ABSTRACT

BACKGROUND

Prāṇāyāma is the 4th limb, among the practices of *aṣṭāngayoga*. It has been described in the as cessation of breathing, in the aphorisms of the sage *Patanjali* (Saraswati, 2011). The practice of *prāṇāyāma* involves modulation of breath and includes three phases viz., *pūraka* (inhalation), *recaka* (exhalation) and *kumbhaka* (holding of breath) (Nagendra, 2007). The practice of Breath Holding (*Kumbhaka*) is considered as an essential part of the practice of *prāṇāyāma*. Although the effects of the practice of different *prāṇāyāma* techniques have been studied, there is lack of clear understanding about the effects of *kumbhaka*.

The traditional texts of yoga emphasize on the practice of intermittent breath holding, however, such practice has sought very limited scientific attention. The proposed multiple health benefits of intermittent yogic breath holding include an increase in hemoglobin by increasing erythropoietin, increase in vascular endothelial growth factor leading to the formation of collaterals, reduction in blood pressure and resistance to cellular damage and thereby delayed ageing (Malshe, 2011). A study demonstrated reduced pulse rate and increased galvanic skin resistance, following alternate nostril breathing (ANB) with intermittent breath holding (Turankar et al., 2013). Another study demonstrated an increase in oxygen consumption while performing Ujjayi Pranayama with breath holding for a short duration. In contrast, lowered oxygen consumption was observed with prolonged breath holding (Telles & Desiraju, 1991). Since the practice of ANB and Ujjayi Pranayama are found to influence the human physiology even without

the practice of breath holding (Bhavanani, Ramanathan, Balaji, & Pushpa, 2014; Lee & Ghiya, 2012; Mason et al., 2013), the effects of intermittent breath holding remain unclear.

AIM AND OBJECTIVES

The present study is proposed to understand the immediate changes in the neuro-cognitive abilities and cardiac autonomic regulation following yogic breath holding (YBH) in healthy volunteers. The objectives of the study were to investigate the effects following the practice of YBH on i) cardiovascular responses, ii) baroreceptor sensitivity, iii) heart rate variability and iv) performance in Stop Signal Task.

METHODS

Participants

A total of seventy-six volunteers of both genders with their ages ranging from 18 to 30 years participated in the study. They were students of a Yoga University from South India. They had a minimum experience of practice of yoga of 6 months.

Design

For assessing the cardiovascular and autonomic changes, we adapted self as control design, wherein, each participant was assessed twice, during the experimental and control session. The assessments were done for the duration of 5 min before and immediately after the practice of YBH or control sessions. For the assessment of performance in Stop Signal Task, repeated measures design was adapted. Each participant was assessed thrice; at baseline, following the practice of YBH and control sessions.

Assessments

(a) Electrocardiogram (ECG) and respiration were recorded using 16-channel human physiology system (Power Lab 16/35, AD Instruments, Australia).

(b) Blood pressure (BP) was monitored using Finapres Continuous Non-Invasive Blood Pressure (NIBP) Systems (Finapres Medical Systems B.V., Netherlands).

(c) Stop Signal Task (SST) paradigm (Verbruggen et al., 2008) was presented using the Inquisit Millisecond software package 4.0 (Millisecond Software, LLC, Seattle, USA).

Intervention

The experimental session included the regulated yogic breathing for 20 minutes incorporating phases of inhalation (*puraka*), internal retention of breath (*antarkumbhaka*), exhalation (*recaka*) and external retention of breath (*bahyakumbhaka*) in a ratio of 1:1:1:1 for 6 seconds each. The period of 6 seconds was ensured through verbal cues in a pre-recorded audio track. Participants were trained in the intervention breathing for 20 min/day, 6 days/week for 8 weeks, in order to familiarize the participants with the practice of YBH, prior to the day of assessment.

During the control session, the participants were seated erect, performing regular breathing with breath awareness for the same duration of 20 min in the same test environment, including the audible cues.

Data Analysis

i) For the cardiovascular and autonomic changes

The data were analyzed using Statistical Package R version 3.2.4 (www.r-project.org). Repeated measures analyses of variance (RM-ANOVA) were performed with two Within-Subjects factors, i.e., (i) Sessions with two levels; intervention and control and (ii) States with two levels, pre, and post-intervention

ii) For the performance in Stop Signal Task:

RM‑ANOVA followed by post-hoc Bonferroni adjustment was done to compare data recorded at baseline and following YBH and control sessions. Paired samples t‑test was applied to the data while comparing the performance at the baseline to post‑YBH and post‑control sessions, respectively.

RESULTS AND DISCUSSIONS

i) Cardiovascular and autonomic changes

Enhanced heart rate variability and baroreflex sensitivity was observed following the practice of the YBH session. There was an increase in the total peripheral resistance and LF nu, which is indicative of a possible sympathetic shift in the autonomic activity. There was also reduction noted in heart rate, cardiac output and stroke volume.

ii) Performance in Stop Signal Task

The results demonstrate an enhanced response inhibition following the practice of intervention in the Stop-Signal paradigm. However, a similar effect

was observed following control session, during which the participants performed breath awareness.

CONCLUSION

Yoga breathing with intermittent breath holding leads to differential autonomic regulation, a gain in baroreflex sensitivity along with enhanced response inhibition. The results indicate the practice of intervention breathing to be safe in healthy volunteers with prior training in yoga.