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Effect of Four Mukhi Rudraksha on Cognitive Dysfunction in Stressed Working Females

Shiva Sharma[1], D.V. Rai[2] and Manisha Rastogi[3]

[1]Ph. D. Scholar, Department of Biomedical Engineering, School of Biological Engineering and Life Sciences, Shobhit Institute of Engineering and Technology (Deemed to be University), Meerut, Modipuram, Meerut, India.
[2]Professor, Department of Biomedical Engineering, School of Biological Engineering and Life Sciences, Shobhit Institute of Engineering and Technology (Deemed to be University), Meerut, Modipuram, Meerut, India.
[3]Assistant Professor, Department of Biomedical Engineering, School of Biological Engineering and Life Sciences, Shobhit Institute of Engineering and Technology (Deemed to be University), Meerut, Modipuram, Meerut, India.

(Corresponding author: Manisha Rastogi)
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Abstract: Background: Chronic stress exerts significant adverse effect over neurocognitive functions due to prolonged activation of neuro-hormonal circuits.
Aim: The present study investigated the effect of four Mukhi (4M) Rudraksha (*Eleocarpus ganitrus*) (L.) bead on cognitive dysfunction in stressed working females.
Experimental Procedure: A total of 73 female participants with moderate stress level, impaired cognitive functioning and ready to provide informed consent were randomized into two groups Group 1: placebo control (n=30) and Group 2: physical wearing of 4M Rudraksha rosary (n=43). Neurocognitive and Electroencephalogram (EEG) parameters were recorded using Central Nervous System Vital Signs Analyzer (CNSVSA) and EEG BIOPAC MP36 system at baseline and 6 months respectively.
Results: The results showed significant improvement in composite memory, verbal memory, reaction time, cognitive flexibility, and frequency of δ wave ($P<0.05$, $P<0.01$) on physical wearing of Rudraksha. Further, in correlation analysis, significant correlations were obtained in visual memory and execution function with α ($r = 0.578809$, $p = 0.002435$) and β ($r = -0.5681$, $p = 0.003051$) respectively in Group 2. Amelioration of stress induced cognitive impairment is attributed to the electromagnetic property of Rudraksha bead which might have restored the disrupted neuronal polarization status.
Conclusion: Despite, the small sample size included for the analysis which was also one of the major study challenges, the present study outcomes provide scientific evidences about the efficacy of 4M Rudraksha bead in amelioration of stress induced cognitive dysfunction in females. It is suggested that 4M Rudraksha bead may serve as a safe, easy accessible, user friendly, eco-friendly, cost-effective, and holistic approach to curb cognitive and other mental health disorders.

Keywords: Brain wave, Electromagnetic effect, Homeostasis, Neurocognition, Traditional Medicine.

I. INTRODUCTION

Stress is defined as an adaptive biological mechanism which on one side promotes survival mechanism, while on the other side poses detrimental health effects, if chronically imposed in high intensity [1]. Biologically, stress response involved the activation of hypothalamic–pituitary–adrenal (HPA) axis with consequent release of Corticotrophin Releasing Hormone (CRH), adrenocorticotropin (ACTH) and stress hormones thereby influencing entire systemic physiology. Prolonged, HPA axis activation poses several health hazards such as disturbed insulin homeostasis, arterial diseases, impaired immune functions, compromised repair mechanisms, and altered brain structure and functions [2]. Stress hormone, mainly cortisol can easily cross the blood brain barrier and specifically targets amygdala, hippocampus, and pre-frontal cortex (PFC) which are associated with cognitive functions [3-4]. A large body of evidences about the negative impact of chronic stress on cognitive functions such as perception, attention, memory, language and executive control processes comes from clinical conditions such as depression, anxiety, schizophrenia and post-traumatic stress disorders (PTSD) with suitable applications over stress induced cognitive impairment [5-6]. Considering the similarity between the components of stress and neuropsychiatric disorders, search of therapeutic interventions to curb stress induced cognitive impairment is the need of an hour [7].

In this context, traditional Indian system of medicine can provide cost-effective, user friendly, easily accessible, safe and holistic approach to fight stress induced cognitive dysfunction. In Ayurveda, *Eleocarpus ganitrus* (L.) beads commonly known as Rudraksha is stated for its multiple pharmacological activities including neuropsychiatric ailments such as anxiety, depression, Parkinson's and Alzheimer's disease [8-13]. Additionally, the ancient literature also mentioned the Mukhi specific pharmacological activity of Rudraksha beads where 4 Mukhi Rudraksha was recognized for brain and cognitive functions, although the scientific evidences for the same are highly sparse [14]. The present study aims to evaluate the effect of 4 Mukhi Rudraksha on stress induced cognitive impairment in otherwise healthy professionally working women.

II. METHODOLOGY

A. Study design

The study was conducted as a pilot randomized placebo controlled study with due approval from Institutional Ethical Committee (SU/KSVAMCRC/2017-03). Full time employed female teachers working in the non-Government colleges of Meerut and Saharanpur cities of Uttar Pradesh, India were recruited for the study. The complete study design is demonstrated in Fig. 1. A total 73 female participants with moderate stress score and displaying cognitive impairment in CNSVS analyser were selected for the study and randomized into two groups. Group 1 (n=20) served as placebo control where participants were provided with visually similar Rudraksha rosary (108 beads) and Group 2 (n=25) participants were given original 4 Mukhi Rudraksha rosary for physical wearing for 6 months.

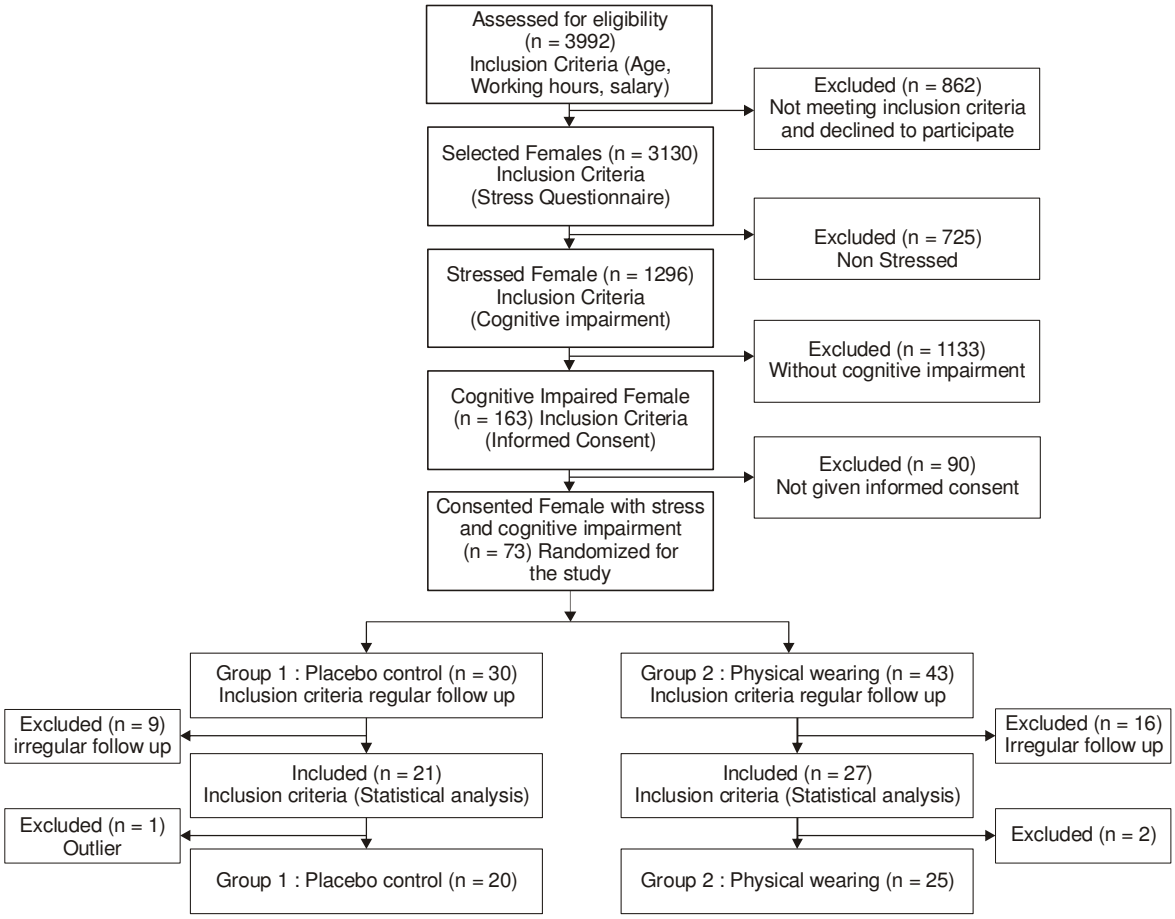

Fig. 1. Study design demonstrating inclusion and exclusion criteria along with sample size recruited and analyzed in the entire study to assess stress induced cognitive impairment in females.

B. Stress Score

Stress level of all the participants was analysed using EOCS scale involving five-point scale such as “always”, “frequently”, “sometimes”, “rarely” and “never” with scoring as 4, 3, 2, 1 and 0 respectively. The Questionnaire involved a total of 35 questions and the outcome score range from 0 to 140. Stress score of more than 100 was considered as low evidences of stress level while 99 to 51 and 50 to 0 as moderate and high evidences of stress level respectively. In addition to the questionnaire, generalized symptoms were also recorded on the scale of 0-4 depending upon their severity starting from Never, Rarely, Sometimes, Often, and All the time respectively.

C. Cognitive and EEG Parameters

A series of cognitive parameters such as Neurocognition index, Composite memory, Verbal memory, Visual memory, Processing speed, Executive function, Psychomotor speed, Complex attention, Cognitive flexibility, Reaction time etc. were recorded using Central Nervous System (CNS) Vital Signs Analyzer at baseline and 6 months. A total of 7 tests were used to assess the cognitive performance which has taken an overall time of 30 minutes. *Verbal memory score* was analysed by identifying the previously presented fifteen words on the screen from a cluster of the new words whereas *visual memory score* was generated by using the shapes of cluster. Input was recorded by pressing the space bar after identification of the clusters. *Finger tapping test* was used to assess motor speed where the subjects were allowed to press space bar as many times as they can in 10 seconds with their index finger of right and left hand separately. Complex attention was scored through *Symbol Digit Coding* test where participants were asked to type the number of highlighted symbols.

Continuous performance test analyzed the attention and reaction time where participants were asked to respond to a target stimulus “B” but not to any other letter. *Stroop test* and *shifting attention* test were performed to determine reaction time, processing speed, executive

function and decision making as prescribed in standard protocol.

While performing cognitive tasks in CNS Vital Sign Analyzer, brain waves were recorded simultaneously using electroencephalogram (EEG) BIOPAC MP36 System with EEG100C amplifier module. EEG cap with pre-positioned electrodes as per International 10-20 montage system plus mating cable to interface an EEG amplifier with BIOPAC MP36 unit was used. To reduce the interference and record the perfect EEG signal, 50 Hz notch filter and 35 Hz LPN filter was selected and data was recorded in both frequency as well as time domain in order to achieve signal frequency and amplitude respectively. Sample graph of the recorded EEG signal using BIOPAC MP-36 system is shown in Fig. 2.

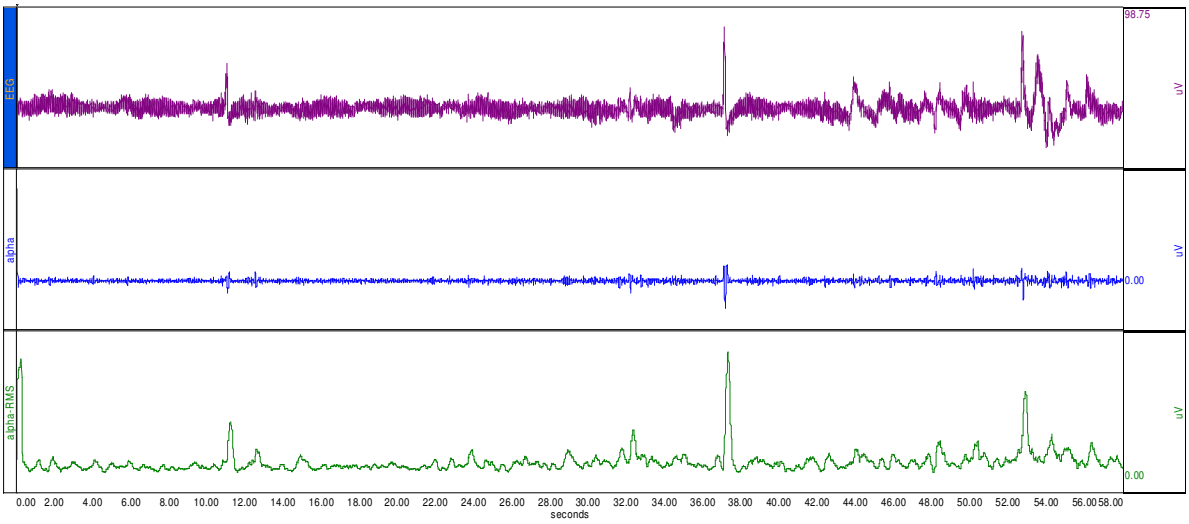

Fig. 2. Representative EEG signal for stressed female (Group 1) showing depressed alpha activity recorded using BIOPAC MP-36 System.

D. Statistical analysis

Data of participants who have completed the full study was processed for statistical analysis. All results were presented as Mean ± SD. Statistical data analysis was performed using Graph Prism Pad Software version 8.0 and $P<0.05$ was considered as statistically significant. The intergroup variation was measured by unpaired test followed by Pearson's correlation test.

III. RESULTS

A. Demographic variables and stress score before Intervention:

Table 1 and 2 represent the demographic variables, stress score and its associated symptoms in the study participants. The mean age and stress score of the participants were 38.6 years and 60 (moderately stressed) respectively with no significant difference between any of the variables.

Table 1: Demographic Parameters.

Parameter Mean (SD) or N (%)		**Group 1 (n=20)**	**Group 2 (n=25)**
Age		36 (4.50)	37.6 (4.89)
Type of Family	Joint	8 (40%)	16 (64%)
	Nuclear	12 (60%)	9 (36%)
Salary	12k-15k	4 (20%)	3 (12%)
	16k-20k	11(55%)	12 (48%)
	21k-25k	5 (25%)	10 (40%)
Working Hours	5-6 Hrs	03 (15%)	01 (4%)
	6-8 Hrs	16 (80%)	22 (88%)
	8-10 Hrs	01 (5%)	02 (8%)

Data representing mean (SD) or N (%) for different demographic parameter among Group 1 and Group 2 participants.

Table 2: Stress Score and Symptoms.

Parameter Mean (SD)	Group 1 (n=20)	Group 2 (n=25)
Stress Score	62 ± 0.71	58 ± 0.80
Headaches/migraine	3.55±0.51	3.24±0.77
Aches and pains	2.89±1.10	3.24±0.77
High blood pressure	3.4±0.59	3.12±0.66
Poor sleep patterns	3.2±0.76	3.36±0.81
Skin Rashes	2.5±1.05	2.8±1.04
Indigestion	2.4±0.68	2.9±0.81
Stomach ulcers	0.55±0.94	0.6±0.86
Asthma	1.1±1.25	0.88±1.20
Anxiety	2.65±0.81	2.88±0.88
Heart disease	1.85±1.039	3.22±1.22
Changes in appetite	2.85±0.81	3.08±0.75
Exhaustion	2.95±0.82	3.28±0.67
Inability to concentrate	3.15±0.93	3.32±0.69
Erratic moods	2.9±0.91	3.2±0.76
Low self esteem/confidence	2.7±0.86	3.44±0.65
Irritated	3.4±0.75	3.09±0.76
Angry	3.05±0.88	3.36±0.75
Frustrated	3.1±0.78	3.26±0.93
Helpless	3±0.97	3.36±0.73
Anxious	2.55±0.75	3.24±0.72
Depressed	3.2±0.83	3.32±0.80

Data represented as Mean and SD. Statistical analysis was performed using student T test. No statistical significance was found within the groups.

B. Effect of Rudraksha on Cognitive Performance and EEG waveforms

Outcomes of neuropsychological tests conducted using CNS Vital Sign analyzer were illustrated in Table 3. Physical wearing of Rudraksha for 6 months showed significant improvement in almost all neurocognitive parameters except from psychomotor and processing speed as well as simple and complex attention both when compared with placebo or baseline data. Similarly, Table 4 demonstrates the effect of Rudraksha over amplitude and frequency of EEG waveforms. Physical wearing of Rudraksha showed significant increase and decrease in signal strength of α and β waveforms respectively with concomitant increase in frequency of these waveforms when compared with placebo or baseline values ($P<0.01$, $P<0.05$).

Table 3: Neurocognitive Performance on Physical wearing of Rudraksha.

Parameter Mean (SD)	Group 1 (n=20)		Group 2 (n=25)	
Cognitive Parameters	Before	After	Before	After
Neurocognition index	23.95±3.64	24.65±3.52	24.36±15.30	28.8*±5.57$
Composite memory	18.80±5.50	21.4±4.09	16.5±7.68	29.28±6.38*/$
Verbal memory	17.5±5.21	21.1±3.07	18.92±5.38	28.16±3.69*/$
Visual memory	14.7±4.09	20.6±3.67	16.72±6.1	27.44*±5.80$
Psychomotor speed	15.45±4.54	17.95±4.87	15.52±4.36	14.92±5.92
Reaction time	16.35±5.46	17.92±5.46	15.24±.69	25.96*±7.64$
Complex attention	16.4±5.22	17.25±5.47	16.76±5.26	17.36±5.62
Cognitive flexibility	15.45±4.68	19.99 ±3.87	15.52±4.84	28.36*±6.57$
Processing speed	15.2±5.18	15.7±5.72	14.8±5.54	16.66±7.16
Executive function	15.05±3.66	16±4.51	14.88±4.61	25.6±5.32*/$
Simple Attention	15.05±4.95	14.8±4.52	15.4±4.56	17±4.19
Motor Speed	16.7±4.69	17.0±3.91	17±4.85	18.76±6.75

Data represented as Mean and SD. Statistical analysis was performed using unpaired Student's t test. *$P<0.05$ for before and after intervention whereas $^{\$}P<0.05$ for placebo vs intervention groups.

Table 4: Alteration in EEG waveform (amplitude and frequency) on Physical wearing of Rudraksha.

Parameter Mean (SD)	Group 1 (n=20)		Group 2 (n=25)	
	Before	After	Before	After
δ amp.	116.76±35.34	113.29±33.46	112.52±29.17	100.07±7.08
Θ amp.	56.23±25.54	63.90±25.19	53.84±24.04	65.57±4.35
α amp.	56.91±13.16	54.88±11.52	50.16±10.60	91.66*±5.31$
B amp	18.59±4.06	17.44±4.69	17.02±4.33	8.45*±1.24$
FFT δ	0.195±0.15	0.20±0.14	0.11±0.14	3.34*±0.51$
FFT Θ	4.11±0.66	4.09±0.60	4.01±0.54	3.61±0.79
FFT α	6.03±0.78	5.80±0.86	5.91±0.75	8.47*±1.06$
FFT β	40.21±3.24	40.73±3.10	41.35±2.32	33.94*±4.24$

Data represented as Mean and SD. Statistical analysis was performed using unpaired Student's t test. *$P<0.05$ and $^{\$}P<0.05$ for before vs after and placebo vs intervention respectively.

C. Correlation

Further, in correlation studies increase in visual memory on physical wearing of 4M Rudraksha is positively correlated with α waveform ($r = 0.578809$, $p = 0.002435$) and enhanced execution function was negatively associated with β frequency ($r = – 0.5681$, $p = 0.003051$).

IV. DISCUSSION

The present study investigated the efficacy of 4M Rudraksha beads on amelioration of stress induced cognitive dysfunction in working females. Physical wearing of Rudraksha rosary significantly improved executive function, cognitive flexibility, reaction time, visual memory, verbal memory, composite memory, and overall neuropsychological performance, as indicated by neurocognition index. These variables accounted for the working memory status which is dependent on prefrontal cortex (PFC), hippocampus and subcortical regions including hypothalamus, amygdala, and brainstem nuclei [15-16]. Several studies reported the chronic stress induced disruption of PFC through hyperactivation of hypothalamic-pituitary-adrenal (HPA) axis which in turn disturbs the hormone and neurotransmitter release milieu specifically catecholamines in the PFC resulting in cognitive impairment [17-19]. Further, dopaminergic DA-D1 receptor, and noradrenergic alpha-1 and alpha-2 receptors play crucial role in these pathways and are directly involved in working memory impairment [20-21]. Over activation of D1 receptors stimulate hyperpolarization-activated/cyclic nucleotide-gated (HCN) ion channels resulting in non-selective permeability of Na+ and K+ out of the cell which otherwise would not have been allowed [22]. It is hypothesized that physical wearing of 4M Rudraksha might have influenced the neuronal cell membrane potential and consequent disturbed neurotransmission by virtue of its electromagnetic property. In our recent study, we have scientifically documented for the first time, the weak ferromagnetic characteristics of 4M Rudraksha attributed to the presence of 23 mineral elements with different magnetic properties [23]. Further, another preliminary study from our group demonstrated the presence of inductive, capacitive, resistive, and reactance capacity of Rudraksha bead [24]. Together, both studies provide strong scientific evidences about the presence electromagnetic properties of Rudraksha as mentioned in traditional system of medicine. Due to its electromagnetic property, it is possible that Rudraksha bead might have created a magneto-magnetic and electro-electrical coupling interface after receiving stimulus from body's magnetic and electrical field, thereby generating magnetic flux. Further, this magnetic flux subsequently interacted with the electric field of cell membrane after entering in the human body and tissues resulting in the induction of secondary current which apparently played crucial role in the restoration of neuronal hyperpolarization/ depolarization status and therefore catecholaminergic neurotransmission in PFC [25-26]. The proposed restorative mechanism is supported by previous studies where researchers demonstrated the significant changes in neurotransmission as well as synchronization of neuronal circuits after exposure with extremely low frequency magnetic field and weak electrical field respectively, similar to Rudraksha beads in the present study [27-29]. In-addition, modulation of the electrical conductivity of entire body including nervous system can also be attributed to the enhanced electrical conductivity of blood due to the Rudraksha induced magnetization of ferrous ions of haemoglobin [30-31].

Alterations in the electrical activity of brain on physical wearing of 4M Rudraksha was confirmed in EEG results where significant changes in α and β waveforms were noticed when compared both with placebo as well as baseline data. Stress conditions were reported to produce decreased alpha waves power and increased beta wave power and the present study results are in corroboration with these findings [32-34]. In general, while alpha waves are associated with a calm, open, and balanced psychological state, beta waves reflect concentration, thought, and listening. Several studies reported desynchronization of alpha waves followed by replacement with beta waves during cognitive impairment [35-36]. In our study, significant correlation was obtained between increase in visual memory and execution function and alterations in α waveform and β frequency respectively on physical wearing of Rudraksha suggesting improved cognitive functioning due to synchronization and restoration of stress induced disrupted electrical activity in brain.

The present study specifically worked on female gender as stress accumulation tends to be higher on them due to social and cultural obligations. Further, several animal studies reported that female rats were more sensitive towards stress induced cognitive dysfunction which in turn is driven by estrogen status. These studies observed maximum stress sensitivity and poor working memory performance during proestrous stage due to exacerbated glucocorticoid release, blockade of extraneuronal catecholamine transporters, and elevated extracellular dopamine concentration in PFC, therefore disrupting D1 and alpha-2a noradrenergic receptors balance [37-41].

The major study limitations were absence of non-stressed females as healthy control, less sample size, lack of use of standard electromagnetic therapy, and restricted study inclusion criteria due to involvement of moderately stressed females only because of limited resources and participant's availability. Nevertheless, the present study outcomes provide adequate scientific evidences about the beneficial effect of 4M Rudraksha in amelioration of stress induced cognitive dysfunction.

V. CONCLUSION

To conclude, Rudraksha bead may serve as a safe, easy accessible, user friendly, eco-friendly, cost-effective and holistic strategy to curb stress induced cognitive impairment. Large randomized clinical trials with ample sample size and inclusion of both gender as well as other stress levels are warranted to further elucidate its nootropic mechanism of action in mental health disorders as reported in traditional system of system.

Conflict of interest. None.

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