0.31	34	0.82	0.21	31	0.87	0.3	34	0.77	0.21
Theta <i>during</i>	31	0.88	0.25	34	0.76	0.25	31	0.85	0.26	34	0.77	0.24
Theta <i>post</i>	31	0.89	0.34	34	0.76	0.25	31	0.77	0.3	34	0.72	0.28
Low Alpha <i>pre</i>	31	0.66	0.25	34	0.63	0.25	31	0.67	0.28	34	0.56	0.29
Low Alpha <i>during</i>	31	0.59	0.27	34	0.49	0.23	31	0.59	0.3	34	0.5	0.24
Low Alpha <i>post</i>	31	0.61	0.33	34	0.46	0.28	31	0.51	0.31	34	0.5	0.29
High Alpha <i>pre</i>	31	0.68	0.28	34	0.59	0.29	31	0.72	0.31	34	0.63	0.33
High Alpha <i>during</i>	31	0.6	0.27	34	0.46	0.25	31	0.61	0.31	34	0.51	0.25
High Alpha <i>post</i>	31	0.55	0.28	34	0.44	0.26	31	0.54	0.29	34	0.51	0.29
Low Beta <i>pre</i>	31	0.2	0.16	34	0.18	0.17	31	0.19	0.2	34	0.22	0.22
Low Beta <i>during</i>	31	0.19	0.15	34	0.16	0.17	31	0.17	0.18	34	0.19	0.21
Low Beta <i>post</i>	31	0.17	0.14	34	0.15	0.21	31	0.14	0.16	34	0.17	0.23
High Beta <i>pre</i>	31	0.1	0.13	34	0.11	0.15	31	0.13	0.22	34	0.14	0.16
High Beta <i>during</i>	31	0.08	0.09	34	0.1	0.15	31	0.13	0.22	34	0.15	0.22
High Beta <i>post</i>	31	0.04	0.06	34	0.1	0.19	31	0.14	0.29	34	0.17	0.28
High Gamma <i>pre</i>	31	0.03	0.04	34	0.06	0.09	31	0.04	0.08	34	0.06	0.07
High Gamma <i>during</i>	31	0.04	0.04	34	0.06	0.07	31	0.04	0.06	34	0.05	0.07
High Gamma <i>post</i>	31	0.03	0.03	34	0.06	0.09	31	0.04	0.11	34	0.06	0.09
Mid Gamma <i>pre</i>	31	0.11	0.28	34	0.24	0.36	31	0.09	0.12	34	0.11	0.21
Mid Gamma <i>during</i>	31	0.07	0.09	34	0.1	0.11	31	0.08	0.15	34	0.08	0.14
Mid Gamma <i>post</i>	31	0.05	0.05	34	0.07	0.1	31	0.07	0.19	34	0.07	0.18

a slight difference.

There was significant difference within sessions in both the groups in Low Alpha state at the baseline (Sports mean:  $M_{pre}=0.66$ ;  $M_{during}=0.59$ ;  $M_{post}=0.61$ , Yoga mean:  $M_{pre}=0.63$ ;  $M_{during}=0.49$ ;  $M_{post}=0.46$ ,  $p<0.001$ ). Post hoc tests showed that difference between pre-during session ( $p_{bonf}<0.001$ ) and pre-post session ( $p_{bonf}=0.002$ ) were statistically significant. Post-test results have also showed significant difference within sessions in both the groups in Low Alpha state (Sports mean:  $M_{pre}=0.67$ ;  $M_{during}=0.59$ ;  $M_{post}=0.51$ , Yoga mean:  $M_{pre}=0.56$ ;  $M_{during}=0.5$ ;  $M_{post}=0.5$ ,  $p<0.001$ ). Post hoc tests showed that difference between pre-during session ( $p_{bonf}=0.025$ ) and pre-post session ( $p_{bonf}=0.004$ ) were statistically significant. In the post-test results, the sports group showed a significant difference at the end of the session whereas the yoga group showed a significant difference at the beginning of the session. Similarly, there was significant difference within sessions in both the groups in High

Alpha state at the baseline ( $p < 0.001$ ). Post hoc tests showed that difference between pre-during session ( $p_{bonf} = 0.001$ ) and pre-post session ( $p_{bonf} < 0.001$ ) were statistically significant. Post-test results have also showed significant difference within sessions in both the groups in High Alpha state ( $p < 0.001$ ). Post hoc tests showed that difference between pre-during session ( $p_{bonf} = 0.001$ ) and pre-post session ( $p_{bonf} < 0.001$ ) were statistically significant.

There was a significant difference in between groups in High Gamma state at the baseline (Sports mean:  $M_{pre} = 0.03$ ;  $M_{during} = 0.04$ ;  $M_{post} = 0.03$ , Yoga mean:  $M_{pre} = 0.06$ ;  $M_{during} = 0.06$ ;  $M_{post} = 0.06$ ,  $p = 0.047$ ). But there was no significant difference in post-test between groups in terms of High Gamma state. There was a significant difference within sessions in both the groups in Mid Gamma state at the baseline (Sports mean:  $M_{pre} = 0.11$ ;  $M_{during} = 0.07$ ;  $M_{post} = 0.05$ , Yoga mean:  $M_{pre} = 0.24$ ;  $M_{during} = 0.1$ ;  $M_{post} = 0.07$ ,  $p = 0.004$ ). Post hoc tests showed that difference between pre-during session ( $p_{bonf} = 0.013$ ) and pre-post session ( $p_{bonf} = 0.012$ ) were statistically significant. However, after the intervention, there was no significant difference within sessions in both the groups in terms of Mid Gamma state. There were also no significant differences in both the groups concerning other variables.

We used independent samples t-test to evaluate any difference in psychological variables (assessed only at the baseline) between yoga and sports groups. The results showed no statistical difference between yoga and sports groups for all the psychological variables.

**Table 2. Repeated Measures ANOVA before and after the intervention on EEG variables**

Variables	Main Effect	Pre	Post
Attentio	Group	F(1,63)=0.454, p=0.503, es=0.007	F(1,63)=0.000162, p=0.99, es=2.56e-06
Attention	Time	F(1.39,87.43)=0.899, p=0.377, es=0.014	F(1.5,94.25)=0.953, p=0.366, es=0.015
Meditation	Group	F(1,63)=0.002, p=0.964, es=3.25e-05	F(1,63)=0.994, p=0.323, es=0.016
Meditation	Time	F(1.49,93.64)=8.426, p=0.001, es=0.118	F(1.69,106.32)=6.99, p=0.003, es=0.1
Delta	Group	F(1,63)=1.585, p=0.213, es=0.025	F(1,63)=2.151, p=0.147, es=0.033
Delta	Time	F(1.64,103.36)=1.136, p=0.316, es=0.018	F(1.83,114.98)=0.812, p=0.437, es=0.013
Theta	Group	F(1,63)=2.546, p=0.116, es=0.039	F(1,63)=2.083, p=0.154, es=0.032
Theta	Time	F(2,126)=0.34, p=0.712, es=0.005	F(1.77,111.25)=3.213, p=0.05, es=0.049
Low Alpha	Group	F(1,63)=2.155, p=0.147, es=0.033	F(1,63)=1.311, p=0.257, es=0.02
Low Alpha	Time	F(1.66,104.81)=11.758, p=7.78e-05, es=0.157	F(2,126)=8.059, p=0.000509, es=0.113
High Alpha	Group	F(1,63)=3.658, p=0.06, es=0.055	F(1,63)=1.284, p=0.262, es=0.02
High Alpha	Time	F(1.69,106.29)=14.736, p=8.66e-06, es=0.19	F(1.63,102.67)=15.392, p=7.49e-06, es=0.196
Low Beta	Group	F(1,63)=0.46, p=0.5, es=0.007	F(1,63)=0.256, p=0.615, es=0.004
Low Beta	Time	F(1.53,96.11)=1.115, p=0.319, es=0.017	F(1.51,95.03)=2.128, p=0.137, es=0.033
High Beta	Group	F(1,63)=1.142, p=0.289, es=0.018	F(1,63)=0.11, p=0.741, es=0.002
High Beta	Time	F(1.56,98.23)=1.95, p=0.157, es=0.03	F(1.31,82.24)=0.42, p=0.572, es=0.007
High Gamma	Group	F(1,63)=4.117, p=0.047, es=0.061	F(1,63)=0.822, p=0.368, es=0.013
High Gamma	Time	F(1.48,93.19)=0.062, p=0.89, es=0.000987	F(2,126)=0.585, p=0.559, es=0.009
Mid Gamma	Group	F(1,63)=2.62, p=0.111, es=0.04	F(1,63)=0.052, p=0.821, es=0.00082
Mid Gamma	Time	F(1.07,67.57)=8.44, p=0.004, es=0.118	F(1.32,82.9)=0.712, p=0.438, es=0.011

## 4 Discussion

At the baseline, there was no significant difference in between-groups in terms of psychological variables like adult attachment scale, general health questionnaire, mindfulness attention awareness scale, and social desirability scale. This showed both the groups had comparable psychological profiles. In the EEG variables, meditation score, low alpha, high alpha, and mid gamma bands were found to be different between the groups. The post hoc tests showed that the changes were detected between pre versus during and pre versus post comparisons, and the during versus post comparisons were not significant. This shows compared to the baseline, the changes are substantial at during and post.

Comparing our results with the existing results in the literature, in a study, meditation improved relaxed alertness and internalised attention by increasing amplitude in the alpha and theta waves<sup>(23)</sup>. There is a high frequency in attention and a low frequency in meditation in delta, theta, alpha, beta, and gamma waves<sup>(24)</sup>.

Low-frequency alpha power reflects internal attention or non-task-related cognitive activities<sup>(25)</sup>. EEG studies have revealed a significant increase in alpha and theta activity during meditation<sup>(26)</sup>. Our study results also fit with previous study results.

High gamma-band EEG is closely related to emotion. The brain is more active and more efficient in responding to negative stimuli than to positive ones<sup>(27)</sup>. During touching, EEG waves, delta, theta, beta, and gamma signals were higher than during meditation<sup>(28)</sup>. According to the correlation findings of a study, subjects whose gamma energy did not increase after mindfulness training had their anxiety and high arousal levels reduced, and in subjects whose gamma energy levels increased, anxiety and high arousal levels decreased to a lesser extent<sup>(29)</sup>. As our study results showed that there was no significant difference in post-test in high gamma and mid gamma bands, it may not have hampered the emotional stability.

Discussing the strengths and limitations of our study, we tried to find the effect of Simplified Kundalini Yoga meditation (Thuriya Meditation) on technical education students who underwent 20 weeks of follow up sessions and assessed using a single-channel EEG. To the best of our knowledge, this was the first EEG study on technical students to measure the effect of Simplified Kundalini Yoga meditation. This research focused solely on first-semester students. During their four years of engineering school, there may be positive changes in the brain waves of students. Hence, it is suggested that the same type of study be conducted over different periods during their course time. We also suggest that along with the EEG test some psychological variables be tested and correlated to find subjective changes in the students. We didn't exclude severe distress subjects from the study. In future studies, severe distress subjects may be excluded or analysed separately.

## 5 Conclusion

We conclude that the SKY meditation technique can influence the state of mediation, low alpha, high gamma and mid gamma EEG bands. Sports groups have also shown comparable improvements. Hence, meditation and sports activities can be suggested in technical educational institutes for the promotion of positive health.

## 6 Acknowledgement

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## 7 Ethics Statement

The studies involving human participants were reviewed and approved by the Institutional Ethics Committee of SVYASA Yoga University (IEC Reference no. RES/IEC-SVYASA/99/2017). The participants provided their written informed consent to participate in this study.

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