Chapter 3
Cardiorespiratory and Endocrine Mechanisms Behind the Effectiveness of Pranayama

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ABSTRACT

The benefits of pranayama for positive health are well known. Even though there are many studies published on the effectiveness of pranayama, there are very few papers that actually have systematically studied the physiological mechanisms involved, causing the benefits of pranayama, especially with respect to the cardiac function. This chapter attempts to have a detailed look at the physiology behind deep breathing. The chapter also conjectures that voluntary, deep breathing with attention may have a role to play in faster recovery from surgeries and prevent or delay the onset of Alzheimer's disease, Parkinson's disease, and maybe even cancer. Extended, carefully controlled, and detailed studies are needed to prove or disprove these conjectures.

INTRODUCTION

Indian tradition has always extolled the practice of different types of deep yogic breathing techniques, generally known as *pranayama*, for better health of a human being. Taylor et al. (2010) attempted a framework to integrate the mechanisms of the bidirectional interaction of mind and body that mediate efficacy of mind-body therapies. Telles et al. (2014) have proposed that yoga regulated breathing is a bidirectional mind-body practice. A number of studies (Pramanik et al., 2009; Dhungel et al., 2008; Russo et al., 2017) have shown reduction of heart rate and blood pressure after different types of *pranayama* practices. However, not many have looked into the physiological and neural mechanisms of how yoga breathing is intimately connected to the cardiovascular, chemoreflex and endocrine systems of the human body, thus leading to positive health, especially that of the heart. A variety of deep yoga breathing exercises are in practice, such as one involving a sound coming from a constricted throat (*ujjayi*), alter-

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nate nostril breathing (*nadi shuddhi*), forceful abdominal breathing (*kapalabhati*), cooling *pranayama* (*sheetali*), humming bee breathing (*bhramari*) and forced respiration with movement (*bhastrika*), which are performed at varying rates. In this article, the word *pranayama* is used in a very generic sense to denote a wide spectrum of many different types of deep yoga breathing practices and it needs to be emphasized that it clearly is not just one specific thing.

Fast and deep breathing is activated by the autonomic nervous system during strenuous exercises such as aerobic exercise, climbing a steep mountain or sprinting. This is because the increased muscle activity demands increased oxygen and the cells need more oxygen to burn more calories to release energy. However, interestingly, it is the brain, rather than the skeletal muscles, which consume more oxygen in general. Since many of human occupations today involve brain work, rather than physical work, it is important to delve deeper into the physiological and control mechanisms of voluntary, deep breathing and the role of the latter in ensuring efficient functioning of the brain.

This article carefully studies the respiratory physiology and the cardio-respiratory control circuits and identifies possible mechanisms behind the effect of yoga breathing in enhancing cardiac health (Ramakrishnan, 2019). In this article, deep yoga breathing refers to voluntarily taking deep breaths in a regular, systematic and near-periodic manner. It is proposed that voluntary, attentive, deep yoga breathing is a very effective cardiac exercise, while also having the potential to prevent many other ailments. While the article attempts to unravel some of the neural, physiological, chemical and hormonal connections, there may be other mechanisms playing a role in its effectiveness in assisting the overall health – including that of the brain. For example, Jerath et al. (2006) advance the hypothesis that only the stretch receptors are responsible for the effects observed.

NEURAL CONTROL AND PHYSIOLOGICAL PROCESSES BEHIND RESPIRATION

Oxygen is a Critical Nutrition for the Brain and the Body

The human body has approximately 130 trillion cells, working as a single unit, with total co-operation and understanding. Everyone starts her/his life as a single cell in their mother's womb and the rest of the cells are put together systematically over a period of time by restructuring the food one consumes and the oxygen one breathes in. Almost 99 percent of the mass of the human body is made up of six elements, namely oxygen, carbon, hydrogen, nitrogen, calcium, and phosphorus. Only about 0.85 percent is composed of another five elements: potassium, sulphur, sodium, chlorine and magnesium. Oxygen is the most abundant element contained within living organisms, constituting about 65 percent of the human body (Emsley & John, 2011). Oxygen is required by each and every cell of the body for its metabolic activity. Even though the adult brain weighs less than 2 percent of the body weight, it consumes about 20 percent of the oxygen inhaled by the human beings. This makes it clear how crucial the level of oxygen in the body is in order that the brain and the body function efficiently.

Carbon dioxide (CO_2) is the waste gas produced when carbon is combined with oxygen as part of the body's energy-making processes (metabolism) in each of the body's cells. Oxygen is supplied and CO_2 is removed from every cell by the circulation of blood. Respiration exchanges oxygen from the environment for carbon dioxide from the body's cells. Thus, respiration is fundamental to the health of human brain. Brain cells start dying, if devoid of oxygen for more than 4 minutes. This is why people lose