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Research Paper: Physiological impacts of Ajapajapa Yogic Meditation on HRV index, RMSSD, PNN50, Heart Rate and GSR following three-month training course in comparison to F.G. Meditation

Farshad Nazaraghaei [1], **K. Krishna Bhat** [2]

1.Department of Human Consciousness and Yogic Sciences, Mangalore University, Mangalore, Karnataka, India
2. Retired Professor, Department of Human Consciousness and Yogic Sciences, Mangalore University, Mangalore

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ABSTRACT

The findings of this study is based on following, comparing and contrasting certain physiological effects of two types of meditation; Ajapajapa Yogic Meditation (AYM) in combination with Anapanasati on one hand and Farshad's Geometric Meditation (FGM) on the other hand, on practitioners of these sets of meditative techniques.

To assess physiological impacts of Ajapajapa Yogic Meditation (AYM) on the treatment of psychological stress and anxiety in comparison to FGM, we initially recruited 72 St. Aloysius College students to take part in this meditation research program. Then they were randomly assigned into 3 groups including AYM, FGM and control group.Prior to and following theAYM and FGM courses, the pre and post experimental physiological data were collected using Vilistus to register Heart Rate Variability (HRV), Root Mean Square of Successive Differences (RMSSD), Proportion derived by dividing NN50 by the total number of NN (PNN50), Heart Rate and Galvanic Skin Response (GSR) signals. The total number of volunteers from whom the post experimental data were collected was 62. For each meditation group we conducted a three-month meditation program, 3 one-hour sessions per week.

In both experimental groups, statistically significant reduction in the heart rate and GSR and also increase in RMSSD, PNN50 and HRV index were seen in comparison to the control group.

Since AYM and FGM both seem to be effective methods for the reduction of psychological stress and anxiety, they could be adopted in clinical populations. Moreover, the implementation of these methods for stress management can also be suggested.

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**** Corresponding Author:***
Farshad Nazaraghaei, PhD
Address: *Department of Human Consciousness and Yogic Sciences, Mangalore University, Mangalore, Karnataka, India*
Tel: *98 7132348790*
E-mail: *farshad.meditation@gmail.com*

1. Introduction

Anapanasati is the main meditation technique in Tibetan, Zen, Theravada, Chan and Tianti traditions of Buddhism and the core aspect of various contemporary mindfulness programs (Bhikkhu, 2003). Anapanasati meditation practitioners should observethe sensations appeared in the body during inspiration and expiration. Anapanasati is the first subject matter of meditation expounded by Buddha himself in the Maha Satipathana Sutha; the great discourse on the foundations of mindfulness. Anapanasati here means awareness of breathing during which the attention is focused on the inhalation and exhalation (Mahathera & Ariyadhamma, 2013). Yet, practically speaking, once a comparison is drawn between Anapanasati as a fundamental meditative technique in many mindfulness traditions and a method such as Ajapajapa, an extra aspect of the latter makes it distinct from the former; and that is the mantra.

Japa means repeating or remembering mantra and Ajapajapa means constant awareness of the mantra which is the basis for Kriya Yoga (Bharati, 2009; Easwaran, 2009). The Japa or Soham mantra is sometimes claimed to have had its origins inIsha Upanishad (verse 16). It has also been mentioned in several Advaita Vedanta Upanishads, and Swara Yoga as well as the classical yoga treatises such as Gherand Samhita and Shiva Samhita, all of which teachin unison that the following mantras should be repeated during the inspiration and expiration, respectively: “So”and “Ham”(Mallinson, 2004; Nair, 2007). This mantra repetition feature of Ajapajapa Yogic Meditation (AYM) is what Farshad’s Geometric Meditation (FGM) lacks; however, there are other characteristics which make FGM a unique method on its own.

In a special perspective, FGM techniques disclose a unique model of relationship between the mind and the body through which a complete synchronization and overlap between the mind, the breathing, the geometric forms and the body take place. In this model,the meeting point is a specific part of the body, the vehicle is breathing, a geometric shape is the mediator of this meeting and the attention element is the driver (Farshad, 2014). The specific sort of attention manipulation which starts with narrowing the scope of attention within a limited area and follows by the expansion of attention scope towards the wider domain is called meditation which leads to the modulation of awareness, experience of altered states of consciousness, formation of inner peace and mental silence (Farshad, 2017). In geometric meditation, the attention is organized along various directions and takes up different geometric forms including lines, surfaces, and solid figures, in complete overlap with varied parts of the body, and is fully synchronized with inhalation or exhalation, finally, geometric somatic breathing based meditation techniques in FGM lead to the pointed or compressive attention stage (Farshad, 2014; Farshad & K. Krishna, 2017).

Some studies have revealed multifaceted mysteries of physiological characteristics of different meditation techniques. One study shows specific changes in the heart rate variability and EEG signals and also the same manifested physiological features in four groups of subjects during four different meditation techniques (Goswami et al., 2011). In a study a hypothetical physiological homeostatic response measured which disclosed that simultaneous function of the heart and breathing in the form of cardiac and respiratory rates during meditation may cause an increased homeostatic and harmonic response in the cellular membrane potentials of neurons and other cells throughout the body (Jerath, Barnes, Crawford, 2014). One research indicates that regular focused attention meditation practice may enhance the emotional stability through the observation and analysis of physiological responses (Lee et al., 2015). Electrophysiological alteration in response to meditation were seen in a study, demonstrated that increased heart coherence and the simultaneous alpha activations or heart-brain synchronicity may lead to retrieve the physiological synchrony following a period subsequent to the homeostatic depletion (Kim, Kang, Lee, Kim, & Whang, 2013). In a PhD thesis, in the University of California, the effects of four-week yogic breath meditation have been examined revealing that yogic breathing based meditation might help to prevent the decline in adaptive coping behaviors and in acting with

awareness (Voege, 2014). A review of literature regarding neuro-psycho-physiological impacts of AYM concludes that despite numerous studies which have been conducted to disclose multidimensional impacts of meditation, neurological, psychological and physiological influences of various yogic meditation techniques including AYM are still unknown (Nazaraghaei & Bhat, 2017). In a pilot validation study, in the department of neuroscience of Shiraz University of Medical Sciences, the neurophysiological impacts of FGM have been measured; the study shows encouraging results (Nazaraghaie, Torkamani, Kiani & Nami, 2017).

2. Method

Hypotheses of the current study

We have hypothesized that AYM as well as FGM are effective methods for the treatment of psychological stress and anxiety but there are 3 different null hypotheses as well as 3 hypotheses for each parameter in this study. The first null hypothesis indicates that all population means among AYM, FGM and the control group in the pre-experimental session are the same. It denotes that the data set in each parameter is homogeneous therefore our first hypothesis specifies that all population means among the three groups are not the same. The second null hypothesis points out that all population means among the three aforementioned groups in the post-experimental session are the same so our second hypothesis indicates that all population means among the three groups in the post-experimental session are not the same. The third null hypothesis for each parameter in this study is related to the difference between the mean values for the pre-experimental and the post-experimental session in each single group which signifies that the difference between paired observations is zero. But our third hypothesis declares that the difference between paired observations is not zero.

Procedure

To assess "neuro-psycho-physiological impacts of AYM in combination with Anapanasati on the treatment of psychological stress and anxiety in comparison to FGM by using Vilistus" in the current study, we initially recruited 72 of St. Aloysius College students through an announcement. Then they were randomly assigned into 3 groups including AYM, FGM, and the control group. The total number of volunteers from which the post-experimental data were collected was 62; 20 in AYM, 21 in FGM and 21 in the control group, with the mean age of 18.8 years old (between 17 to 20), all right handed, with no prior meditation experience and no major health problems. For each meditation group, we conducted a three-month meditation program, 3 one-hour sessions per week, on every alternate day, 8 to 9 am. Volunteers were also encouraged for daily meditation practice at home for at least 30 minutes. Subjects in the control group didn't participate in the meditation classes or any other mind-body interventional courses during the period of the study. Prior to the commencement of the meditation program and after the course, all the subjects attended the data collection session. Various neuro-psycho-physiological data were collected using Vilistus (DSU, 4 channels, UK) to register EEG, HRV index, RMSSD, PNN50 and GSR signals. Peripheral Oxygen Saturation (SpO2) was measured using Jumper Pulse Oximeter (JPD-500A); and finally, two psychological questionnaires were filled out by the subjects: Beck Anxiety Inventory (BAI) and Perceived Stress Scale (PSS). These two questionnaires were used to assess the level of psychological stress and anxiety in the subjects of the study. Prior to and following the meditation course, the pre and post-experimental EEG data (2 channels, F3-A1, F4-A2 montage) according to the international 10/20 system were collected from all the subjects. During the procedure of the pre and post-EEG data collection, participants were asked to count down from 200 to zero when their eyes were open (EO session) for the time period of 7 minutes and 30 seconds then they were asked to close their eyes (EC session) and take a simple rest for the same period of time while in both states they were sitting on the chair. After the collection of EEG, HRV and GSR signals by Vilistus (DSU-UK), specialized Vilistus Pro software, version 4.10.6 was employed for signal processing and the conversion of signals from its original form to quantitative statistical parameters as mean, standard deviation, variance and etc for each subject. The psychological question-

naires, BAI and PSS, were also scored according to the standard manual. After the conversion of all EEG, HRV and GSR signals, SpO2, BAI and PSS to a quantitative form and numerical data for all 62 participants and drawing the mean values, removing the outliers, adjusting the missed values and normalizing the data, SPSS (version.20.0) was used for the analysis of neuro-psycho-physiological parameters and hypothesis testing.

3. Result

Heart Rate

Considering the results of data analysis of the heart rate during the pre-experimental session, our first null hypothesis is accepted through the one-way ANOVA test which reveals no statistically significant difference for the mean values of the heart rate among the three groups. So, it seems that the mean values of the heart rate among the three groups are homogeneous in the pre-experimental session whereas during the post-experimental session our second null hypothesis is rejected; therefore, the second hypothesis is accepted because of the existence statistically significant difference which shows heterogeneity among the three groups (Table 1). Using the Tukey's HSD test which depicts statistically significant difference between the AYM and the control group as well the FGM group and the control group, the third and fourth null hypothesis are both rejected. Meanwhile, the same test confirms the fifth null hypothesis since there is no statistically significant difference between the AYM and the FGM groups (Table 2). The sixth and seventh null hypotheses are rejected using student's paired t test which discloses statistically significant difference between the pre and post-experimental mean values for boththe AYM and the FGM groups; so,the sixth and seventh hypotheses are accepted. In the control group,the eighth null hypothesis is accepted since there is no statistically significant difference (Table 3).

RMSSD

Considering the results of data analysis of RMSSD during the pre-experimental session, our first null hypothesis is rejected through the one-way ANOVA test which points out statistically significant difference for the mean values of RMSSD among the three groups. Thus, it seems that the mean values of RMSSD among the three groups are heterogeneous in the pre-experimental session whereas during the post-experimental ses-

Table 1. HR, RMSSD, HRV, PNN50, GSR before and after the experiment

variable	group	N	Before			After		
			mean	SD	p.value	mean	SD	p.value
HR	Yogic Meditation	20	83.90	8.48	0.085	75.67	5.06	0.025*
	FG Meditation	21	85.45	8.57		77.23	7.40	
	Control Group	21	82.09	10.94		80.73	5.12	
RMSSD	Yogic Meditation	20	40.45	12.04	0.015*	62.46	20.94	0.123
	FG Meditation	21	40.48	15.47		49.87	17.69	
	Control Group	21	54.67	23.03		59.38	21.92	
HRV	Yogic Meditation	20	9.62	2.44	0.010*	12.82	4.50	0.228
	FG Meditation	21	9.13	2.28		11.67	3.28	
	Control Group	21	11.45	2.76		10.84	3.02	
PNN50	Yogic Meditation	20	18.12	14.29	0.003*	36.65	20.99	0.184
	FG Meditation	21	14.86	12.37		24.98	15.54	
	Control Group	21	32.00	20.73		31.65	23.05	
GSR	Yogic Meditation	20	153.95	96.70	0.751	96.80	60.42	0.123
	FG Meditation	21	176.36	103.78		121.52	93.64	
	Control Group	21	160.14	93.37		155.04	107.77	

*Significant Difference

sion, our second null hypothesis is accepted; so, the second hypothesis is rejected due to existence of no statistically significant difference indicating homogeneity among the three groups (Table 1). Using Tukey's HSD test for the analysis of the pre-experimental data which shows statistically significant difference between the AYM group and the control group as well as the FGM group and the control group, we reject the third and fourth null hypotheses. On the other hand, thefifth null hypothesis is confirmed through the comparison of the difference between the AYM and the FGM group which displays no statistically significant difference (Table 2). The sixthand seventh null hypotheses are rejected using student's paired t test which proves the existence of statistically significant difference between the pre and post-experimental mean values in the AYM and the FGM group; so, the sixth and seventh hypotheses are accepted. In the control group,the eighth null hypothesis is confirmed due to the existence of no statistically significant difference (Table 3).

HRV index

Considering the results of data analysis of HRV index during the pre-experimental session, our first null hypothesis is rejected using one-way ANOVA test which indicates statistically significant difference for the mean values of HRV index among the three groups. So, it seems that the mean values of HRV index among the three groups are heterogeneous in the pre-experimental session whereas during the post-experimental session our second null hypothesis is accepted; therefore, the second hypothesis is rejected since there is no statistically significant difference demonstrating homogeneity among the three groups (Table 1). Using Tukey's HSD test for the pre-experimental data analysis which discloses no statistically significant difference between the AYM group and the control group as well as the FGM group and the AYM group, the third and fifth null hypotheses are confirmed. Meanwhile, the fourth null hypothesis is rejected through the comparison of the difference between the FGM and the control group which shows statistically significant difference (Table 2). The sixthand seventh null hypotheses are rejected using student's paired t test which indicates statistically significant difference between the pre and post-experimental mean values in the AYM and the FGM group; so the sixth and seventh hypoth-

Table 2. Tukey's HSD-Multiple Comparison

variable	Group (I)	index	FG Meditation (J)	Control Group (J)
HR (After)	Yogic Meditation	Mean difference (I-J)	-1.56	-5.06
		p.value	0.88	0.006 *
	FG Meditation	Mean difference (I-J)	-	-3.50
		p.value	-	0.009 *
RMSSD (before)	Yogic Meditation	Mean difference (I-J)	-0.28	-14.21
		p.value	1.00	0.032 *
	FG Meditation	Mean difference (I-J)	-	-14.18
		p.value	-	0.030 *
HRV (before)	Yogic Meditation	Mean difference (I-J)	0.48	-1.83
		p.value	0.80	0.059
	FG Meditation	Mean difference (I-J)	-	-2.31
		p.value	-	0.011 *
PNN50 (before)	Yogic Meditation	Mean difference (I-J)	3.26	-13.87
		p.value	0.79	0.022 *
	FG Meditation	Mean difference (I-J)	-	-17.13
		p.value	-	0.003 *

* Significant difference

Table 3. Difference between pre and post experiment (HR, RMSSD, HRV, PNN50, GSR)

Group	Mean Difference (before-after)	Paired differences		t	P.value
		Mean difference	SD		
Yogic Meditation		8.22	11.49	3.20	0.005*
FG Meditation	HR (before – after)	8.21	10.51	3.57	0.002*
Control group		-0.64	14.56	1.36	0.078
Yogic Meditation		-22.00	18.01	-5.46	0.001*
FG Meditation	RMSSD (before – after)	-9.39	19.33	-2.22	0.038*
Control group		-4.71	29.47	-0.73	0.472
Yogic Meditation		-3.19	4.57	-3.12	0.006*
FG Meditation	HRV (before – after)	-2.53	2.80	-4.15	0.001*
Control group		0.612	3.79	0.73	0.468
Yogic Meditation		-18.52	21.32	-3.88	0.001*
FG Meditation	PNN50 (before – after)	-10.12	12.45	-3.72	0.001*
Control group		0.345	26.60	0.05	0.953
Yogic Meditation		57.15	78.68	3.24	0.004*
FG Meditation	GSR (before – after)	54.84	117.13	2.14	0.044*
Control group		5.09	99.40	0.23	0.817

* Significant difference

eses are accepted. In the control group,the eighth null hypothesis is confirmed due to the existence of no statistically significant difference (Table 3).

PNN50

Considering the results of data analysis of PNN50 during the pre-experimental session, our first null hypothesis is rejected through the one-way ANOVA test which demonstrates statistically significant difference for the mean values of PNN50 among the three groups. So, it seems that the mean values of PNN50 among the three groups are heterogeneous in the pre-experimental session whereas during the post-experimental session, our second null hypothesis is accepted; therefore, the second hypothesis is rejected since there is no statistically significant difference indicating homogeneity among the three groups (Table 1). Using Tukey's HSD test which reveals statistically significant difference between the AYM group and the control group as well as the FGM group and the control group, we reject the third and fourth null hypotheses. Meanwhile, the fifth null hypothesis is accepted through the comparison of the difference between the AYM and FGM group which shows the existence of no statistically significant difference (Table 2). The sixth and seventh null hypotheses are rejected using student's paired t test which depicts statistically significant difference between the pre and post-experimental mean values in the AYM and FGM groups. So, the sixth and seventh hypotheses are accepted. In the control group, the eighth null hypothesis is confirmed due to the existence of no statistically significant difference (Table 3).

GSR (conductance)

Considering the results of data analysis of GSR during the pre-experimental session, our first and second null hypotheses are accepted using the one-way ANOVA test which displays no statistically significant difference for the mean values of GSR among the three groups. So, it seems that the mean values of GSR among the three groups are homogeneous during the pre and post-experimental sessions; therefore, our first and second hypotheses are rejected (Table 1). Since, there is no statistically significant difference exhibiting homogeneity among the three groups, further application of Tukey's HSD test is not required. The sixthand seventh null hypotheses are rejected using student's paired t test which reveals sta-

tistically significant difference between the pre and post-experimental mean values in the AYM and FGM groups. Thus, the sixth and seventh hypotheses are confirmed. In the control group, the eighth null hypothesis is accepted due to the existence of no statistically significant difference (Table 3).

4. Discussion

Before turning to the discussion of the results of this study, it seems necessary to highlight the following point. Since, both comprehensive and comparative researches investigating alterations in the physiological parameters such as those included in the current paper are rare, the findings of this study can be considered as a preliminary step in detailed analysis of the effects of AYM and FGM on physiological parameters involved in this particular field of research. Therefore, further scientific inquiry into the above-mentioned area of research is suggested by the author of the present paper.

Conclusion of the Heart Rate results during the pre and post-experimental sessions

ANOVA application depicts that the mean values of the heart rate are homogeneous during the pre-experimental session but heterogeneous during the post-experimental session. Statistical analysis through student's paired t test proves that bothAYM and FGM methods have statistically significant impact on the reduction of the heart rate in this study. The finding of this study is in line with the findings of earlier major studies (Jerath et al., 2014; Nazaraghaie et al., 2017).

Conclusion of RMSSD results during the pre and post-experimental sessions

ANOVA test indicates that the mean values of RMSSD are heterogeneous during the pre-experimental session but homogeneous during the post-experimental session. Statistical analysis through student's paired t test discloses that both AYM and FGM methods have statistically significant impact on the increment of RMSSD in this study. The finding of this study is in agreement with the finding of an earlier study (Kim et al., 2013).

Conclusion of HRV index results during the pre and post-experimental sessions

ANOVA application demonstrates that the mean values of HRV index are heterogeneous during the pre-experimental session but homogeneous during the post-experimental session. Statistical analysis through student's paired t test displays that both AYM and FGM methods have statistically significant impact on the increment of HRV index in this study. The finding of the current study matches the findings of some earlier studies (Jerath et al., 2014; Kim et al., 2013; Voege, 2014).

Conclusion of PNN50 results during the pre and post-experimental sessions

ANOVA test exhibits that the mean values of PNN50 are heterogeneous during the pre-experimental session but homogeneous during the post-experimental session. Statistical analysis through student's paired t test reveals that both AYM and FGM methods have statistically significant impact on the increment of PNN50 in this study. The finding of the current study appears similar to the finding of an earlier study but it is a less researched parameter in meditation field (Nazaraghaie et al., 2017).

Conclusion of GSR during the pre and post-experimental sessions

ANOVA application confirms that the mean values of GSR are homogeneous during the pre-experimental and post-experimental sessions. Statistical analysis through student's paired t test discloses that both AYM and FGM methods have statistically significant impact on the reduction of GSR in this study. The finding of the current study corresponds to the findings of earlier major studies (Kim et al., 2013; Nazaraghaie et al., 2017).

Ethical Considerations

Compliance with ethical guidelines

All procedures in this study involving human participants were in accordance with the institutional research committee and with the 1964 Hel-

sinki Declaration.

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Authors contributions

Farshad Nazaraghaei, research scholar of the Department of Human Consciousness and Yogic Sciences, Mangalore University, as the corresponding author of the paper.
Prof. K. Krishna Bhat, retired Professor of the Department of Human Consciousness and Yogic Sciences, Mangalore University, as the research guide.

Conflict of interest

The authors have no conflict of interest to declare.

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Informed Consent

Informed consent was obtained from all participants in the present study.

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