Chapter 1

Introduction

1.0 INTRODUCTION

Voluntary breath holding (VBH) is practiced commonly by the underwater divers and the physiology associated with it, is still not completely understood. The most common response of the body to VBH, is to utilize the oxygen available, optimally and therefore, various physiological changes occur, including bradycardia, reduction in stroke volume, cardiac output and peripheral vasoconstriction. The initial phase of Breath holding (BH) alters the physiology maximally, whereas the hemodynamic changes stabilize in the later part of extended BH (Costalat, Coquart, Castres, Tourny, & Lemaitre, 2013; Joulia, Lemaitre, Fontanari, Mille, & Barthelemy, 2009; Lemaître et al., 2005). This also leads to cerebral vasodilation in response to hypercapnia, generated as a result of metabolic activity (Molinari, Liboni, Grippi, & Negri, 2006). Such cerebral hemodynamic autoregulation, though, is impaired in divers, while performing maximal BH (Cross, Kavanagh, Breskovic, Johnson, & Dujic, 2014). The changes in cerebral hemodynamics are correlated to the blood gas concentrations, especially the partial pressure of carbon dioxide (CO_2) (Cross et al., 2014). It is understood by another study done on 14 healthy volunteers that the rate and rhythm of breathing, and the partial pressure of CO_2 are important factors to be considered while evaluating cerebral autoregulation. Further, it is demonstrated that, the physiological impact of BH depends on one's psychology (Laurino et al., 2012).

BH is also an essential part of the practice of *Prāṇāyāma*, a yogic technique. *Prāṇāyāmaa* is the forth limb, among the practices of *aṣṭānga yoga* (eight libed

yoga). It has been described in the as cessation of breathing, in the aphorisms of the sage *Patanjali* (Saraswati, 2002; Saraswati, 2011). The practice of *prāṇāyāma* involves modulation of breath and includes three phases viz., *pūraka* (inhalation), *recaka* (exhalation) and *kumbhaka* (retention of breath) (Muktibodhananda, 2002; Nagendra, 2007; Saraswati, 2002; Saraswati, 2011). The practice of *kumbhaka* (breath retention) is further classified into three, namely, *antarkumbhaka* (internal retention), *bāhyakumbhaka* (external retention) and *kevalakumbhaka* (automatic retention) (Muktibodhananda, 2002). *Haṭhayoga pradīpikā* of *Svātmārāma* describes eight practices of breath retention, emphasizing the impact it has on the body-mind complex. As described in *Haṭhayoga pradīpikā,* the mind moves as the breath moves and when the breath stops, the mind seizes to exist (Muktibodhananda, 2002). Patanjali describes that the mind is prepared for the practice of sustained attention (*dhāraṇā*) as an effect of *prāṇāyāma* (Saraswati, 2011). Yogic texts describe various effects of *Prāṇāyāma*, yet it remains to be substantiated fully using emperical research.

Research on *Prāṇāyāma* and particulary on Yogic breath holding (YBH) is in its stage of infancy, despite it being the very definition as per the traditional texts. In a pilot study, subjects practiced 20 minutes of anulom vilom *prāṇāyāma* with BH per day, for one week. There was increased parasympathetic activity follwing the intervention, as indicated by reduced pulse rate and increased galvanic skin

resistance (GSR), when compared to control (Turankar et al., 2013). There was no change observed in the blood pressure (BP). *Ujjayi prāṇāyāma* is a prcatice that involves sensory awareness of breathing by feeling the breath at the throat. *Ujjayi prāṇāyāma* was performed with BH at the end of inspiration, for short and prolonged durations in a study. There was significant increase in oxygen consumption reported, while performing kumbhaka for short duration, in contrast, lowering of oxygen consumption was observed with longer periods of kumbhaka (Telles & Desiraju, 1991). Malshe, in a concept paper, proposes multiple health benefits of intermittent hypoxia, such as increase in hemoglobin by increaseing erythropoietin, increase in vascular endothelaial growth factor (VEGF) leading to formation of coronary collaterals, reduction in blood pressure and reduced effects of ageing by resistance to cellular damanege (Malshe, 2011). These concepts need to be substantiated through empirical research. Though there are limited studies on the effects of YBH, the effects of *prāṇāyāma* have been explored through empirical scientific studies.

Various yogic breathing practices influence cognitive capacities in different ways. A recent 3 armed study observed that slow and fast *prāṇāyāma* improve executive functions, and reaction time, when compared with the control group (Sharma et al., 2014). Another study has shown reduction in systolic blood pressure (SBP) and diastolic blood pressure (DBP) in subjects practicing alternate nostril yoga breathing (ANB) along with improvement in Purdue pegboard scores with both hands when compared to controls (Telles et al., 2013). ANB also improved

the peak amplitude of P300 waves in an event related potential study, demonstrating positive influence on the cognitive processes for sustained attention (Telles, Singh, & Puthige, 2013). A fast breathing technique of *prāṇāyāma*, *bhastrika*, performed for 18 minutes, demonstrated reduced anticipatory errors, implying better judgment (Telles, Yadav, Gupta, & Balkrishna, 2013). Another fast breathing yoga practice, *kapālabhāti* (KPB) along with eye exercises, showed improvement in visual reaction time (Gosewade, Shende, & Kashalikar, 2013). A study on letter substitution task following KPB for different durations showed increased errors in the substitution task post practice, which might be attributed to an excited state after the practice (Pradhan, 2013). These findings are in line with the traditional explanation of improvement in cognition due to mastery on *prāṇāyāma*.

Cognitive abilities are closely related to the autonomic nervous system (ANS) activity, since stress and relaxation has an impact of cognition. In general, there is increased sympathetic drive while performing cognitive tasks, as cognitive tasks are perceived as demanding situations (Duschek, Muckenthaler, Werner, & del Paso, 2009; del Paso, Langewitz, Mulder, van Roon, & Duschek, 2013). The effects of *Prāṇāyāma* on the autonomic functions have been explored, since the nasal cycle and breath rate influence the autonomic balance.

Several studies have been conducted on various practices of *prāṇāyāma* demonstrating the influence on autonomic variables, in both healthy and diseased populations. One such study compared various methods of nostril manipulation as described in yoga texts, found that breathing through right nostril leads to

sympathetic arousal, whereas the left nostril breathing to that of parasympathetic (Bhavanani, Ramanathan, Balaji, & Pushpa, 2014). Another study on ANB revealed parasympathetic shift of the autonomic balance in the 30:15 test using heart rate variability (HRV) (Sinha, Deepak, & Gusain, 2013). As mentioned earlier, a pilot study on *Anulom vilom prāṇāyāma* with retention (*kumbhaka*) for one week, demonstrated reduced pulse rate (PR) and increased GSR, indicating shift towards parasympathetic activity (Turankar et al., 2013). Several studies have demonstrated *prāṇāyāma* to reduce blood pressure, heart & pulse rate and to influence autonomic variables in patients with hypertension (Adhana et al., 2013; Bhavanani, Madanmohan, Sanjay, & Basavaraddi, 2012; Goyal, Lata, Walia, & Narula, 2014). Bhavanani suggessted that the shift in autonomic functions towards parasympathetic is due to enhanced baroreflex activity, thereby influencing vagal tone (Bhavanani, Madanmohan, Sanjay, & Madanmohan, 2012). A study performed on uninostril breathing in 21 healthy volunteers, found that right uninostril yoga breathing increased SBP, DBP and mean arterial pressure (MBP), whereas ANB reduced SBP and DBP and left uninostril breathing reduced SBP and MBP (Raghuraj & Telles, 2008). Similar effect is observed in another independent study, demonstrating increased sypathetic activity with right nostril breathing and opposite with the left (Bhavanani et al., 2014). A study on comparing NS with Kapalabhati (high frequency yoga breathing) demonstrated increased low frequency (LF) and decreased high frequency (HF) component on heart rate varability (HRV) following, whereas NS did not show any change. This indicates increased sympathetic tone following Kapalabhati (Raghuraj, Ramakrishnan,

Nagendra, & Telles, 1998)(). A study, on *Ujjayi prāṇāyāma* performed by 17 naïve subjects, demonstrated that slow breathing with inspiratory and expiratory Ujjayi enhances brararoreflex sensitivity (Mason et al., 2013). In a study, right uninostril breathing was used as a means of functional vagotomy in cases of open and closed angle gloucoma. The intraocular pressure in patients with gloucoma reduced after practice of right nostril breathing for 20 minutes by almost 25 percent (Backon et al., 1990). Right uninostril yoga breathing was shown to significantly increase the oxygen consumption by 37%, when compared to alternate and left uninostril breathing, demonstrating the impact of manipulation of nostrils on metabolic status of an individual (Telles, Nagarathna, & Nagendra, 1996). In the same experiment, it was also observed that there was an increase in the GSR wih the left nostril breathing, implying reduction of sympethetic activity.

From these studies, it is understood that there is an influence of rate of breathing and nostril manipulation on the ANS. Slow breathing in general is associated with a parasympathetic shift, whereas there is a sympathetic drive during rapid breathing practices. The possible mechanisms postulated are, enhancement of baroreflex sensitivity, efferent connections from the repiratory inputs, etc., thereby influencing the sympathovagal balance.

This reveals the need for studies in the field of *Prāṇāyāma* and especially with use of YBH, considering the importance of the practice in the texts of yoga. YBH, being one of the most important practice in the traditional yoga literature, the lack of studies necessitate the need for further inquiry. Considering this, the current

study is proposed as an exploratory attempt to ascertain the effects of YBH on the neurocognitive functions and psychophysiology in healthy volunteers.