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Meditation Research: A Comprehensive Review

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ABSTRACT
Research on Meditation has already gained immense prominence and is the most favored subfield of heart and brain research. However, like the other intricate, complex medicinal interventions, meditation symbolizes a concoction of explicit and not so explicit components of therapy. On the other hand, meditation is rather distinctive that it is quite tricky to homogenize measure and validate for the given research data from the subjects. As a consequence, it is a lot demanding to distinguish its exact effects to please the technical routine of fundamental interferences that inspires therapy based on facts. There are lots of challenges involved in mediation research including the diversity in meditation techniques, issues concerning the implementation of a meditation technique, personal disparities across the Meditators, and identifying the difference between these meditation techniques and placebo effect. Researchers are recording the activities of brain, heart and other biological systems to study the impact of the various kinds of mediation on the psychological and physiological status of the human entity and arriving at various constructive conclusions for the benefit of the human kind. In this paper, a comprehensive review on meditation, various types of meditation, meditation data acquisition by researchers, the methodology, and applications of meditation research is presented for the welfare of the human entity.
Keywords **–** Data acquisition, Meditation, Meditation therapy, Meditation research, Meditation techniques

I. INTRODUCTION

Meditation has proved to be an essential tool that assists in reducing stress to a great extent [1]. A lot of research has already been done into mediation all across the world and modern, sophisticated equipments are employed in recording the electrical activities of the brain and heart of novice, moderate and expert Meditators to help identifying the consequences of meditation. There are lots of other kinds of stress reduction techniques being practiced in diverse parts of the world but not all these techniques are equally and consistently effective. [1]. A lot of constructive changes have been reported to happen in the brain and the other parts of the human body for those practicing meditation. Practicing meditation is no hassling task that helps bringing in structural and functional modifications in the human organs including the heart and brain with recurrent practice over a prolonged period. Meditation is practiced all across the world and diverse countries have given different names for the meditation that they practice. A case study has revealed a considerable, constructive behavioral modification of the human entity that practice meditation, thereby reducing the number of visits to the physicians by a great extent and the individual concerned is found to save $200 on the clinician's visit with effective practicing of meditation [2]. Also, another study has concluded the reduced use of medical care by Meditators in comparison to those who don't practice meditation [3]. Mindfulness based meditation programs are secular in nature and a lot of people from across the world practice mindfulness based meditation for its plentiful benefits [4]. There are diverse kinds of meditation techniques that vary in complexity including stringent, synchronized practices to common suggestions. On regular practice, meditation is believed to assist build up consistent, insensible behaviors of micro dimensions that can possibly create distinguished constructive effects on physiological and psychological performance of the human entity. People practicing meditation for just a few minutes, twice a day have shown beneficial effects. Meditation involves a complicated form of relaxation called the parasympathetic response wherein meditation techniques and other kinds of relaxation procedures assist reducing the activities of the sympathetic component of the Autonomous Nervous System and promoting the activities of the parasympathetic component by reducing the release of stress hormones like cortisol. The process slows down the rate of heart and increases the blood flow to the viscera. There are a lot of other cardio and neurophysiologic effects involved with practicing meditation however these are yet to be proved. The majority of meditation techniques to be had in the present time are not dependably providing the fundamental experience of psychological silence and for this reason these meditation techniques are called as quasi-meditation techniques. These quasi-meditation techniques will include techniques like consistent reiteration of mantras and other syllables, visualizations, or other kinds. These quasi-meditation techniques assist relaxation process by lessening stress and promoting attention. On the other hand, clinical tests have shown only a little disparity between the quasi meditation techniques and usual physical rest. Of the available lot

of meditation techniques, there are three notable techniques to be practiced including the Transcendental Meditation (TM), Mindfulness Meditation and Sahaja yoga meditation (SYM). Of the three, the TM is the usual kind of mantra mediation that is intended to put off disturbing thoughts by chanting mantra.

Meditators practicing TM are instructed to be submissive and, are instructed to chant the mantra more vigorously on getting any disturbing thoughts. TM can be practiced for a minimum of 15 minutes twice a day, morning and evening. A human entity practicing TM is found to have a controlled blood pressure and reduced blood cortisol levels, thereby alleviating stress to the fullest [5]. There are also a few adverse reports portraying the infrequent, unfavorable psychological [6] and physiological effects [7] of practicing TM.

Mindfulness Meditation is another kind of meditation that serves as the building block for other meditation techniques including the Vipassana meditation. Mindfulness Meditation techniques are intended to make use of focused attention by employing a physical breath sensation to promote mental serenity. A Meditator practicing mindfulness meditation on a regular basis can impartially observe thoughts and as a result improve self understanding. Mindfulness Meditation techniques are extremely effectual in alleviating chronic pain [8]. Vipassana is a special kind of Mindfulness Meditation and unpleasant events linked with Vipassana have been explored even though it is indistinct as to which meditation form these studies rely on [9].

There are also other kinds of meditation like the SYM that is wholly intended to support the practice of 'thoughtless awareness'. This meditation technique is suited for the human population as a whole with no restriction based on age and race and taking research into count, the SYM is extremely simple to study and analyze [10]. The meditation technique can be practiced for 15 minutes twice a day and no adverse effects are found with the SYM technique. Apart from these techniques, there are other meditation techniques available including the Buddhist meditation techniques like Zen Meditation that include a comprehensive selection of meditation techniques, aimed to increase concentration, attention, insight, harmony, and super normal powers [11].

Apart from these meditation techniques, the Christians practice a form of meditation called the Christian meditation in which a prearranged attempt is made to stay connected with the almighty [12].

II. METHODOLOGY

Opher Caspi et al. [13] suggested that the entire study on mediation techniques can be classified into two models, namely the efficacy-effectiveness and the explanatory model. The work was focused on arriving at optimal design solutions including the qualitative-quantitative methods and practical clinical trials that can be applied on any form of meditation research. The work also suggests studying the individual differences across the Meditators of varying meditation practices.

There are lots of literature available studying the effects of meditation on the human subjects. Peng et al. [14] analyzed the beat to beat heart rate and respiratory signals of 10 expert Meditators at times of segmented breathing, relaxation response and breath of fire. Gerhard Litscher et al. [15] carried out research on the heart rate variability changes to Tai Chi and Jogging and he performed continuous monitoring of Electrocardiogram (ECG) on two healthy subjects, during the resting periods before and after an active sports session. The experiment was carried out during the practice of jogging and Tai Chi and the Heart Rate Variability (HRV) parameters were studied. Damodar Prasad Goswami et al. [16] analyzed the heart rate variability signal at the time of meditation using a concept called the second order difference plot. The objective was to identify the presence of any kind of similarity between the physiological parameters under meditation and non-meditation conditions. The experiment Comprised of four diverse groups of Meditators practicing different kinds of meditation and also the data has been collected from Physionet for validation.

Hoshiyama et al. [17] studied the hemodynamic events happening in a human entity practicing Zen meditation. Five numbers of expert and novice Meditators were taken for experimental analysis and the study was conducted for four sets of Zen Meditations with a session length of twenty five minutes, at a practice hall. Dirk Cysarz et al. [18] conducted experiments on identifying the synchronization of cardiac and respiratory activities during Zen Meditation practice. Diverse exercises like mental task, Zen meditation and spontaneous breathing was been asked to be performed by novice Meditators of nine numbers and the ECG and respiratory signals are spontaneously recorded.

Leonaite. A. Vainoras [19] performed analysis of the effects of HRV changes due to Progressive Muscle Relaxation (PMR) and Mindfulness Based Stress Reduction (MBSM) relaxation techniques and about twenty five hospitalized subjects of the male gender were made to participate in the sessions practicing PMR and MBSM. Atefeh Goshvarpour et al. [20] analyzed during meditation, the lagged Poincare plots in the ECG signals and identified the impact of diverse lags on the Poincare plots width in the ECG signals during the time of mediation. The work made use of the ECG signals from the Physionet database and six different Poincare plots lags were constructed and the width for each lag was computed. Kang – Ming Chang et al. [21] investigated the effect of leg crossing during meditation and employed Pulse Transit Time (PTT) as the recorded data. Fourteen subjects took part in the analysis and the half lotus leg cross posture and free

leg stretch posture are analyzed. Masaki Hoshiyama et al. [22] studied the value of repeatability in heart rate for people practicing Zen meditation. The experimental analysis was performed on five numbers of Zen experts and novice Meditators and around eight sets of Zen meditations were conducted in a practice hall for each session lasting to about twenty five minutes. The power spectral analysis was then conducted to identify the disparity in the heart rate value for Zen Meditators of expert and novice levels.

Giuseppe Pagnoni et al. [23] studied the effects of age on the volume of gray matter and performance of attention during the time of Zen meditation. The study was conducted on thirteen regular Zen Meditators and equivalently matched control groups to identify the disparity in the usual age related decrease in gray matter volume and attention. Srinivasa et al. [24] conducted a study on the HRV at times of breathing deep for normal and hypertensive patients. Around eighty eight normotensive and seventy seven hypertensive patients were selected for the experimental trial and the subjects were asked to respire six times deep for every minute. The ECG for lead II is recorded and heart rate changes were simultaneously calculated.

Ramesh Manocha et al. [25] studied the physiological changes associated with the practice of SYM. An observation was made under controlled laboratory conditions on the changes in skin temperature between the mediators and non-Meditators. A temperature controlled room was utilized for recordings and the palmar skin temperature and heart rate is computed. Gloria Y. Yeh et al. [26] studied the effects of Tai Chi therapy on the functioning of human body for patients with acute and chronic heart complexities. The experiment analyzed the effect of a tai Chi program practiced by the people for duration of twelve weeks and the improvement in the heart functioning of the people practicing Tai Chi. Thirty Chronic Heart Failure (CHF) patients were made to participate in the study and the changes in the quality of life is studied. Maura Paul et al. [27] studied the randomized controlled trials effects of TM of metabolic syndrome in CHF patients. A placebo-controlled trial for sixteen weeks of TM with perfect time and frequency matching was conducted with 103 subjects with Coronary Heart Disease (CHD). Blood Pressure (BP), lipo-protein level, insulin resistance and HRV parameters are measured.

Shr-Da Wu et al. [28] studied the effect of inward attention meditation on the parasympathetic activity of a human entity. The HRV was calculated during the Zen Meditation and TM sessions and these sessions emphasized slow breathing. Inward attention is a significant issue for Zen Meditators that helps entering into the transcendental conscious state. Antonino Raffone et al. [29] studied the neural correlation of mindfulness and concentration with functional Magnetic Resonance Imaging (fMRI) recordings for neuro-imaging techniques have been proven to exhibit significant changes in the neural correlates of diverse states of meditation. This fMRI study was made on the neural correlates of mindfulness based and concentration based meditation techniques on expert Buddhist Meditators. Dilwar Hussain et al. [30] studied the current status and future prospects of the psychology of meditation and provided a wide-embracing view of the current state of meditation research. The work has reviews principal findings concerned with meditation and its impact on diverse kinds of human functional disorders. The paper discusses on the significance of concentrative and mindfulness based meditation techniques and its beneficial effects. Kachouri et al. [31] analyzed the HRV signals during two different kinds of meditation using wavelet transform. The wavelet transforms helped extracting the physiological rhythms and studying the Autonomous Nervous System of subjects practicing Tai Chi and Yoga. Braboszcz et al. [32] studied the meditation and neuroscience from the basic research level to that of clinical practice. The chapter reviews the constructive effects of meditation of physiological, psychological, attention and affective stages and the technical terms employed to identify these changes. The chapter also presents a clinical application for regulation of emotions.

Paul Grossman et al. [33] studied the health benefits of MBSR techniques. A meta- analysis was done on twenty reports that met the standard of acceptable quality and significance to be included into the study. Yvonne Greene [34] performed a comparison of mindfulness based meditation techniques and self observation and employed twenty four college students with expertise in meditation or self observation process for the study. Sudheesh et al. [35] investigated the impact of music and meditation on the Galvanic Skin Response (GSR). Music and meditation was given as a stimuli making use of GSR to calculate the subject's emotional response. Nikitas Papasimakis et al. [36] investigated the breakdown of long Range correlations at times of fluctuation of the heart rate during a meditation session. The work employed average wavelet coefficient method to study the scaling features of HRV during a meditation session. Frederick Travis [37] studied the Electroencephalogram (EEG) patterns during a TM session and compared the EEG and autonomic patterns at times of transcending during a TM session.

Pradhan et al. [38] analyzed the dimensional complexity of the electrical activity of the human brain during a yogic meditation session. The study worked on four channels of EEG during the pre and post meditative periods. Renu Madhavi et al. [39] analyzed and characterized the HRV data of diverse sets of meditation subjects using approximate entropy and this non-linear method of HRV analysis helped analyzing the cardiac health by non-invasive means. Meditators, depressed subjects, healthy subjects and

congestive heart failure subjects were taken for analysis and the effect of Autonomous Nervous System on the functioning of the human heart is investigated. Satyajit R. Jayasinghe [40] reviewed the effect of Yoga in the cardiac health of the human entity. The efficiency of yoga in the prevention of Ischemic Heart Disease (IHD) is studied and a reliable rehabilitation procedure is discussed. The article studies the constructive effects of yoga and its impact on cardiac health. Ruth E. Taylor-Piliae [41] studied employing Tai Chi as an addition to exercise training during cardiac rehabilitation. The article suggests promising benefits from practicing Tai Chi as an appendage to cardiac rehabilitation exercise programs.

III. RESULTS AND DISCUSSIONS

The meditation techniques in existence have proven to provide constructive benefits to the human kind in many aspects. In the work carried out by Peng et al. [14] on the heart rate dynamics during three meditation kinds, the heart rate and the respiratory dynamics were found to be extremely identical during the processes of segmented breathing and relaxation response. Also, the author witnessed elevated amplitude and reduced frequency oscillations of the order of 0.05 to 0.1 Hz owing to Respiratory Sinus Arrhythmia (RSA) at the time of segmented breathing and relaxation response. Coherence was found to increase significantly between the breathing and hear rate cycles in comparison to the baseline value.

Gerhard Litscher et al. [15] identified a significant variation in the HRV response to Tai Chi and Jogging. The Poincare plots of beat to beat variability showed ellipses of diverse shape and magnitude and Tai Chi and jogging were found to give a clear picture of the HRV monitoring even under the most complex circumstances. Experiments carried out by Damodar Prasad Goswami et al. [16] on the HRV signal analysis during meditation using a second order difference plot revealed a different shape for different clusters and the study revealed prominent changes in the HRV of subjects at the time of meditation. The tool was mentioned to be of immense use in clinical settings and management of stress.

Hoshiyama et al. [17] on his analysis of HRV linked with Zen Meditation by experts revealed that the power spectral analysis showed a prominent change in the frequency components and the Low Frequency (LF) and High Frequency (HF) components were found to increase for expert Meditators. The Detrended Fluctuation analysis (DFA) of HRV was found to be around 0.5 for experts and 0.78 for novices. This decrease in DFA value in experts is attributed to the efficient regulation of mind and thoughts during the process of meditation. Dirk Cysarz et al. [18] performed analysis on the synchronization of the cardiac and respiratory activities during Zen Meditation technique and found that the low breathing frequencies paved the way to decrease the HF component of HRV however the LF and the extent of RSA was found to increase. A high degree of cardio respiratory synchronization was observed even in beginners that suggested that there is no need for prior expertise in meditation that demand for physiological implications. Leonaite. A. Vainoras [19] found significant changes induced by the PMR and MBSM techniques on the HRV parameters. The MBSR program was found to be highly effective in treating patients with stress disorders. The analysis of lagged Poincare plots during meditation by Atefeh Goshvarpour et al. [20] revealed that the width of the Poincare plot increased with lag during meditation The ease of calculation of the width of Poincare plot and its adaptation to the disordered nature of the physiological signals was found to be extremely helpful in analyzing the heart rate signals at the time of meditation.

Research on the leg crossing postures effect on the PTT conducted by Kang – Ming Chang et al. [21] revealed that the PTT is found to vary depending on the distance between the heart and the limbs and the leg crossing postures that delay the rate of flow of blood. Masaki Hoshiyama et al. [22] demonstrated a decrease in the Very Low Frequency (VLF) component of the HRV for expert Zen Meditators in his research on the analysis of repeatability value in heart rate during Zen Meditation. This decrease in the VLF components of HRV was attributed to the least distracted meditation from the experienced Meditators and a subsequent increase in the repeatability value that permits successful, persistent regulation of mind of body.

Research on effect of age on the gray matter volume and attentional performance in Zen Meditators conducted by Giuseppe Pagnoni et al. [23] revealed an anticipated negative correlation of gray matter volume and attentional performance with age in controlled subjects while the Zen Meditators were not found to exhibit any noteworthy correlation of these measures with age. The research revealed the fact that recurrent practice of meditation offers neuro-protective benefits and lessens the behavioral decline linked with the aging procedure. Srinivasa et al. [24] identified no prominent changes in the HRV between men and women during his study on the changes in HRV parameters at the time of deep breathing in normotensive and hypertensive classes.

A notable finding was demonstrated by Ramesh Manocha et al. [25] in their research on the skin temperature changes associated with meditation in comparison to the rest and the study revealed a prominent change in the heart rate and palmar skin temperature in the Sahaja Yoga Meditators in comparison to those at normal rest condition. Gloria et al. [26] demonstrated the positive effects of TM on CHD patients that helped perking up the BP and insulin resistance components of the metabolic syndrome. The cardiac Autonomous Nervous System tone was significantly improved in comparison to the controlled subjects for those undergoing a TM session for sixteen weeks that enables effective stress

management in CHD patients. Research on the inward attention meditation by Shr-Da

Wu et al. [28] demonstrated common and different effects of HRV equally between the states of normal and inward attention meditation. Antonino Raffone et al. [29] performed fMRI study on the Buddhist monks and revealed selective activation and deactivation patterns linked to the Buddhist meditation that revealed further the participation of left fronto-parietal areas in meditation techniques based on mindfulness. Dilwar Hussain et al. [30] demonstrated a positive effect of meditation on the human physiological parameters including heart beat, improved cortical activity, and reduced BP, increased metabolic rate, sufficient respiration, improved perception and cognition. Research on HRV by Kachouri et al. [31] revealed a prominent change in the HRV parameters during the two meditation techniques.

Health benefits on MBSR programs was researched by Paul Grossman et al. [33] that revealed the efficacy of MBSR in coping with clinical and non-clinical complexities. Studies conducted on comparing the effectiveness of mindfulness based meditation techniques and cognitive self-observation techniques by Yvonne Greene [34] showed considerable, reliable increase in many dimensions of self-actualization and a noteworthy decrease in stress-related complexities. Changes in the GSR due to music and meditation as investigated by Sudheesh et al. [35] showed a prominent change in the GSR value that was used as a measure of subjective mental states at the time of hearing to music and meditation. Investigating into the breakdown of long range correlations in heart rate fluctuations at the time of meditation, Nikitas Papasimakis et al. [36] found that the correlations induced due to meditation were considerably weaker at longer scales of time. Entropy analysis of these correlations revealed a prominent change in the physiological mechanisms. Analyzing the effects of transcending from other experiences at the time of TM, Frederick Travis [37] identified lower breath rates and higher RSA amplitudes, together with high alpha amplitude and coherence. Also, at the time of transcending, the skin conductance response was found to be high.

Pradhan et al. [38] analyzed the dimensional complexity of the electrical activity of the brain during meditation and identified a significant increase in the average fractal dimensional value at the time of meditation. Studies conducted by RenuMadhavi et al. [39] on the analysis of HRV using Approximate Entropy (ApEn) for different sets of meditation data revealed constructive changes in the ApEn values that signified betterment of the cardiac health after the meditation procedure. The values of ApEn were found to be lower in subjects under depression in comparison to the healthy entities. The reduced value of ApEn demonstrated reduced heart dynamism and autonomic dysfunction. These results were extremely helpful in analyzing and identifying a CHF data from a set of records.

IV. CONCLUSION

Meditation is supposed to be a particular procedure that is concerned with the awakening of inborn, fostering "kundalini" energy and this awakening sources it to climb from its position and penetrate through each of the chakras [42], settling to a state of equilibrium and alignment. This internal silence turns out to be a source of personal peace that counteracts the complexities of day to day existence, improving creativity, efficiency and self-assurance. Yoga and Meditation was used in a combined way and directed at the accomplishment of an inimitable state of impulsive, psychosomatic integration [43]. A vast amount of research on meditation has occurred in the past few decades with mixed results [44]. However, the arrival of TM in the 1960's paved the way for the researchers and scientists to learn an unvarying technique. A lot of attractive and motivating results were obtained in comprehensive studies on meditation techniques on the other hand, issue with the method and understanding of data have been identified [45]. There are other meditation techniques offering results often notable but lacking consistency. Regardless of the wonderful advances in contemporary medicine we are yet to build up truly successful strategies to contract with the common public health complexities that source the majority of the mortality and morbidity among the human kind [46].

The effectiveness of meditation techniques for stress management has been demonstrated to be helpful in a lot of diseases, as it perks up the psychological and physical well being of the human entity and lifestyle understanding [47]. Meditation changes the body and mind together and research on the impact of diverse kinds of meditation is the most favored trend among the present day researchers. Working together with Meditators, researchers help understanding the concept of meditation and its impact on the physiological and psychological well-being of the human community. A lot of research needs to be done in exploring the underlying similarity among the various types of meditation and their constructive effects on the psychological and physiological changes in the human kind that paves the way for a healthy existence.

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