CHAPTER-1

Introduction

1.0 INTRODUCTION

Yoga is the science of holistic living which promotes positive health and helps in disease management as well as rehabilitation. It works at physical, mental, emotional, psycological and spiritual planes of being. The Word Yoga is derived from the Sanskrit root "*yuj*", which means 'to join' or 'to unite' (i.e. union of the individual consciousness with the universal consciousness (Saraswati, 2008). Yoga is one of the commonly used lifestyle modifications today. But, Yoga has originated in India 5000 years back as an ancient *vedic* science (Iyengar, 2002), which is being evaluated scientifically and applied in the field of health and disease (Ankad et al., 2011 & Singh et al., 2008). As a systematic discipline it consists of Purificatory techniques (*shatkarma*), Physical postures (*asanas*), Voluntarily regulated breathing practices (*pranayama),*Meditation and Relaxation techniques along with some specialized advanced practices such as yogic gestures (*mudras*), musculoskeletal locks *(bandhas),*(Saraswati, 2008).Breath is the dynamic bridge between body and mind and *Pranayama* (breathing techniques) provides various methods to maneuver the same (Muktibodhananda, 1984). The word *Pranayama* is comprised of two roots: '*prana*' and '*ayama*'. *Prana* means 'vital energy' or 'life force'. *Ayama* is defined as 'extension' or 'expansion'. Thus, the word *Pranayama* means 'extension or expansion of the dimensions of *prana*'. The practice of *Pranayama* includes three important aspects of breathing viz., 1) *Pooraka* (inhalation), 2) *Rechaka* (exhalation), 3) *sahita Kumbhaka* (voluntary breath retention) which include *Antar Kumbhaka* (internal breath retention) & *Bahir Kumbhaka* (external breath retention). An advanced stage of *Pranayama* which occurs during high states of meditation is called as *kevala Kumbhaka* (spontaneous breath retention) (Saraswati, 2008).

Different types of pranayamas produce specific physiological responses (Madanmohan et al., 2005); for example, in a study of slow pranayama, reduction in heart rate and blood pressure

were reported (Sharma et al., 2013) whereas a study on bhastrika pranayama, the bellows type rapid and deep breathing, it was reported to significantly increase the heart rate, rate pressure product and double product unlike other pranayama's (Madanmohan et al., 2005).

In a study on 2 month practice of various *Pranayama* was shown to reduce stress level; low frequency (LF) of heart rate variability (HRV) spectrum (indicative of reduction in sympathetic drive to heart); and increase in high frequency (HF) of HRV spectrum (indicative of increase in parasympathetic output to the heart) along with reduction in LF/HF ratio (indicative of a better sympatho-vagal balance) (Bhimani et al., 2011). Hence, *Pranayama* produces relaxed state and in this state parasympathetic activity overrides sympathetic activity (Goyal et al., 2015).

Regular practice of *Pranayama* was shown to produce reduction in the sympathetic tone within a period as short as 7 days (Turankaret al., 2013).Another study reported, the alteration in autonomic responses to breath holding is probably by increasing vagal tone and decreasing sympathetic discharges (Bhargava et al., 1988). In patient with hypertension (Goyal et al., 2015)and arrhythmia (Dabhade et al., 2012), addition of *Pranayama* have shown to produce better control of blood pressure (BP) (Goyal et al., 2015), and significant reduction in the indices of ventricular repolarization dispersion (Dabhade et al., 2012) respectively.In a previous study on slow *Pranayama* such as *Nadishuddhi, Mukhbhastrika, Pranav* and *Savitri Pranayams* practiced for 20 minutes daily for the duration of 3 months shown to modulate ventricular performance by increasing parasympathetic activity and decreasing sympathetic activity (Udupa et al., 2003).

Brain is one of the most highly perfused organs in the body. Because, even though brain comprises about 2% of body weight, it receives 15–20% of total cardiac output. Acute hypoxia and/or hypercapnia are known to produce marked dilation of cerebral arteries and

arterioles and increased blood flow, while hypocapnia causes constriction and decreased blood flow(Cipolla,2009).Cerebral auto-regulation is the ability to maintain CBF despite minute-to-minute variation in cerebral perfusion rate. It regulates constant CBF by lowering the resistance by inducing vasodilatation when CPP decreased and increasing the resistance by vasoconstriction when CPP increased (such as an increase in BP) (Kassab et al., 2007). The importance of auto-regulation in normal brain function is highlighted by the fact that significant brain injury occurs when auto-regulatory mechanisms are lost (Cipolla, 2009).

Hypertension is associated with pathologic changes in the brain and its vasculature including vascular remodeling (Manolioet al., 2003)such as reduction in lumen diameter and the number of vessels in the cerebral vasculature (Pires et al., 2013), cerebral microbleeds, and impaired cerebral auto-regulation (Manolio et al., 2003). Impaired auto-regulation also reported in various diseases such as symptomatic or asymptomatic carotid stenosis or occlusion (Tsivgoulis et al., 2008), ≥ 50% of MCA stenosis (along with cerebrovascular resistance) (Chen et al., 2014 & Gong XP et al., 2006), severe obstructive internal carotid artery disease (Reinhard et al., 2008), obstructive sleep apnea (OSA) (Nasr et al., 2009) etc.

Impaired cerebral auto-regulation indicates an increased risk of subsequent ischemic events such as stroke (Pires et al., 2013, Tsivgoulis et al., 2008, Chen et al., 2014, Gong et al., 2006, Reinhard et al., 2008 & Nasr et al., 2009).After a stroke and subarachnoid hemorrhage the auto-regulatory capacity was reported to partly or completely be lost (Aaslid et al., 1989).The epidemiological studies have shown a high degree of co-morbidity among vascular disease and dementias, including Alzheimer's disease, as well as migraine and epilepsy, suggested that primary vascular pathology may be an etiological factor causing neuronal dysfunction or degeneration in these diseases (Stanimirovic et al., 2012).

Deficits in CBF is related to memory (Birdsill et al., 2013), and cognitive decline (Pires et al., 2013). This effect might attribute cerebral hypoperfusion which is reported to elevate the risk

of brain white matter lesions and cognitive impairment (Tarumi et al., 2015). Cerebral tissue densities of the gray cortex (polio-araiosis) and of the white matter (leuko-araiosis) declined during aging. It reflects the neuronal degenerative changes that progress concurrently with cerebral perfusion declines (Moretti et al., 2008).Lower CBF was reported to associated with abdominal obesity (Birdsill et al., 2013), OSA (Urbano et al., 2008),and metabolic syndrome. Decreased cerebral perfusion is associated with increased number of risk factors (Birdsill et al., 2013) and cognitive disorders in patients with metabolic syndrome (Efimova et al., 2015).

Cerebral hemodynamic is one of the most important brain physiological parameters that can change due to various physiological challenges. CBF through the large vessels within the Circle of Willis can be monitored using transcranial Doppler ultrasound (TCD) (Yang et al., 2015). TCD can aptly be called as the doctor's stethoscope of the brain. It is the only diagnostic tool that can provide relatively inexpensive, non-invasive, real-time measurement of blood flow characteristics and cerebrovascular hemodynamics within the basal arteries of the brain (Bathala et al., 2013) such as middle cerebral artery (MCA) (Yang et al., 2015).

One or the other cerebral hemodynamic variables such as CBF, cerebro vascular resistance, cerebral perfusion and auto-regulation were reported to impaired in various disease such as hypertension (Manolio et al., 2003),abdominal obesity, metabolic syndrome (Birdsill et al., 2013), stroke (Aaslid et al., 1989), epilepsy, Alzheimer's disease (Stanimirovic et al., 2012), memory (Birdsill et al., 2013)and cognitive functions(Pires et al., 2013 & Tarumi et al., 2015).

Whereas, yogic practices including pranayama were reported to be effective in the management of hypertension (Tyagi et al., 2014 & Telles et al., 2013), obesity, metabolic syndrome (Schmid et al., 2014),stroke (Siu et al., 2015 & Mishra et al., 2012), epilepsy, Alzheimer's disease (Mishra et al., 2012), memory (Gothe et al., 2014) and

cognitive functions (Kyizom et al., 2010 & Sharma et al., 2014).previous studies have reported the effect of Kapalbhati, Bhastrika, (Sharma et al., 2013)and Bhramari Pranayama (Pramanik et al., 2010) on cardiovascular variables and there is only one case study has reported the cerebrovascular hemodynamics of middle cerebral artery practice of rapid yoga breathing and Kumbhaka (breath holding) (Naveen et al 1999) before and after the practice.Only very few studies have reported the cardiovascular effect (Telles et al., 2014) of particular pranayama (alternate nostril breathing) technique during the practice and none of the studies have reported the cerebrovascular hemodynamic changes during the practices.

Though Kumbhaka is the most important aspect of pranayama, it should only be practiced for as long as is comfortable and is not recommended for persons with cardiovascular diseases (CVD) and high blood pressure (BP) (Saraswati, 2008). Moreover, a précised scientific reason for not recommending it to such people is less known. It is very much essential to understand the underlying physiological mechanisms before applying them as therapeutic agents in pathological conditions. Though yogic breathing techniques such as Bhramari, Bhastrika, and Kapalbhati kriya are commonly practiced, there is a limited number of studies have shown its physiologic effects (Johnson et al, 2004).

To the best of our knowledge there are no known previous studies evaluating the impact of different pranayamas techniques and high frequency breathing- Kapalbhati (a yogic kriya) oncerebral hemodynamics though they have more intensified application. Hence this study is intended to understand cerebrovascular changes during the practices of two breath retention technique- *Antar kumbhaka & Bahir Kumbhaka*, two pranayama technique- *Bhastrika* (bellows breath) & *Bhramari* (humming bee breath) and a *yogic kriya- Kapalbhati* (frontal brain cleansing breath).