The Effect of Specific Techniques of Nasal Breathing [Pranayama] on Intra-Ocular Pressure in Normal Individuals, a Randomized Trial

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Purpose: Glaucoma is an optic neuropathy where intraocular pressure is the only modifiable risk factor. Yoga is thought to adversely affect intraocular pressure (IOP) but we do not know if yogic breathing exercises can influence IOP. With this study, we aimed to determine the effect of specific nasal breathing techniques on intraocular pressure in normal individuals.

Patients and Methods: One hundred and sixty-four normal subjects were randomly assigned to one of four specific breathing groups - right nostril breathing (RNB), left nostril breathing (LNB), alternate nostril breathing (ANB), normal breathing (NB). The IOP was measured in both eyes at baseline and following the breathing exercise; and the change was analyzed.

Results: Eighty-five women and 79 men participated and there was no significant difference in baseline age or IOP between the groups. In RNB, IOP reduced significantly in both right and left eyes, from 14.3 ± 3.0mmHg to 13.9 ± 2.6mmHg, (p=0.022) and from 14.7 ± 3.2mmHg to 14.2 ± 3mmHg (p=0.016) respectively. In LNB, there was no significant IOP change in the right eye, whereas in the left eye, there was a significant reduction from 14.2 ± 2.7mmHg to 13.3 ± 2.5mmHg (p<0.0001). There was no significant IOP change in ANB and NB.

Conclusion: Specific breathing techniques like right and left nostril breathing, alternate nostril breathing are safe and do not raise IOP in normal subjects. Additionally, right and left nostril breathing techniques have a beneficial effect of lowering IOP.

Keywords: eye, glaucoma, yoga, risk-factor, breathing exercises

Introduction

Glaucoma is the second most important cause of blindness in the world. It is a condition of the eye characterized by optic neuropathy and corresponding visual field defects, where raised intraocular pressure (IOP) has been implicated as the most common risk factor. IOP is also the only variable in the pathogenesis of glaucoma, which can be controlled and/or lowered by medical or surgical treatments.

Yoga has been shown to have beneficial effects on general health. Conversely, over the years, the effect of yoga on the eye has been thought to be ambiguous. Various problems in the eye were attributed to yogic practices. A frequent question encountered during glaucoma management is whether the patient can continue practicing yoga. In recent years interest has been rekindled in yoga and the eye, especially yoga and intraocular pressure.

Various yogic breathing techniques have been shown to alter the brain hemisphere activity, and influence the autonomic nervous system. Right nostril breathing is thought to increase the sympathetic activity and left nostril breathing brings about dominance of parasympathetic activity. It is known that the autonomic nervous system has a regulatory effect on IOP by modifying the production or drainage of aqueous humor. Whether yogic breathing exercises can alter IOP, whether they are safe or whether they can be used as additional IOP lowering methods in glaucoma are...
areas that have not been studied well. Therefore, we carried out this study to determine the effect of different techniques of nasal breathing on intraocular pressure in normal individuals.

Materials and Methods
This was a prospective randomized multi-arm clinical trial conducted at a tertiary hospital from February 2020 to December 2021, which was approved by the Institutional ethical committee (IEC approval number: 595/2019). It was registered with Clinical Trials Registry - India (registration number: CTRI/2020/02/023098, registration date: 03/02/2020). The tenets of Declaration of Helsinki were adhered to and informed consent was obtained from all participants.

Inclusion and Exclusion Criteria
Participants for the study were enrolled from among the patients or their bystanders visiting the Ophthalmology outpatient department of our hospital, between ages of 18 and 80 years. Participants with the following were excluded - shallow anterior chamber, angle closure disease, participants already on antiglaucoma medications, participants who consumed one liter or more fluids in the last one hour, gross deviated nasal septum, nasal polyps, any other nasal obstruction, rhinitis, significant respiratory disorders, hypertension (on beta-blockers or any other drugs affecting the autonomic nervous system), cerebro-vascular disorders, autonomic nervous system disorders like orthostatic hypotension, postural orthostatic tachycardia syndrome.

Detailed Description of Study Process
A total of 164 normal subjects were included in the study who were allocated to their intervention groups using stratified random block randomization (Figure 1). The participants were divided into 41 blocks of four participants, each of whom were assigned to one of the intervention groups. The groups were Right nostril breathing group (RNB), Left nostril breathing group (LNB), Alternate nostril breathing group (ANB), Normal breathing group (NB). The participants were made to sit comfortably and written informed consent was obtained. Pulse and blood pressure (BP) were recorded followed by measurement of IOP by Goldmann applanation tonometer (GAT) was performed. The IOP was measured using a well-calibrated GAT ensuring that all sources of error were minimalized. The right eye IOP was measured first and then the left eye, readings were taken until three consecutive readings were within one mmHg.

The participants were then taken to a well-ventilated and well-sanitized room and asked to remove their masks and then carry out the breathing exercise for five minutes. They were then instructed to put the mask back on and immediately taken to the examination room for IOP, pulse and BP measurement. The same examiner measured the IOP before and after the exercise. As our study was conducted during the COVID-19 pandemic, all IOP measurements were done with a mask on. The enrollment of participants, randomization and assignment to intervention groups were done by a single investigator. The investigator who measured the IOP before and after the exercise was blinded to the intervention.

The primary outcome measure was intraocular pressure change following the breathing exercise. The secondary outcome measure was the effect on pulse and blood pressure.

Breathing Exercise Instructions
In the right nostril breathing group, the participants were instructed to firmly close the left nostril with index finger and breathe normally from the right nostril for five minutes. In the left nostril breathing group, the participants were asked to firmly close the right nostril with index finger and breathe normally from the left nostril for five minutes. In alternate nostril breathing group, the participants were asked to breathe in normally from the right nostril (keeping left nostril closed) and breathe out from the left, and then breathe in from the left (keeping right nostril closed) and breathe out from the right nostril. They were asked to continue this process for the next five minutes. In the normal breathing group, the participants were instructed to breathe normally through both nostrils for five minutes. In all the groups, subjects were instructed not to breathe forcefully or hold their breath during the exercise.
Statistical Analysis
A minimum sample size of 41 participants in each group was calculated for a power of 80% at 95% confidence interval to detect a difference in outcome of one mmHg. The collected data were analyzed with IBM SPSS Statistics for Windows, Version 23.0. (IBM Corp., Armonk, NY, USA). To describe the data, descriptive statistics, frequency analysis and percentage analysis were used for categorical variables; the mean with standard deviation and median with interquartile ratio (IQR) were used for continuous variables. To detect significant difference between the bivariate samples in Paired groups the Wilcoxon signed rank test was used and for multivariate analysis, the Kruskal Wallis test. With all these statistical tools the probability value less than 0.05 was considered as significant.

Results
Baseline Data
Out of the 164 participants, 85 (51.8%) were women, and 79 (48.2%) were men of mean age 45.3 ± 15.4 years. The gender and age distribution across the groups are given in Table 1. There was no significant difference in the baseline intra-ocular pressures of either the right eye or left eye across the groups (p=0.724 and p=0.877 respectively).

Right Nostril Breathing Group
In RNB group, the mean IOP in the right eye reduced significantly to 13.9 ± 2.6 mmHg from 14.3 ± 3.0 mmHg after the breathing exercise (p= 0.022). In the left eye, the mean IOP reduced to 14.2 ± 3 mmHg from 14.7 ± 3.2 mmHg, p= 0.016. Both eyes combined, there was a reduction in IOP of 0.5 ± 1.2mmHg (p=0.001 with Wilcoxon signed rank test). Out of 41 subjects in RNB, the right eye pressure either reduced or remained unchanged in 29 (71%) subjects. In the left eye, in 35 (85%) subjects the IOP either reduced or remained unchanged.
Left Nostril Breathing Group

In LNB group, there was no significant change in the right eye IOP after the breathing exercise (Table 2), where as in the left eye, there was a significant reduction from 14.2 ± 2.7 mmHg to 13.3 ± 2.5 mmHg (p< 0.0001). Both eyes combined, there was a reduction in IOP of 0.6 ± 1.4 mmHg (p< 0.0001 with Wilcoxon signed rank test). Out of 41 subjects in LNB, in 33 (80.5%) subjects the IOP in the right eye either reduced or remained unchanged. In the left eye, in 36 (88%) subjects the IOP either reduced or remained unchanged.

Alternate Nostril Breathing and Normal Breathing Groups

In ANB, there was no significant change in the IOP in either eye after the breathing exercise (Table 2). Similarly in NB, there was no significant change in IOP after five minutes of normal breathing, in either eye.

Pulse and Blood Pressure

In the LNB and NB groups, there was statistically significant reduction in the pulse rate (Table 3). There were no cases with onset of bradycardia or tachycardia following the breathing exercise, nor was there any sudden rise or drop in blood pressure. No patients complained of any discomfort during or after the breathing exercise.

Table 1 Baseline Characteristics Across the Groups

<table>
<thead>
<tr>
<th></th>
<th>RNB Group</th>
<th>LNB Group</th>
<th>ANB Group</th>
<th>NB Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Women</td>
<td>22</td>
<td>20</td>
<td>23</td>
<td>20</td>
</tr>
<tr>
<td>Men</td>
<td>19</td>
<td>21</td>
<td>18</td>
<td>21</td>
</tr>
<tr>
<td>Age (yrs)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>45.3</td>
<td>43.7</td>
<td>46.5</td>
<td>45.4</td>
</tr>
<tr>
<td>Median</td>
<td>44.0</td>
<td>44.0</td>
<td>49.0</td>
<td>48.0</td>
</tr>
<tr>
<td>Standard deviation</td>
<td>16.2</td>
<td>15.1</td>
<td>16.4</td>
<td>13.4</td>
</tr>
<tr>
<td>25th percentile</td>
<td>28.5</td>
<td>30.5</td>
<td>30.5</td>
<td>35.0</td>
</tr>
<tr>
<td>75th percentile</td>
<td>57.5</td>
<td>55.5</td>
<td>61.5</td>
<td>56.0</td>
</tr>
<tr>
<td>Right eye pre-intervention IOP (mean ± SD)</td>
<td>14.3 ± 3</td>
<td>13.9 ± 2.9</td>
<td>14.0 ± 2.6</td>
<td>14.4 ± 2.9</td>
</tr>
<tr>
<td>Left eye Pre-intervention IOP (mean ± SD)</td>
<td>14.7 ± 3.2</td>
<td>14.2 ± 2.7</td>
<td>14.1 ± 2.6</td>
<td>1.1 ± 3.2</td>
</tr>
</tbody>
</table>

Notes: *Statistically not significant with p=0.724, **statistically not significant with p=0.877 (by Kruskal Wallis test).

Abbreviations: RNB, right nostril breathing; LNB, left nostril breathing; ANB, alternate nostril breathing; NB, normal breathing; IOP, intraocular pressure; SD, standard deviation.

Table 2 The Mean Intraocular Pressures Before and After the Breathing Exercise in Each of the Study Groups

<table>
<thead>
<tr>
<th>Group</th>
<th>Eye</th>
<th>Mean IOP Before (mmHg ±SD)</th>
<th>Mean IOP After (mmHg ±SD)</th>
<th>Z value</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Right nostril breathing</td>
<td>Right eye</td>
<td>14.3 ± 3</td>
<td>13.9 ± 2.6</td>
<td>-2.284</td>
<td>0.022*</td>
</tr>
<tr>
<td></td>
<td>Left eye</td>
<td>14.7 ± 3.2</td>
<td>14.2 ± 3.0</td>
<td>-2.406</td>
<td>0.016*</td>
</tr>
<tr>
<td>Left nostril breathing</td>
<td>Right eye</td>
<td>13.9 ± 2.9</td>
<td>13.6 ± 2.9</td>
<td>-1.275</td>
<td>0.202</td>
</tr>
<tr>
<td></td>
<td>Left eye</td>
<td>14.2 ± 2.7</td>
<td>13.3 ± 2.5</td>
<td>-4.148</td>
<td>&lt; 0.0001*</td>
</tr>
<tr>
<td>Alternate nostril breathing</td>
<td>Right eye</td>
<td>14.0 ± 2.6</td>
<td>14.2 ± 2.8</td>
<td>-0.835</td>
<td>0.404</td>
</tr>
<tr>
<td></td>
<td>Left eye</td>
<td>14.1 ± 2.6</td>
<td>14.1 ± 2.9</td>
<td>-0.104</td>
<td>0.917</td>
</tr>
<tr>
<td>Normal breathing</td>
<td>Right eye</td>
<td>14.4 ± 2.9</td>
<td>14.2 ± 2.9</td>
<td>-1.429</td>
<td>0.153</td>
</tr>
<tr>
<td></td>
<td>Left eye</td>
<td>14.1 ± 3.2</td>
<td>14.1 ± 2.9</td>
<td>-0.369</td>
<td>0.712</td>
</tr>
</tbody>
</table>

Notes: *Statistically significant at p < 0.05, **highly significant at p < 0.01.

Abbreviations: IOP, intraocular pressure; SD, standard deviation.

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Discussion

In this study, we report the effects of different breathing techniques on the intraocular pressure. Right nostril breathing, left nostril breathing, and alternate nostril breathing are types of “Pranayama” and their effect was evaluated in comparison with normal breathing in healthy individuals. We found that individual nostril breathing, either right or left, did not increase the IOP but did bring about a significant decrease.

We recruited normal, i.e., non-glaucomatous individuals in this study as a phase one trial, so as to establish the safety of the breathing exercises prior to proceeding with glaucoma patients. We concentrated on a specific aspect of yoga concerning regulation of breathing and the effect it had on IOP. The yogic art of regulation of breathing is called “Pranayama”.17 Right nostril breathing is called “Surya nadi pranayama”, left nostril breathing is known as “Chandra nadi pranayama” and alternate nostril breathing is “Anuloma viloma pranayama”.16 The “Kumbaka” variation of Anuloma viloma/ANB which entails holding the breath between inhalation and exhalation was not practiced in our study.

In our study, it was seen that both RNB and LNB had a higher proportion of eyes with reduction of IOP, whereas alternate nostril breathing or normal breathing did not show any significant change of IOP. Previous literature has shown that right nostril related breathing has sympathomimetic properties whereas left nostril breathing techniques has parasympathetic dominance.16,18 In the eye, both sympathetic and parasympathetic drugs are known to reduce IOP. This is an indication that, by stimulating either the sympathetic pathway or the parasympathetic pathway, by utilizing the appropriate Pranayama technique, we can potentially lower the IOP. Meditation, yoga and Pranayama have been shown to have an effect on nitric oxide in the body.19–21 Nitric oxide also has an IOP lowering effect by increasing the outflow of aqueous at the trabecular meshwork.22,23

The average reduction in IOP in the RNB group was 0.5 ± 1.2 mmHg and in the LNB group was 0.6 ± 1.4 mmHg. This was statistically significant, but was lower than in previously reported studies.11,18 It has to be noted that in our study, the IOP was rechecked after a single session of breathing exercise. Even though it is a small reduction in IOP, it has been determined in the past that even a drop of one mmHg of pressure can reduce the chance of glaucoma progression by 10%.24,25 Further study is needed to determine whether similar reduction of IOP would be seen in patients with glaucoma.

In the ANB group, the mean IOP increased from 14.0 mmHg to 14.2 mmHg in the right eyes, this was not statistically significant. Even though it is a small increase in IOP, it has been determined in the past that even a drop of one mmHg of pressure can reduce the chance of glaucoma progression by 10%.24,25 Further study is needed to determine whether similar reduction of IOP would be seen in patients with glaucoma.

Table 3 Pulse, Systolic Blood Pressure, and Diastolic Blood Pressure Before and After the Breathing Exercise

<table>
<thead>
<tr>
<th>Group</th>
<th>Before (Mean ± SD)</th>
<th>After (Mean ± SD)</th>
<th>Z value</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Right nostril breathing</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pulse</td>
<td>70.9 ± 9.4</td>
<td>71 ± 9.4</td>
<td>-0.708</td>
<td>0.479</td>
</tr>
<tr>
<td>SBP</td>
<td>123.4 ± 12.8</td>
<td>122.6 ± 13.5</td>
<td>-1.559</td>
<td>0.119</td>
</tr>
<tr>
<td>DBP</td>
<td>76.6 ± 8.6</td>
<td>75.4 ± 8.6</td>
<td>-1.857</td>
<td>0.063</td>
</tr>
<tr>
<td>Left nostril breathing</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pulse</td>
<td>73.7 ± 9.6</td>
<td>72.6 ± 8.8</td>
<td>-2.261</td>
<td>0.024*</td>
</tr>
<tr>
<td>SBP</td>
<td>123.7 ± 18.8</td>
<td>122.4 ± 20.8</td>
<td>-0.943</td>
<td>0.346</td>
</tr>
<tr>
<td>DBP</td>
<td>79.2 ± 11.3</td>
<td>77.7 ± 10.8</td>
<td>-1.864</td>
<td>0.062</td>
</tr>
<tr>
<td>Alternate nostril breathing</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pulse</td>
<td>74.2 ± 10.3</td>
<td>73.3 ± 10.4</td>
<td>-1.337</td>
<td>0.181</td>
</tr>
<tr>
<td>SBP</td>
<td>118.8 ± 21.1</td>
<td>120.5 ± 12.9</td>
<td>-0.048</td>
<td>0.962</td>
</tr>
<tr>
<td>DBP</td>
<td>75.9 ± 7.5</td>
<td>75.8 ± 7.8</td>
<td>-0.058</td>
<td>0.954</td>
</tr>
<tr>
<td>Normal breathing</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pulse</td>
<td>74.6 ± 10.7</td>
<td>73.8 ± 10.1</td>
<td>-2.104</td>
<td>0.035*</td>
</tr>
<tr>
<td>SBP</td>
<td>125.3 ± 14.6</td>
<td>125.2 ± 14.6</td>
<td>-0.222</td>
<td>0.824</td>
</tr>
<tr>
<td>DBP</td>
<td>76.1 ± 8.7</td>
<td>75.7 ± 8.6</td>
<td>-1.313</td>
<td>0.189</td>
</tr>
</tbody>
</table>

Notes: Pulse was measured in beats per minute and blood pressure was measured in mmHg. *Significant at p<0.05 using Wilcoxon signed rank test.

Abbreviations: SBP, systolic blood pressure; DBP, diastolic blood pressure; SD, standard deviation.
on IOP. It is important to note that none of the other groups had a mean increase in IOP following the breathing exercise. Special attention has to be paid to not hold the breath (Kumbhaka) during the exercise as it might lead to a rise in IOP.

Bhavanani et al, in analyzing the effects of different techniques of nasal breathing, found that LNB techniques tended to lower heart rate and blood pressure-related parameters whereas RNB techniques increased them. We found that the heart rate/pulse dropped significantly in the LNB group as well as the NB group, even though it was within the normal physiologic range. There were no significant changes in the blood pressure parameters in any of the groups.

Yoga is practiced by many individuals either for health reasons or as part of their lifestyle. One of the frequent questions encountered in ophthalmology, in the context of glaucoma is whether they can continue to practice yoga. Previous reports have determined that certain yogic postures like “shirsana” or head-stand can have a deleterious effect on glaucoma.

In the recent past there have been two studies on yogic breathing exercises and intraocular pressure. Paidimarri et al studied the effect of Anulom-vilom alternate nostril breathing and their findings were similar to the findings in one of the groups in our study, the alternate nostril breathing group. In the study by Udenia et al, the effect of diaphragmatic breathing and anuloma viloma pranayama was investigated and it was found to have a significant lowering effect on IOP. Along with anuloma viloma, we also studied the effect of right nostril breathing and left nostril breathing exercises. These are additional Pranayamas in practice and their effect on IOP has not been reported in the recent past.

Studies by Backon et al, Koçer et al, and Chen et al reported IOP lowering effects of “forced” right unilateral nostril breathing. The effect of left forced unilateral breathing was variable. In contrast to these studies, the breathing exercise advised by us was without force. Mohan et al evaluated the effect of unilateral as well as forced unilateral nostril breathing in young healthy individuals and found that right nostril breathing significantly reduced IOP, but not left nostril breathing. The intervention groups were divided based on the nasal cycle. Our study differs from this as we included a wider age range of participants who were randomized into intervention groups, and we found that both right and left nostril breathing lowered IOP.

The strength of our study is that we sought to determine the effects on IOP of specific, individual Pranayama techniques and not a combination of breathing techniques which is also termed Pranayama. We established that these specific yogic breathing exercises do not adversely affect IOP in normal individuals. We found that unilateral breathing which is not forced, can also bring down the IOP and it need not be dependent on the phase of the nasal cycle. To the best of our knowledge, this has not been reported previously.

A limitation of our study is that we evaluated the IOP after only a single episode of breathing exercise. The long-term effects on IOP and also the frequency of practicing the breathing techniques to effectively lower IOP need to be assessed in future studies. Further research is required to determine the effect of these Pranayamas on glaucoma patients. Additional efforts are needed to evaluate the effect of Pranayamas on the progression of glaucoma either as an addition to medical management or as stand-alone treatment. The same examiner measured the IOP before and after the exercise to avoid inter-observer variability, but this could have been a source of bias. Mask usage during IOP measurement can sometimes affect the readings and could have been a confounder, but extra care was taken in our study to avoid contact between the tonometer and mask.

Conclusion
With this study, we were able to determine that specific pranayama techniques like right and left nostril breathing, alternate nostril breathing were safe and had no adverse effect of raising IOP in normal subjects. Additionally, right and left nostril breathing techniques may have a beneficial effect of lowering IOP.

Data Sharing Statement
The data that support the findings of this study are available from the corresponding author upon reasonable request.

Ethical Statement
This research was reviewed and approved by the institutional review board of Kasturba Medical College Manipal, Manipal Academy of Higher Education (registration number ECR/146/Inst/KA/2013/RR-19). Informed consent was
obtained from all participants. The trial was registered prospectively with Clinical Trials Registry - India (registration number: CTRI/2020/02/023098, Registration date: 03/02/2020).

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Author Contributions
All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

Disclosure
The authors report no conflicts of interest in this work.

References


