RESEARCH ARTICLE

Effectiveness of mantra meditation as a neurophysiological phenomenon for stress management in undergraduate medical students

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ABSTRACT

Background: Meditation has widely been used to combat stress and its effects, yet the universality of its effectiveness and duration remains unclear. Aim and Objectives: This study aimed to evaluate differences in its effectiveness among individuals with different baseline stress levels and recommend duration of practice to produce constructive outcomes. Materials and Methods: A total of 30 undergraduate medical students (15 males and 15 females) with a mean age of 21 (±0.95) years volunteered for the study. Preliminarily, using the perceived stress scale (PSS), they were categorized into high (0), moderate (25), and low (5) stress groups; following which they were pre-tested for heart rate (HR), HR variability, and galvanic skin resistance (GSR), subject to a computer game stressor. Students were then instructed to undertake meditation sessions and were tested for the same parameters at intervals of 3 and 6 weeks from the pre-test. Results: Moderate stress individuals showed a significant ($P \leq 0.05$) increase in high frequency band, GSR, RMSSD (square root of the mean of the sum of the squares of the differences between adjacent RR intervals) and the percentage of RR 50 counts; accompanied with a significant decrease in PSS score, low frequency to high frequency ratio and HR; with parameters becoming significant within 3 weeks of practice, and no further significant changes in the 3–6 weeks period. None of the parameters were significant for the low stress group, although similar trends were observed. Conclusion: The study indicated the usefulness of a 3-week meditation program for individuals with moderate or high stress, and recommendation to include a meditation program into the undergraduate medical curriculum. Positive effects were attributed to a shift of sympathovagal balance to parasympathetic dominance.

KEYWORDS: Meditation, Stress, Shiv Yog; Heart Rate, Heart Rate Variability; Galvanic Skin Resistance; Autonomic Functions

INTRODUCTION

Meditation is a process that involves resting the mind and achieving a state of inner consciousness that is different from the normal waking state. It can be broadly explained as a practice of emotion and mind regulation resulting in specific attentional sets with involvement of specific areas of the brain.¹ While regulation of attention remains the central feature of meditation,² models also suggest interplay with emotional and cognitive flexibility resulting in non-judging awareness that further propagates into beneficial effects.³ Meditation has long been regarded as a means to reduce stress among many other claimed benefits its effectiveness remains yet to be fully understood and comprehended, with doubts still lingering over underlying mechanisms and required duration of practice; although recent investigations do

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provide directional evidence towards meditative states providing increased neural and cognitive plasticity and prompt evaluation of clinical implications.[4]

A stress response develops as a process of adaptation, but severity and prolongation may lead to disease and affliction. It is reported to impair cognition[5] and is etiologically linked to a variety of diseases, which makes it relevant to all people in general but people requiring high levels of alertness, memory, and concentration fall at a higher risk of stress-induced ailments. Stress management has emerged as a topic of high priority for medical professionals in recent years and meditation has emerged as potentially one of the most powerful stress relieving methods. Undergraduate medical students are among the highly stressed groups of population as they undergo training in arguably the most rigorous professional training, designating them as ideal subjects for the study to assess the effects of meditation.

There exists a great degree of variability in meditation programs with differences in promoted mental activity, required training or qualification, requirement of an instructor, and emphasis on spirituality or religion while some approaches may even include dietary (Ayurveda) and movement (Yoga) therapies. The meditation used for this study was based on positive creative visualization and mantras, which did not require prior initiation. Creative visualization is a process involving voluntary genesis or mental imagery and their modifications for a variety of purposes as needed by the practitioner, while mantras are sacred words believed to have spiritual or psychological prowess. Meditation influences the brain and through neural plasticity, causes functional and structural alterations in the brain leading to harmonization to result in a better experience of life.

Heart rate variability (HRV) is an accepted method for studying stress[6] and is indicative of the effectiveness and balance between sympathetic and parasympathetic nervous systems and is indicative of an individual’s ability to cope with stress as a measure of indication of the constant interactions between the two circuits. Galvanic skin response (GSR), also known as skin conductance or electrodermal activity, is also a reliable indicator of stress and is a sensitive parameter that is easily triggered by emotional arousal under the influence of sympathetic nervous system. Autonomic functions thus serve as a measure to understand an individual's stress reactivity making it a suitable method to study the impacts of meditation on the aforementioned parameters. Recent researches although indicate the positive effects of meditation on adults and its ability to reverse stress induced changes[7] its degree of effectiveness remains to be extensively investigated before it can be accepted as a clinical intervention for stress management beyond a reasonable doubt. There is also no documentation if any differences of effectiveness exist between individuals with different levels of baseline stress, neither is well-defined time duration recommended universally.

The current study aimed to evaluate the effectiveness of meditation programs in reduction of psychological stress as well as acute stress reactivity by assessing perceived stress and autonomic functions in undergraduate medical students. The study also aimed to evaluate meditation linked changes in regard to duration of practice and investigate the effects of regularity of practice of meditation as a whole, and further separately, for individuals with varying baseline stress levels.

**MATERIALS AND METHODS**

**Study Design, Setting, and Duration**

This is a prospective cross-sectional study and was conducted at the Department of Physiology at a premium Medical College and Hospital in Jaipur, Rajasthan, India, between October 2019 and December 2019.

**Study Population and Sample Size**

The sample size as calculated with the precision/absolute error of 5% and at type 1 error of 5% consisted of 30 voluntary undergraduate medical students. Fifteen males and 15 females between the age group of 18 and 25 years were enrolled in the study. Students with prior history of practicing meditation or relaxing procedures; history of substance abuse, smoking and alcoholism; history of any disease; and ongoing treatment for any medical conditions were excluded from the study.

**Ethical Guidelines**

The study was conducted after taking approval from the Institutional Ethical Committee and written informed consent from the participants.

**Methodology**

After necessary briefing about the study and being kept blind to its design, all subjects were preliminarily asked to fill a validated questionnaire to assess psychological stress. This was done with the help of the most widely disseminated method – the “perceived stress scale (PSS),”[8] of which the 10 point version was used. It is a self-reported scale consisting of 10 items to assess respondent’s feelings and thoughts during the past 30 days. Each of the items on the scale are rated on a 5-point Likert scale (0: never; 1: almost never; 2: sometimes; 3: fairly often; and 4: very often). The scale consists of six positively (1, 2, 3, 6, 9, and 10) and four negatively (4, 5, 7, and 8) worded items. Negatively worded items are re-coded with a reverse scoring during analysis (0: very often; 1: fairly often; 2: sometimes; 3: almost never; and4: never). Total scores range from 0 to 40, with higher scores indicating higher levels of perceived stress. On the basis of their official PSS scoring, subjects were divided into high stress (Score: 0–13); moderate stress (Score: 14–26); and low stress (Score: 27–40) groups. Thereafter, all participants
were subjected to a stressor in the form of “computer games” played for 5 min. The games were playable with a few keys but difficult to master, resulting in repeated defeats and constraints experienced by the individual, leading to stressful conditions.\cite{9} This was followed by an immediate recording/testing of HRV and GSR in that particular order as quantitative biomarkers of stress, with subjects in an upright position sitting on a chair in a quiet room. This pre-meditation test was carried out in three groups of subjects each on successive days to allow all the subjects to be examined during the same time of the day (1–2 PM) to negate diurnal variations. The values observed for each participant served as its own baseline and control. After the completion of the pre-meditation session, the subjects were provided with a 20-min pre-recorded meditation session- “Shiv Yog Family Prayer Meditation” according to the same order and groups in which they were tested. The process was a meditative procedure based on mantras and creative visualization. The meditation session was conducted in a gathering at a fixed meditation room in the department of physiology daily for 6 weeks. Attendance record was thoroughly maintained. The participants were again analyzed for perceived stress and autonomic function testing (HRV and GSR) after 3 weeks (interim) and 6 weeks (final) post-meditation, respectively. The interim and the final testing were performed in accordance with a similar protocol as the pre-test. Figure 1 illustrates a flowchart depicting the performed methodology [Figure 1].

**Measurement of Autonomic Functions**

For measuring HRV, electrocardiogram signals were recorded by a digital physiograph (ADInstruments, Sydney, Australia; Model- ML 4818). After digital filtration, QRS peaks were extracted to determine RR intervals. Short-term recordings free of ectopic beats, missing data, and noise effects were used. “Frequency” and “Time” domain indices were computed from 5-min segments. Frequency domain was assessed by “Power Spectral” analysis using “Fast Fourier Transformation.” The “Frequency” domain indices included low frequency (LF; 0.04–0.15 [Hz]), high frequency (HF; 0.15–0.4 [Hz]), total power, LF in normalized units (LFnu), HF in normalized units (HFnu), and the Ratio of power in low frequency band to power in high-frequency band (LF:HF). LFnu, HFnu, and LF:HF ratios have been well studied parameters of sympathovagal balance and hence were recommended to evaluate the effect of meditation in the current study. “Time” domain indices were computed using RR Tachogram and statistically analyzed. They included Mean-RR (Mean of RR interval), SDNN (standard deviation [SD] of RR interval), RMSSD (square root of the mean of the sum of the squares of the differences between adjacent RR intervals), RR 50 (the Number of pairs of adjacent RR intervals differing by more than 50 ms in the entire recording), and the Percentage of RR 50 counts (pRR50) (calculated by dividing RR 50 count by total number of RR intervals). GSR was measured with the help of digital physiograph (ADInstruments, Sydney, Australia; Model- ML 4818) with two electrodes placed on the fingers of the subjects. The measured parameter, also known as Skin Conductance, is expressed in Kiloohms (kΩ). All measurements were documented and saved using Microsoft Excel software (Microsoft, USA; Version 2010).

**Statistical Analysis**

Data were presented as Mean ± SD and statistical analyses were done using paired Student’s t-test. The mean stress levels obtained for perceived stress and autonomic functions (HRV and GSR) were represented graphically with slopes indicating any change in the rate of stress reduction by comparison between 0 and 3 weeks and 3–6 weeks interval. The data were compared for different stress groups to investigate changes in the implications of meditation among them. Data were also organized individually for each subject and correlated with the number of days of practice out of the stipulated 6 weeks to check if regularity of practice had any effect on the productivity of the procedure. All inferences were drawn at 95% confidence interval and values with *P* values were also organized individually for each subject.

**RESULTS**

A total of 30 students (15 males and 15 females) with a mean age of 21 (± 0.95) years, weighing 64.5 (±11.59) kilograms (kg), and with a mean height of 169.7 (±8.73) centimeters (cm) were enrolled in the study. After the pre-meditation PSS analysis, five subjects were classified as low stress while the remaining 25 were considered as moderate stress individuals. None of them exceeded the score of 26 to be categorized as high stress individuals. The mean attendance was 19.7 out of 21 days among the first 3 weeks and a mean of 39.3 days out of the total 42 stipulated days of practice. Anthropometric profiles of moderate and low stress subjects are depicted in Table 1.

All the variables accounting for Perceived Stress and Autonomic Functions (except “Low Frequency”) demonstrated significant changes in the moderate stress group. Contrarily, low stress group failed to demonstrate significant changes in majority of the variables except perceived stress between 3 and 6 weeks which was statistically significant. Table 2 describes the detailed comparative analysis of the effect of meditation on perceived stress and autonomic reactivity to acute stress in moderate and low stress individuals. Comparative analysis of significance of perceived stress and autonomic functions between the two groups is depicted in Table 3.

Comparative analysis of frequency domain between moderate and low stress groups is illustrated in Figures 2 and 3. Increase in HF (*P* < 0.01) and decrease in LF:HF ratio (*P* < 0.01) was assessed to be statistically significant.
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Table 1: Anthropometric description of moderate and low stress participants

<table>
<thead>
<tr>
<th>Anthropometric variable</th>
<th>Moderate stress subjects (perceived stress scale score 14–26)</th>
<th>Low stress subjects (perceived stress scale score &lt;14)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number (N)</td>
<td>25</td>
<td>5</td>
</tr>
<tr>
<td>Males</td>
<td>11</td>
<td>4</td>
</tr>
<tr>
<td>Females</td>
<td>14</td>
<td>1</td>
</tr>
<tr>
<td>Age (years±SD )</td>
<td>21.12±0.88</td>
<td>20.4±1.14</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>169.28±9.24</td>
<td>171.8±5.85</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>62.88±11.68</td>
<td>72.6±7.50</td>
</tr>
</tbody>
</table>

Figure 1: Methodology
Table 2: Comparative analysis of the effects of meditation on perceived stress and autonomic reactivity to acute stress in moderate stress and low stress individuals

<table>
<thead>
<tr>
<th>Variable</th>
<th>Moderate stress subjects PSS score (14–26)</th>
<th>Low stress subjects PSS score (&lt;14)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre-Meditation</td>
<td>At the end of 3 weeks</td>
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<tr>
<td>PSS</td>
<td>21.8±3.64</td>
<td>16±5.55</td>
</tr>
<tr>
<td>HR (beats/minute)</td>
<td>95.88±6.60</td>
<td>91.99±5.47</td>
</tr>
<tr>
<td>GSR (Kiloohms/kΩ)</td>
<td>296.50±53.49</td>
<td>338.77±30.56</td>
</tr>
<tr>
<td>LF (Hertz/Hz)</td>
<td>577.99±170.54</td>
<td>598.64±195.35</td>
</tr>
<tr>
<td>HF (Hertz/Hz)</td>
<td>269.62±91.11</td>
<td>337.76±131.78</td>
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<tr>
<td>LF:HF Ratio</td>
<td>2.36±0.81</td>
<td>1.89±0.45</td>
</tr>
<tr>
<td>RMSSD (Millisecond/msec)</td>
<td>47.01±4.82</td>
<td>49.33±5.16</td>
</tr>
<tr>
<td>pRR50 (%)</td>
<td>17.12±2.82</td>
<td>18.55±2.43</td>
</tr>
</tbody>
</table>

*P≤0.05. PSS: Perceived stress scale, GSR: Galvanic skin response, HR: Heart rate, HF: High frequency, LF: Low frequency, RMSSD: Square root of the mean of the sum of the squares of the differences between adjacent RR intervals, pRR50: Percentage of RR 50 count calculated by dividing RR 50 count by total number of RR intervals

Table 3: Comparative analysis of significance of changes in perceived stress and autonomic function through test intervals between moderate and low stress groups

<table>
<thead>
<tr>
<th>Variable</th>
<th>Moderate stress subjects PSS score (14–26)</th>
<th>Low stress subjects PSS score (&lt;14)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0–3 weeks (P value)</td>
<td>3–6 weeks (P value)</td>
</tr>
<tr>
<td>PSS</td>
<td>&lt;0.01*</td>
<td>0.20</td>
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<tr>
<td>GSR (Kiloohms/kΩ)</td>
<td>&lt;0.01*</td>
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<td>HR (Beats/Minute)</td>
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<td>LF (Hertz/Hz)</td>
<td>0.41</td>
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<td>HF (Hertz/Hz)</td>
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<td>0.62</td>
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<tr>
<td>LF:HF Ratio</td>
<td>0.01*</td>
<td>0.013*</td>
</tr>
<tr>
<td>RMSSD (Millisecond/msec)</td>
<td>0.011*</td>
<td>0.20</td>
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<tr>
<td>pRR50 (%)</td>
<td>&lt;0.01*</td>
<td>0.97</td>
</tr>
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*P≤0.05. PSS: Perceived stress scale, GSR: Galvanic skin response, HR: Heart rate, HF: High frequency, LF: Low frequency, RMSSD: Square Root of the mean of the sum of the squares of the differences between adjacent RR intervals, pRR50: Percentage of RR 50 counts calculated by dividing RR 50 count by total number of RR intervals

Figure 2: Comparative analysis of low frequency and high frequency in moderate stress and low stress individuals
suggesting sympathovagal balance toward parasympathetic activity. Comparative analysis of time domain reported significant increase with respect to both RMSSD ($P < 0.01$) and pRR50 ($P < 0.01$) as depicted in Figure 4. There was also a significant increase in GSR ($P < 0.01$) and HR ($P < 0.01$) and a significant decline in the PSS score ($P < 0.01$), as displayed in Figures 5 and 6, respectively. Noteworthy is the fact that significant changes occurred in the initial 3 weeks of meditation practice, while further changes in the 3–6 week interval were insignificant.

**DISCUSSION**

This short-term interventional study indicates significant improvements in perceived stress as well as acute stress reactivity as displayed by the scores of PSS and autonomic functional alteration in 30 previously meditation-naive medical undergraduate subjects. There was a significant decrease in perceived stress within the first 3 weeks which flattens out at around the mean (as per the PSS) which is indicative of improvement in psychological response to external events resulting in the lower perception of stress. The improvement in psychological stress is documented directly by changes in the PSS scores, while acute stress reactivity also improved significantly as displayed by immediate post-stress evaluation of autonomic functions. HRV, through the frequency domain (increasing HF and thus decreasing LF/HF ratio) as well as the time domain (increasing RMSSD and pRR50), are indicative of increased parasympathetic activity within the autonomic nervous system, which is in direct antagonism to the sympathetic action that predominates the acute stress response. While early texts suggested LF to be an indicator of sympathetic activity alone, it has long been accepted to be a marker affected by an aggregation of both sympathetic and parasympathetic modulation.\(^{[10]}\) HF, RMSSD, and pRR50 universally attribute to the parasympathetic limb of the autonomic nervous system. LF:HF ratio is a marker of sympathovagal balance and increased GSR, typically indicates decreased sympathetic activation. Our study showed absence of significant changes in LF, which could be attributed to the combined result of the increased parasympathetic tone (increased HF) and decreased sympathetic tone (increased GSR that is measured in terms of Kiloohms/kΩ that is, resistance, in the present study), culminating in a net result which is insignificant. The physiologic benefits of mantra meditation therefore seem to be related to activating the parasympathetic and quieting the sympathetic activity. The effects on both perceived stress and acute stress reactivity occur significantly in the first 3 weeks of practice, while there are insignificant changes in the 3–6 weeks interval, implying that as the values for moderate stress individuals normalize toward values for low stress individuals, the rate of further decline in stress levels decreases, as can be visualized in Figures 3 and 5. The values for the low stress group do not show any significant changes, but the trends are

![Figure 3: Comparative analysis of low frequency: high frequency ratio in moderate stress and low stress individuals](image1)

![Figure 4: Comparison of effect on time domain in moderate and low stress individuals](image2)
Effectiveness of mantra meditation for stress management undergraduate medical students

There is considerable evidence that daily short-term (3 weeks) meditation is sufficient to produce stress relieving impacts in moderate stress individuals. The insignificance of changes in low stress individuals could also possibly be due to the small sample size of such individuals, but the small sample in itself points to a considerable level of stress in the medical undergraduate students of today. The procedure was also found to be totally safe, with no adverse events reported for the entire duration of the study.

The findings of decreased psychological stress are concurrent with a multitude of studies, including randomized controlled trials, showing an improvement in psychological stress based on empirical findings as well as increased ability to cope with stress by enhancement of one’s ability to modify and monitor coping strategies with 3 weeks of practice. The effectiveness of meditation in lowering psychological stress is well acknowledged, with systematic reviews noting consistent reduction and recommending it as a potential clinical intervention in a variety of psychological pathologies such as anxiety, depression, strains of care-giving over a long time, anger, and marital conflicts. There is considerable evidence that practice of various types of meditation increases the parasympathetic and reduces the sympathetic tone throughout a wide range of practices including meditation, physical postures, and breathing exercises. Similar results have also been documented on comparable subject populations in the previous studies employing mindfulness meditation, and the benefits are documented to be consistent over a variety of practices. While some reviews find the physiological adaptations to stress, inconsistent and requiring further investigation, others state a consistent effect on psychological markers such as cortisol, blood pressure, and HR. Research has also shown that individuals can be trained in meditation practices in a short time frame, though there exists a great deal of variability. A study documented that short-term practice (8 weeks) was associated with increased functional connectivity between the amygdala and the ventromedial prefrontal cortex, which was said to result in reduced amygdala reactivity and better emotional control. Another study found that an average of 6 h of practice over duration of 20 days was associated with positive, approach oriented emotions. As little as, 13 min of daily meditation for 8 weeks have yielded improvements in memory, mood, attention, and emotional regulation. Commercial mindfulness, although, is found to be less effective than even unaided relaxation for short term stress reduction by some authors. Although our study finds significant changes only in the moderate stress group, the trajectory of changes imply that over a longer period of meditation, significant changes might have been obtained in the low stress group as well, as the ability of experienced meditators outperforming normal healthy individuals in physiologic and psychological resilience to stress is well evidenced and documented. The high attendance rates implying acceptability of the practice are noted by other authors as well, with adherence by students for daily programs with meditations up to 20 min, and there is literature supporting the utility of a regular meditation program in medical colleges, as has been evidenced by literature documenting improvement in college student anxiety and overall student well-being following the practice.

Our study design used the participants as their own baselines and control, making the research sensitive to individual differences within the moderate and low stress subjects, analyzed separately as two groups. This enabled us to predict what the stress levels for each group would have been without the intervention being applied as well as verification of the fact that a specific independent intervention of meditation without any other alterations in lifestyle reflected in changes noted in a variety of interdependent variables was what reflected in our results. This also enabled us to graphically

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**Figure 5:** Comparative analysis of galvanic skin resistance and high frequency changes in moderate and low stress individuals

**Figure 6:** Comparative analysis of perceived stress scale score changes in moderate and low stress individuals
chart the trends for each group, allowing us to comment on the rate, effectiveness and the changes thereof of the intervention and further speculate if further significant changes could occur over potentially longer study durations. Our study was limited by the lack of low stress individuals for evaluation. Among the subject sample of volunteers in our study, only 16.77% experienced low levels of perceived stress, making standardization, and interpretation of data for low stress individuals inadequate. The study duration was also limited to 6 weeks, with significant changes noted only in the first 3 weeks in moderate stress, with no further significance of alterations in the 3–6 weeks period [Table 2]. However, as evidenced by provided figures, the values continued to proceed in a similar direction. A longer study duration might have yielded further results as to the time required for serial significant improvements, which is recommended for future research.

**CONCLUSION**

The study concludes that daily short-term (3 weeks) meditation is effective in reducing stress levels in high stress individuals such as medical students, at psychological, perceptual, and autonomic level. The current study advocates meditation as an economical, safe, and easy alternative that could potentially find clinical relevance along with mass scale application and eventually be integrated into the curricula of medical students for stress management. Moreover, this could provide an alternative therapy and potentially be a way of improving the quality of life as well as a point of prevention for various cardiovascular, hormonal, nervous and psychological diseases among others that could predispose to stress and its consequences which on progression could lead to relatively expensive and harmful clinical interventions which in severe cases might prove to be insufficient.

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