CHANGES IN HEART RATE VARIABILITY FOLLOWING YOGIC VISUAL CONCENTRATION (*Trāṭaka*)

A dissertation submitted by

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CONTENTS

CHAPTER 1

INTRODUCTION

Yoga is an ancient Indian science and way of life. Sage *Patānjali* (circa 900 B.C) explains the theoretical aspects *yoga* in 196 aphorisms called yoga *sutrās* (Taimini, 1999). *Patānjali* evolved *Aṣṭāanga yoga* (eight limbed *yoga*) to reach the ultimate reality. Later around 10th Century CE Sage Svatmārāma wrote a text called *Haṭha Yoga Pradīpikā* which explains the method and benefit of *yoga* techniques. He prescribes six cleansing techniques (*kriyās*) viz., *dauti, basti, neti, trātaka, nauli* and *kapālabhāti* to purify the body. The goal of *Haṭha Yoga* is to prepare the body and mind for the practice of Rājayoga *or Aṣṭānga* Yoga (Muktibodhananda, 1993).

The literal meaning of the Sanskrit word *trāṭaka* is "to gaze steadily". Looking intently with an unwavering gaze at a small point until tears are shed is known as *trāṭaka (Haṭha Yoga Pradīpikā*, Ch:2.31). *Haṭha Yoga Pradīpikā* mentions that, practice of *trāṭaka* eradicates all the eye diseases, fatigue and lethargy (*Haṭha* Yoga *Pradīpikā*, Ch: 2.32). Though *trāṭaka* is considered as cleansing technique, the final stage of *trāṭaka* leads to meditative mental state (Nagaratha & Nagendra, 2000).

Recently, a study has been conducted to assess the immediate effect of *trāṭaka* on critical flicker fusion (Mallick & Kulkarni, 2010). The critical flicker fusion (CFF) is defined as the frequency at which a flickering stimulus is perceived to be continuous. There was a significant increase in CFF following *trāṭaka* suggesting changes at the cortical level in the processes that mediate fusion.

Meditation and autonomic changes are researched extensively and shown shift towards vagal tone during meditation (Orme-Johnson, 1973; Telles et al., 2013; Wallace, 1970). However, there was no study evaluating autonomic changes during *trāṭaka* which is similar to meditation. Hence, in the present study, we used heart rate variability (HRV) which is a well-known and extensively used method to evaluate autonomic modulation.

CHAPTER 2

DESCRIPTIONS OF *TRĀTAKA* IN YOGIC TEXTS AND INDIAN SPIRITUAL LORE

2.1 INTRODUCTION

Ancient Indian *yoga* text, *Haṭha Yoga Pradīpika* described six types of cleansing techniques. These are *dauti, basti, neti, trātaka, nauli and kapālabhāti*. *Trāṭaka* is one of those and it is easy to practice. The literal meaning of the Sanskrit word *trāṭaka* is "to gaze steadily". Looking intently with an unwavering gaze at a small point until tears are shed is known as *trāṭaka* (*Haṭha* Yoga *Pradīpika*, Ch:2, V:31). It consists of a steady gazing, without blinking the eyes, at any small object at one meter distance e.g., the flame of a candle or oil lamp, Though *trāṭaka* is very simple, it is very powerful practice and has got many benefits. *Haṭha yoga pradipika* mentions that, practice of *trāṭaka* eradicates all the eye diseases, fatigue and lethargy (*Haṭha* Yoga *Pradīpika*, Ch: 2.32).

Trāṭaka is classified in to two types i.e., *bahiranga trāṭaka* (external) and *antaranga trāṭaka* (internal). *Bahiranga trāṭaka* is performed by steadily gazing, without blinking at a small object. A candle flame is good for this practice. *Antaranga trāṭaka* is done by visualizing the symbol or image. *Antaranga trāṭaka* is difficult to practice in the beginning.

2.2 Aim and Objectives

The present literary review was conducted to compile the authentic information on *trāṭaka* from anscient yogic texts and from indian spiritual lore.

2.3 Materials and Methods

2.3. *A - Source material*

i. *Haṭha Yoga Pradīpika*

ii. *Śiva samhitā*

iii. *Haṭharatnāvali*

iv. *Gheranda samhita*

2.3*. B - Methods*

The above mentioned traditional texts were studied to compile the authentic information on *trāṭaka*. The verses related to the present topic were compiled and presented in a systematic way. The description of *trāṭaka* in various traditional *yoga* texts and Other Indian texts were collected and presented below.

2.4 Concept of *trāṭaka* according to different yoga texts

2.4.1 Trāṭaka according to Haṭha Yoga Pradīpika

Haṭha Yoga *Pradīpika* mentions six types of cleansing technique. These six cleansing techniques are *dauti, basti, neti, trāṭaka, nauli, and kapālabhāti.* It is believed that these cleansing techniques should be practiced before the practice of asana, *prāṇāyāma* and meditation.

धौतिर्बस्तिस्तथा नेतिस्त्राटकम् नौलिकं तथा।

कफालभातिश्चैतानि षट् कर्माणि प्रचक्षते॥

dhautirbastistathā netistrāṭakam naulikaṁ tathā ।
kaphālabhātiścaitāni ṣaṭ karmāṇi pracakṣate ।।

(*Haṭha Yoga Pradīpika,* Ch: 2.22)

Dhauti, basti, neti, trāṭaka, nauli and *kapalabhāti;* these are known as *ṣaṭkarma* or the six cleansing process.

निरीक्षुसंनिश्चलद्रृशा सुक्ष्मलक्ष्यं समाहितः।

अक्षुसंपातपर्यन्तमचार्यैस्त्राटकं स्मृतम् ॥

nirikṣusaṁniścaladṛśā sukṣmalakṣyaṁ smahitaḥ
akṣusaṁpātaparyantamacāryaistrāṭakaṁ smrtama ।।

(*Haṭhayoga Pradīpikā,* Ch: 2.31)

Looking intently with an unawaring gaze at small point until tears are shed is known as *trāṭaka* by the *ācharyas* (teachers).

मोचनं नेत्ररोगाणां तन्द्रादिनां कपाटकम्।

यत्नतस्त्राटकं गोप्यं यथा हाटकपेटकम् ॥

mocanaṁ netrarogāṇaṁ tandrādinaṁ kpaṭakam ।
yatnātastrāṭakaṁ gopyaṁ yathā hāṭakapeṭakamaṁ ।।

(*Haṭhayoga Pradīpikā* Ch: 2.32)

Trāṭaka eradicates all eye diseases, fatigue and sloth and closes the doorway creating these problems. It should be carefully kept secret like a golden casket.

2.4.2 *Trāṭaka according to Gheranda samhita*

Gheranda samhita is another ancient *yoga* text, which is in the form of dialogue between sage *Gheranda* and an inquirer *chanda kapāli*. Here also six cleansing techniques are explained. It explains *trāṭaka* as follows:

निमिषोन्मेषकं त्यकत्वा सुक्षमलक्ष्यं निरिक्षयेत्।

यवदश्रुन पतति त्राटकंप्रोच्यते बुधैः॥

nimiṣenmeṣakaṁ tyakatvā sukṣamalakṣyaṁ nirikṣayet ।
yavadakṣuna patati traṭakaṁ procyate budhaḥ ।।

(*Gheranda samhita* Ch: 1.53)

Gaze steadily without winking at any small object, until tears begin to flow. This is called *trāṭaka* by the wise.

एवमभ्यासवोगेन शाम्भवी जायते ध्रुवम्।

नेत्ररोगा विनश्यन्ति दिव्यदृष्टिः प्रजायते॥

evamabhyāsavogena śāmbhavī jāyate dhruvam।
netrarogā vinaśyanti divyadṛṣṭiḥ prajāyate ।।

(*Gheranda samhita* Ch: 1.54)

By practising this *yoga ṣambhavi ṣiddis* are obtained and certainly all diseases of the eye are destroyed and clairvoyance is induced.

2.4.3 *Trāṭaka According to Haṭharatnāvali*

In this Text, *Srinivasa yogi* mentioned eightfold of cleansing processes, such as *cakri nauli, dhauti, basti, gajakariṇī, trāṭakaṁ* and *mastakabhrānti* (*kapālābhāti*) were motioned as purificatory procedures of different systems of body.

चक्रिनौलिधौतिबस्तिश्च गजकरिणी॥

त्राटकं मस्तकभ्रान्तिः कर्माण्यष्टौ प्रचक्षते॥ २६॥

cakrinaulidhautibastiśca gajakariṇī ।।
trāṭakaṁ mastakabhrāntiḥ karmāṇyaṣṭau pracakṣate ।।
Haṭha ratnāvalī Ch: 1.26 ।।

the eight *karmās*, (purificatory processes) like *cakri* etc., following the tradition of our *guru*.

निरिक्ष्य निश्चलद्दृशा सुक्ष्मलक्ष्यं समाहितः॥

अक्षुसम्पातपर्यन्तमाचार्यौस्त्राटकं स्मृतम्॥५४॥

nirikṣya niścaladṛśā sukṣmalakṣyaṁ samāhitaḥ ।।
akṣusampātaparyantamācāyraustrāṭakaṁ smrutam ।।
Haṭha ratnāvalī Ch: 1.54

One should constantly gaze at a very minute object, remaining one pointed, until tears roll down. According to the adepts, this is *trāṭaka*.

स्फोतनं नेत्ररोगाणं तन्द्रादीनां कपाटकम्।

प्रयत्नात्राटकं गोप्यं यथा रत्नसुपेटकम्॥

sphotanaṁ netrarogāṇaṁ tandrādīnāṁ kapāṭakam।
prayatnātrāṭakaṁ gopyaṁ yathā ratnasupeṭakam।।

Haṭha ratnāvalī Ch: 1.55

This technique removes eye diseases drowsiness and the like. Therefore, it should be carefully guarded like a casket of jewels.

2.5 *Types of trāṭaka*

Trāṭaka is broadly classified to two types' viz. *bahirangā trāṭaka* and *antarangā trāṭaka.* In *bahirangā trāṭaka* focusing is done on an external objects like candle flame, oil lamp, sun, moon, etc. whereas internal visualization is used in antarangā *trāṭaka*. Different such forms of *trāṭaka* is mentioned below.

- ***Bindu trāṭaka:*** *Bindu* means dot. In this *trāṭaka* is done on a dot (Ramachandar, 2000).
- ***Murti trāṭaka*** – *(murti)* means idol so, when *(trāṭaka)* is done on idol it is called as (*murti*) (*trāṭaka*) (Narayana, 2000a).
- ***Vartul trāṭaka*** – Gazing on a circle is called (*vartul*) (*trāṭaka*). Size can be altered according to the practitioners comfort level (Dipavali, & Bibek, 1965).
- ***Pariga trāṭaka*** – moving the gaze along the circumference of a circle. It can be done in two ways, number one approaching in clockwise direction and number two approaching in anti clockwise direction (Dipavali, & Bibek, 1965).

- ***Valay trāṭaka*** – Moving the gaze in a spiral manner. (*valay*) (*trāṭaka*) is also done in two ways, number one approaching in clockwise direction and number two approaching in anti clockwise direction (Bambahadur, 1965).
- ***Maha trāṭaka*** – The word (*maha*) means vast. So, (*maha*) (*trāṭaka*) is practicing (*trāṭaka*) on vast objects. It helps one to acquire the ability to view entire aura around a person's head (Vasu, 1966a).
- ***Jyoti trāṭaka*** - (*jyoti*) means light. So, (*trāṭaka*) done on a flame is called as (*jyoti*) (*trāṭaka*) (Muktibodhananda, S. & Satyananda, 1988) (Gharote, M.L., Devnath, P. & Jha, 2009).
- ***Surya trāṭaka*** – when doing (*trāṭaka*) on the sun when its intensity is mild without any discomfort during the time of rising or setting is called as (*surya*) (*trāṭaka*) (Seshagiri, 2000).
- ***Candra trāṭaka*** – (*trāṭaka*) when done on moon is called as (*candra*) (*trāṭaka*) (Seshagiri, 2000).
- ***Dakśina jatru trāṭaka*** – Here, the face is forward but the gaze is at the tip of the right shoulder (Seshappa, 1999).
- ***Vāma jatru trāṭaka*** – (*trāṭaka*) is done by gazing at the tip of the left shoulder but the face is forward (Seshappa, 1999).
- ***Bhrumadhya trāṭaka*** – (*bhrumadhya*) is literally translated as midpoint between eyebrows. So, gazing at the eye brow centre is called as (*bhrumadhya*) (*trāṭaka*) (Prabhupada, 1972).

- ***Nāśikāgra trāṭaka*** – (*nāśikāgra*) means nose so, performing (*trāṭaka*) taking one"s tip of the nose as the object of *trāṭaka* is called as (*nāśikāgra*) (*trāṭaka*) (Taranatha, 1962).

2.6 Benefits of trāṭaka

मोचनं नेत्ररोआणां तन्द्रदीनां कपाटकं।

यत्नतस्त्राटकं योप्यं यथा हाटकपोतकं॥

mocanaṁ netraroāṇāṁ tandradīnāṁ kapāṭakaṁ।

yatnatastrāṭakaṁ yopyaṁ yathā hāṭakapotakaṁ।।

Haṭha Yoga *Pradīpika Ch: 2*.32

Trāṭaka Eradicates all eye diseases, fatigue and sloth and closes the doorway creating these problems. It should be carefully kept secret like a golden casket.

2.6.1 *Spiritual benefits*

- *Bhrumadhya trāṭaka* – Gazing at the eyebrow centre facilitates attainment of (*khecari*) mudra (Higher yogic practice) (Cidghananandanatha, & Harshe, 1970).
- By constant practice of *trāṭaka*, (*divya*) (*dṛṣṭi*) (clairvoyance) is developed (Narayana, 2000b).
- *Bhakti sāgara* claims that whatever idea is contemplated during the (*trāṭaka*) practice, it will be actually be fulfilled (Satyananda, 2009).
- Practitioner develops willpower as it gets invoked while controlling blinking (Vishnudevananda, 2002).

- *Trāṭaka* is an excellent preparation for meditation (Gitananda, 1988).
- *Āgnācakra* activates with the practice of (*trāṭaka*) (Gharote, 1986).
- *Trāṭaka* is a fine exercise for a wandering mind. It gives total concentration and thoughtless (Vishnudevananda, 2002).
- *Trāṭaka* helps to attain perfection in (*saṁyama*) (higher yogic state) (Omananda, 2005).
- According to School of (*kunḍalinī*) *yoga* the energy is conserved in avoiding blinking during (*trāṭaka*), this energy can be then utilised to make spiritual progress
- Doing (*trāṭaka*) decreases the (*rajaḥ*) component and thus the proportion of (*satva*) component increases (Gitananda, 1988).
- Activation of subtle sense of vision " (*prakāśabhāśa*)" (Comprehension of the language of light), along with (*pranayāma*) one can comprehend the language of sound " (*nādabhāśa*)" then one can interpret any language, even that of birds and animals (Ramachandar, 2000; Vasu, 1966b).
- Practitioner whose *prakāśabhāśa* is activated can be able to view aura around a person or object and also able to get a vision of deities (Vasu, 1966a).

2.6.2 *Psychological benefits*

- During initial practice of (*trāṭaka*), the sub-conscious and the unconscious mind gets activated and thus helps to bring back certain repressed experiences to the level of consciousness (Gore, Bhogal, & Rajapurkar, 1990).

- Intensity of the thoughts disappear in the long practice and one gets relaxation, calmness, lightness and pleasant feelings and wishes to continue (*trāṭaka*) with these feelings (Satayananda, 1981).
- *trāṭaka* gives improved sleep pattern, more balanced state of mind and emotional stability (Bernard, 1944).
- Practice of (*trāṭaka*) also improves memory(Bernard, 1944).

2.6.3 *Physical benefits*

- Trāṭaka exercises and strengthens eye muscles. (Subhash, 2000)
- *Trāṭaka* vitalises vision (Birendra, 2002).
- Practice of (*trāṭaka*) also destroys microbes through tears (Umeshi, 1998).
- Practitioner gets a soothing affect to the cranial nerves (Satyananda, 2007).

2.6.4 *Therapeutic benefits*

- *Trāṭaka* is known to correct refractive errors (Subhash, 2000).
- Beneficial in relieving nervous tension (Bhole, 1971)**.**
- People with anxiety and Insomnia benefits greatly (Omananda, 2005).
- Many of the eye disorders are due to lack of proper blood circulation. So, (*trāṭaka*) helps in improving circulation and overcoming eye disorders related to blood circulation (Subhash, 2000).
- *Trāṭaka* brings a balance in the nervous system.

Summary and conclusions

Ancient yogic text, *Haṭha* Yoga *Pradīpika* mentions six types of cleansing techniques which prepares our body for the practice of asana, pranayama and meditation. These are *dauti, basti, neti, trāṭaka*, *nauli*, and *kapālabhāti*. *Trāṭaka* is one of those six cleansing techniques which is easy to practice. The literal meaning of the sanskrith word *trāṭaka* is "to gaze steadily". Looking intently with an unwavering gaze at a small point until tears are shed is known as *trāṭaka* (*Haṭha Yoga Pradīpika*, Ch: 2.31). The sage *Svatmārāma* mentions that, practice of *trāṭaka* eradicates all eye diseases, fatigue and lethargy (*Haṭha Yoga Pradīpika*, Ch: 2.32).

Trāṭaka is broadly classified to two types viz. *bahirangā trāṭaka* and *antarangā trāṭaka*. In *bahirangā trāṭaka* focusing is done on an external objects like candle flame, oil lamp, sun, moon, etc. whereas internal visualization is used in antarangā *trāṭaka*. *Trāṭaka* has got many benefits. *trāṭaka* is very much helpful in the management of eye disorders. Regular practice of *trāṭaka* is helpful to overcome from depression, insomnia, allergy, anxiety problems.

CHAPTER 3

REVIEW OF SCIENTIFIC LITERATURE

3.1 *Research on trāṭaka*

An early study showed that, combination of focusing and defocusing through *yoga* reduces optical illusion more than focusing alone (Telles, Nagarathna, Vani, and Nagendra, 1997). The *yoga* training consisted of *trāṭaka*, meditation and yoga postures. There was a significant decrease in the degree of optical illusion perceived using Muller Lyer Lines. A study was conducted (MSc Project at S-VYASA) to assess the immediate effect of *trāṭaka* on visual perception in children and adults using Muller Lyer Lines (Jojo, 2008). There was a significant decrease in the degree of optical illusion in children where as adults showed no change.

A study was conducted to evaluate the efficacy of *trāṭaka* and eye exercises in the management of Timira (Ammetropia & Presbyopia) (Gopinathan, Dhiman & Manjusha, 2012). Group A practiced eye exercises and Group B was subjected to *trāṭaka*. After the enrolment of patients for this study, signs and symptoms were assessed both subjectively and objectively before, during, and after treatment. The study showed that subjectively there are significant results in both the groups however objectively there is not much improvement. Recently, a study has been conducted to evaluate the immediate effect of *trāṭaka* on critical flicker fusion (Mallick & Kulkarni, 2010). Thirty healthy volunteers were assessed in two types of session viz., *trāṭaka* and control session. There was a significant increase in CFF following *trāṭaka* suggesting changes at the cortical level in the processes that mediate fusion.

3.2 *Meditation and heart rate variability*

Heart rate variability (HRV) refers to the beat-to-beat alterations in heart rate. Heart rate variability (HRV) is a commonly used non-invasive technique to evaluate autonomic modulation in normal subjects as well as in patients. In general, frequency domain analysis and time domain analysis have been used to interpret the changes in the two branch of the autonomic nervous system. Studying autonomic changes during *yoga* practice is important because it is believed that *yoga* helps to gain control over involuntary functions by gaining mastery over the mind and body by awareness of internal sensations, breath regulation and directed attention. Some of the studies on heart rate variability and meditation have been presented below.

A study assessed changes in heart rate variability following cyclic meditation (which includes *yoga* postures, guided relaxation and supine rest) in 42 male volunteers (Sarang & Telles, 2006). During the *yoga* postures of CM and after CM, low frequency power and the low frequency to high frequency power ratio decreased, whereas high frequency power increased. Heart rate increased during the *yoga* postures and decreased after CM suggesting sympathetic activation during the *yoga* posture phases of CM while parasympathetic dominance after CM.

Another study evaluated heart rate variability changes during nondirective meditation in 27 healthy subjects (Nesvold et al., 2011). Results showed increase in heart rate variability in low frequency and high frequency bands during meditation compared to rest. There was also increase in RR interval during meditation.

A study was conducted to assess the changes in heart rate variability following *Yoga Nidrā* relaxation alone and *Yoga Nidrā* relaxation proceeded by *Haṭha* Yoga *Pradīpika* (Markil, Whitehurst, Jacobs, & Zoeller, 2012). Results showed increase in HF and decrease in LF following both the practice.

Recently, a study assessed autonomic changes in two meditative states viz., dhāranā and dhyāna in thirty healthy male volunteers (Telles et al., 2013). There was a significant increase in skin resistance and photo-plethysmogram amplitude whereas heart rate and breath was reduced. There was significant decrease in the low frequency (LF) power and increase in the high frequency (HF) power suggesting increased vagal tone and reduced sympathetic arousal during dhyāna. Most recently, increase in HF has been observed during vipāsanā meditation compared to baseline (Krygier et al., 2013).

CHAPTER 4

AIM AND OBJECTIVES

4.1 *Aim and objectives of the study*

- To study the immediate effect of *trāṭaka* on heart rate variability and breath rate
- To compile the description of *trāṭaka* from yogic texts and Indian spiritual lore

4.2 *Rationale for the study*

A recent study has shown increase in critical flicker fusion following *trāṭaka* suggesting changes at the cortical level in the processes that mediate fusion (Mallick & Kulkarni, 2010).

4.3 *Hypothesis of the study*

- The practice of *trāṭaka may* change heart rate variability

4.4 *Null hypothesis*

- The practice of *trāṭaka* may not change heart rate variability

CHAPTER 5

MATERIALS AND METHODS

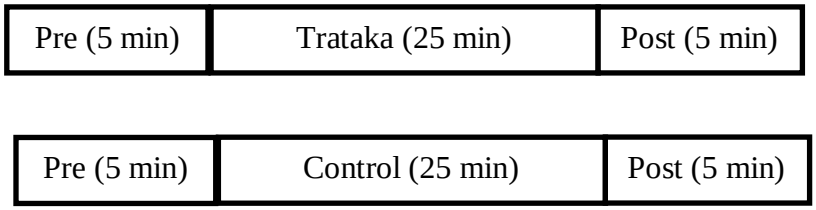
5.1 Participants

Thirty male volunteers with ages ranging from 20 to 33years (group mean age ± S.D., 23.8 ± 3.5) were recruited for the study. They were all students of a *yoga* university in Southern India. Their health status was evaluated by a routine clinical examination and case history. They had normal health and were not on any medication. The predetermined conditions to exclude participants from the trial were any chronic illness. Male volunteers alone were selected as autonomic and respiratory variables are known to vary with the phases of the menstrual cycle (Yildirir, Kabakci, Akgul, Tokgozoglu, & Oto, 2002). The project was approved by the institution's ethics committee. The study protocol was explained to the participants and their signed consent was obtained.

5.2 Design

Self as control design was used. Each participant was assessed in two sessions (*trāṭaka* and control session) on two separate days. Half the subjects practiced *trāṭaka* on first day and control session on second day. The other half was having the order of the session reversed. Duration of both the sessions was of 25 minutes. Participants were assessed before and immediately after the sessions.

Self as control design



5.3 Assessment

Electrocardiogram (ECG) and respiration were recorded using a four channel polygraph (Biopac MP 100, USA).

Heart rate variability and heart rate

The electrocardiogram (ECG) was recorded using a standard bipolar limb lead II configuration and an AC amplifier with 100 Hz high cut filter and 1.5 Hz low cut filter settings. The EKG was digitized using a 12-bit analog-to-digital converter (ADC) at a sampling rate of 1024 Hz and was analyzed off-line to obtain the heart rate variability (HRV) spectrum.

Breath rate

Respiration was be recorded using a volumetric pressure transducer fixed around the trunk about 8 cm below the lower costal margin as the participants sat erect.

Subject at recording

5.4 Intervention

Trāṭaka (a yogic visual concentration)

Fifteen days orientation program was conducted to train participants in *trāṭaka.* Theoretical aspects of *trāṭaka* were explained by a senior *yoga* teacher on the day one. The pre-recorded audio instructions for *trāṭaka* were played during the session. *trāṭaka* practice consists of two distinct stages. The first stage consisted of eye exercises, which is a preparatory practice for *trāṭaka*. The eye exercise includes eyeball movements in the horizontal, vertical, and diagonal directions and circular movements. These were performed with eyes open, in a well-lit room. This was followed by the practice of palming to relax the eyes. Palming consisted of putting slightly cupped palms over the

eyes, so that the eyes perceive complete darkness. First stage lasted for 10 minutes. The second stage *trāṭaka*, was practiced in a dark room. Subjects were asked to fix the gaze on the flame of the candle for about 2 to 3 minutes, suppressing the urge to blink as far as possible. Then visualize the candle flame in between the eyebrows. This process was repeated for 2 - 3 rounds. Finally, subjects were asked to defocus and the practice ended with silence and then prayer. The second stage lasted for 15 minutes. The duration of the whole practice was 25 minutes.

Control session

During control session participants were asked to practice the first stage (eye exercise) for 10 minutes and then for next 15 minutes they sat quietly with closed eyes without doing any concentration or meditation.

5.5 Data extraction

Heart rate variability

Frequency domain analysis of heart rate variability (HRV) was carried out. The energy in the HRV spectrum in the following specific frequency bands was studied. The low frequency (0.04 – 0.15 Hz) and high frequency band (0.15 – 0.4 Hz). According to guidelines, low frequency and high frequency band values will be expressed as normalized units.(Heart rate variability. Standards of measurement, physiological interpretation, 1996)

Herat rate

The heart rate in beats per minute (bpm) was calculated by counting the R waves of the QRS complex in the EKG in 60-second epochs, continuously.

Breath Rate

The breath rate in cycles per minute (cpm) was calculated by counting the breath cycles in 60-second epochs, continuously.

5.6 Data analysis

Statistical analysis was done using SPSS (Version 19.0). Since the same individuals were assessed in repeat sessions on separate days (i.e., *trāṭaka* and *control*), repeated measures analysis of variance was used (ANOVA). Repeated measures analysis of variance (ANOVA) was performed with two 'within subjects' factors, i.e., Factor 1: Sessions; *trāṭaka a*and *control* and Factor 2: States; "Pre", and "Post". This was followed by a *post-hoc* analyses with Bonferroni adjustment comparing 'Post with 'Pre values.

CHAPTER 6

RESULTS

The group mean values and standard deviation for frequency domain measures of HRV, heart rate and breath rate are given in **Table 1** and changes have presented in **Graph 1 to 4**.

Repeated measures analysis of variance (ANOVA)

Repeated measures ANOVA were conducted where subjects were measured before and after *trāṭaka a* as well as *control* session.

There was a significant difference between the States for (i) LFF(1, 29) = 7.58, $P<0.01$; (ii) HF F(1, 29) = 7.60, $P<0.01$; (iii) Hear rate F(1, 29) = 13.08, $P<0.01$; (iv) Breath rate F(1, 29) = 20.52, $P<0.001$. There was a significant difference between the Sessions for (i) Heart rate F(1, 29) = 6.75, $P<0.05$; and (ii) Breath rate F(1, 29) = 9.38, $P<0.01$. There was also a significant interaction between Session and State for (i) Breath rate F (1, 29) = 14.14, $P<0.001$.

***Post hoc* analyses with Bonferroni adjustment**

There was a significant decrease in LF ($P<0.01$) and significant increase in HF ($P<0.01$) after *trāṭaka*. Breath rate ($P<0.001$) and heart rate ($P<0.01$)were significantly reduced after *trāṭaka* compared to before. Control session did not show any change.

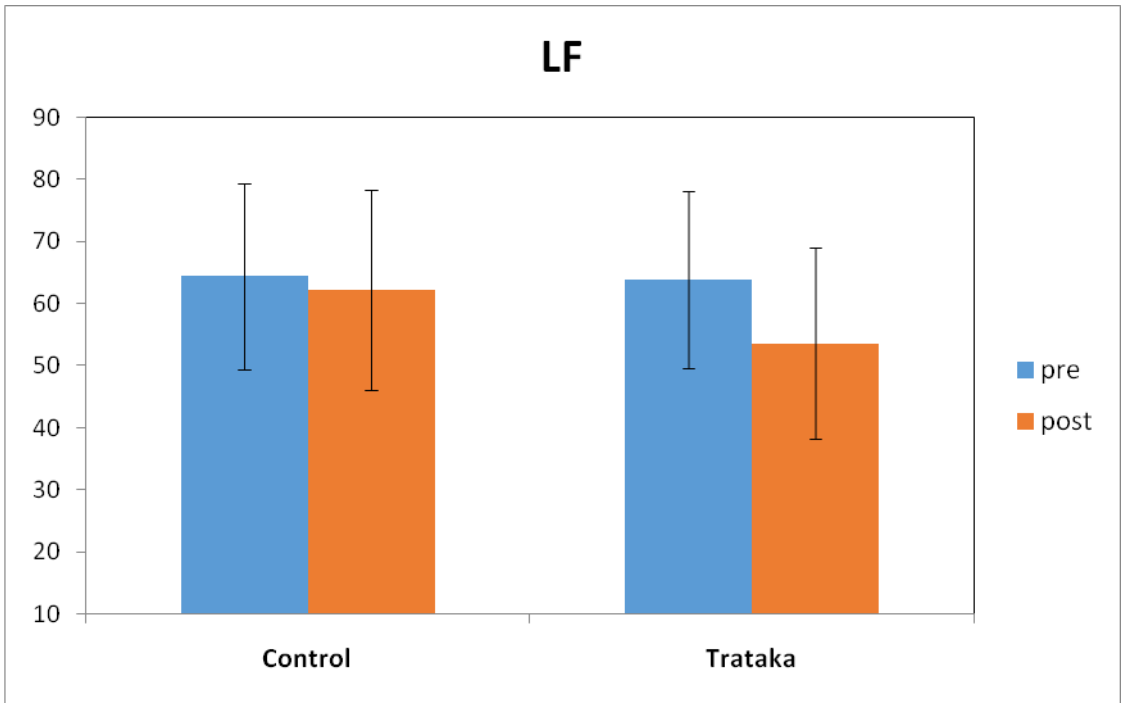
Table 1. Changes in heart rate variability and breath rate before and after *trāṭaka* and control session

Variables	**Control**		**Trāṭaka**	
	Pre	**Post**	**Pre**	**Post**
Low frequency (LF) in n.u. (Hz)	64.40±14.92	62.21±16.17	63.85±14.25	55.24±12.44**↓
High frequency (HF) in n.u. (Hz)	35.60±14.92	37.79±16.14	36.15±14.25	46.42±15.41**↑
LF/HF Ratio	2.79±2.42	2.54±2.64	2.41±1.73	2.24±1.96
Heart Rate (bpm)	72.87±6.61	70.91±8.11	71.20±8.83	67.29±5.84**↓
Breath Rate (cpm)	15.20±1.34	14.85±1.36	15.13±0.96	13.85±1.22***↓

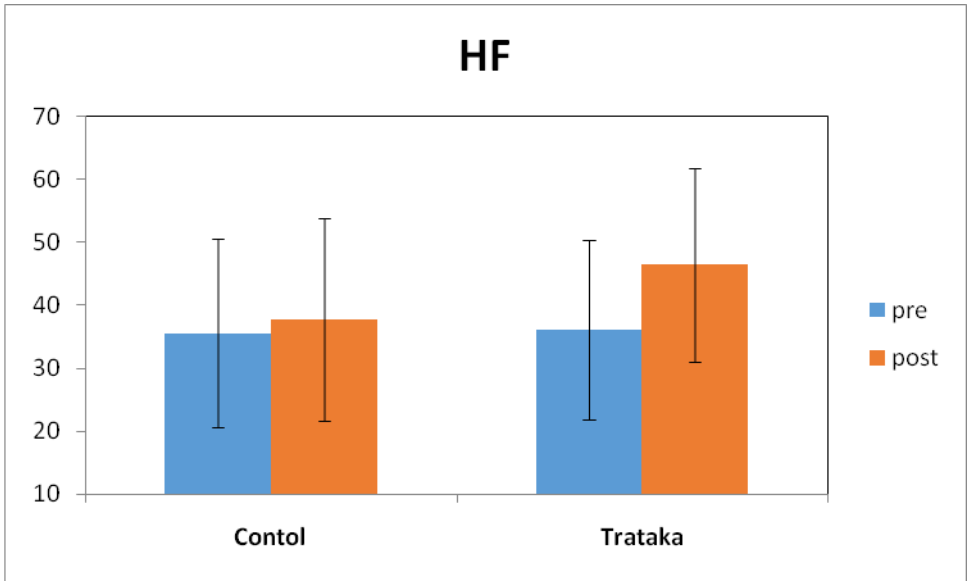
** $P<0.01$; ***$P< 0.001$; RM ANOVA with Bonferroni adjustment comparing Post values with Pre values.

↑: increase; ↓: decrease

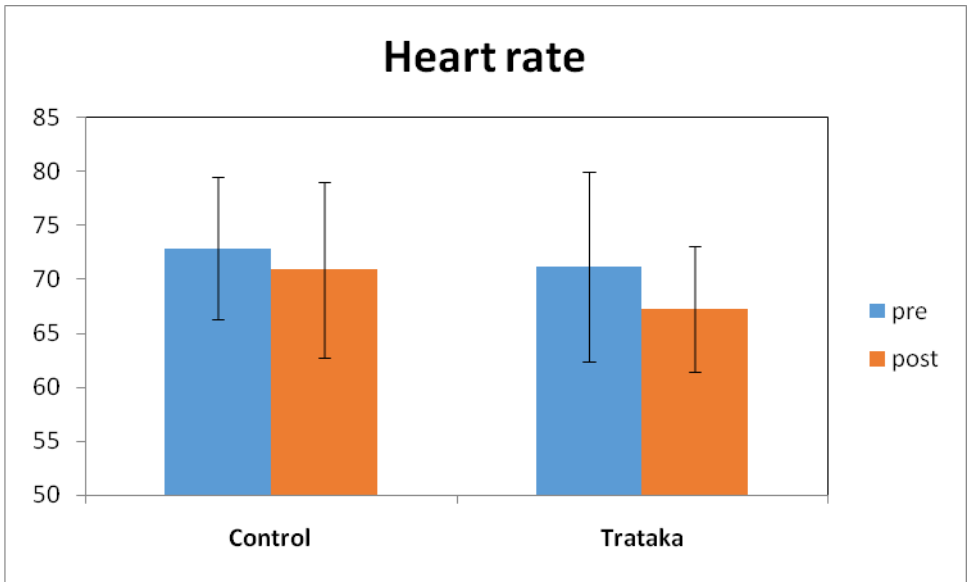
Graph 1. Changes in low frequency before and after *trāṭaka* and control session



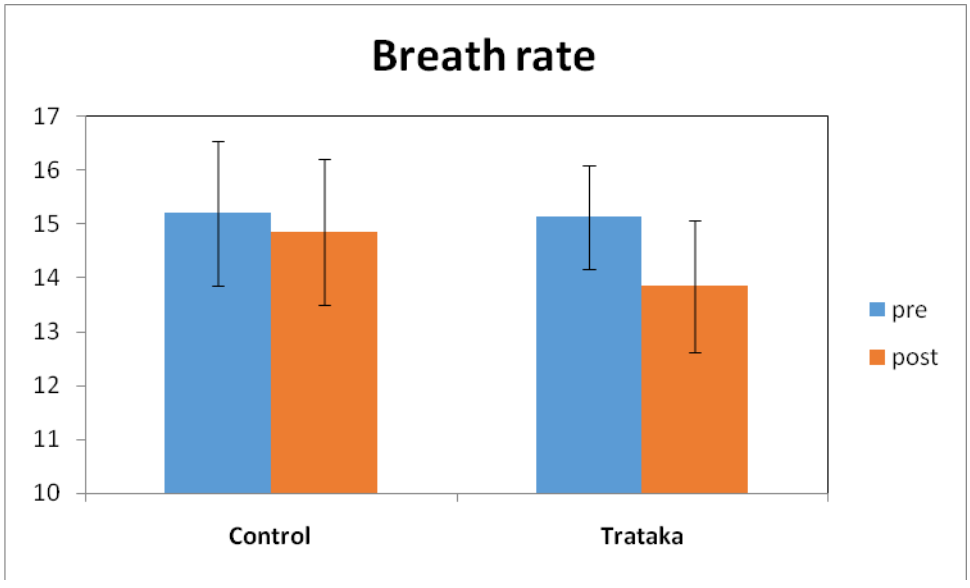
Graph 2. Changes in high frequency before and after *trāṭaka* and control session



Graph 3. Changes in heart rate before and after *trāṭaka* and control session



Graph 4. Changes in breath rate before and after *trāṭaka* and control session



CHAPTER 7

DISCUSSION

In the current study, heart rate variability and breath rate were assessed before and after the practice of *trāṭaka* and control session in thirty healthy male volunteers. There was a significant decrease in LF and increase in HF after *trāṭaka* compared to before. Breath rate and heart rate were significantly reduced after *trāṭaka* compared to before. Control session showed no change.

Heart rate variability refers to beat-to-beat alterations in the heart rate. In general two types of heart rate variability analysis are used. These are frequency domain analysis and time domain analysis. In the present study we have used only frequency domain analysis. Earlier it was believed that the low frequency (LF, 0.04-0.15Hz) band of the HRV is an index of cardiac sympathetic activity and high frequency (HF, 0.15-0.4 Hz) band is correlated with parasympathetic activity (Heart rate variability. Standards of measurement, physiological interpretation, 1996). However this has been questioned subsequently. Recent research findings says, neither the low frequency band (LF,) nor the high frequency (HF,) are considered exclusive markers of sympathetic and parasympathetic tone respectively (Lombardi & Stein, 2011). It is found that, sympathetic activity can also regulate the HF component of HRV, though to a lesser extent than the parasympathetic influence on the LF power. The association between HF power and cardiac parasympathetic activity is stronger. Hence the HRV provides broad changes in cardiac parasympathetic regulation and changes in the LF power and LF/HF ratio have to be considered carefully. The decrease in LF power and increase in HF power after *trāṭaka* suggests increased vagal modulation after *trāṭaka*.

The changes in heart rate are due to several factors. The heart rate is under the control of sympathetic and parasympathetic nerves as well as humeral factors (Andreassi, 2007). Hence it

is difficult to conclude that decrease in heart rate is only due to increased vagal tone or due to sympathetic withdrawal.

Breath rate depends upon numerous factors ranging from the level of physical activity to psychological stress (Stevenson & Riply, 1952). In general, a decrease in breath rate is correlated with relaxation. Though *trāṭaka* practice involves intense focusing, it ends with defocusing and silence. This might induce relaxation after the practice which can explain the decrease in breath rate.

The findings in current study are similar to the earlier study on autonomic changes and two meditative states described in *yoga* texts which showed reduced sympathetic arousal and increased vagal tone during *dhyāna* (Telles et al., 2013). Hence, it is speculated that the practice of *trāṭaka* leads mental state which is similar to meditation.

One of the main limitations of the study is that, assessments were not done during the practice of *trāṭaka*. Changes in HRV during *trāṭaka* might have conveyed much more information. It will be interesting to have longer duration of 'Post' session (10 or 15 min) by which we can understand how much time effect of *trāṭaka* sustains. In future, along with HRV other autonomic variables can be studied before during and after *trāṭaka*.

In summary, considering changes in HRV, heart rate and breath rate, the present results show that, practice of *trāṭaka* leads to increased vagal tone and reduced sympathetic arousal. Though *trāṭaka* is known as cleansing technique, it could induce calm state of mind which is similar to a mental state reached by the practice of meditation.

CHAPTER 8

APPRAISAL

8.1 Summary and conclusion

In the current study, heart rate variability and breath rate were assessed before and after the practice of *trāṭaka* and control session in thirty healthy male volunteers. There was a significant decrease in LF and increase in HF after *trāṭaka* compared to before. Breath rate and heart rate were significantly reduced after *trāṭaka* compared to before. Control session showed no change. In summary, considering changes in HRV, heart rate and breath rate, the present results show that, practice of *trāṭaka* leads to increased vagal tone and reduced sympathetic arousal. Though *trāṭaka* is known as cleansing technique, it could induce calm state of mind which is similar to a mental state reached by the practice of meditation.

8.2 Implication of the study

The findings of the present study substantiate the idea that, practice of *trāṭaka* increases the parasympathetic tone. Hence, *trāṭaka* may be useful to relax the mind and in the management of anxiety.

8.3 Limitations of the study

One of the main limitations of the study is that, assessments were not done during the practice of *trāṭaka*. Changes in HRV during *trāṭaka* might have conveyed much more information. It will be interesting to have longer duration of 'Post' session (10 or 15 min) by which we can understand how much time effect of *trāṭaka* sustains.

8.4 Suggestions for the future

In the present study, only HRV and breath rate has been measured before and after the practice of *trāṭaka*. In future, along with HRV other autonomic variables can be studied before during and after *trāṭaka*. And also longer duration of 'Post' session could study to understand how much time effect of *trāṭaka* sustains.

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APPENDIX-1

INFORMED CONSENT FORM

Title of the project : Immediate effect of *trāṭaka*, a yogic visual concentration on cognitive performance

Investigator : Ramamurthy V, M.Sc., Candidate

Name of the guides : Raghavendra Bhat, M.Sc., Ph.D.

The purpose of the study : To assess the changes in heart rate variability following trāṭaka.

Procedure for measurement: Electrocardiogram (ECG) and respiration will be recorded using a four channel polygraph (Biopac MP 100, USA). ECG will be recorded using a standard bipolar limb lead II configuration and an AC amplifier with 100 Hz high cut filter and 1.5 Hz low cut filter settings. The ECG will be digitized using a 12-bit analog-to-digital converter (ADC) at a sampling rate of 1024 Hz and will be analyzed off-line to obtain the heart rate variability (HRV) spectrum. Respiration will be recorded using a volumetric pressure transducer fixed around the trunk about 8 cm below the lower costal margin.

Please note: You can withdraw from the study at any point of time unconditionally.

I have understood the all above and consent voluntarily to participate in the study.

Place_____

Date_____

Signature of the Participant

Table 1.Low frequency before and after *trāṭakā* and control session