Lifestyle Modification for Prevention & Management of Glaucoma

Ryan Bulson, OD, MS, FAAO
Pacific University Online CE
Overview

• Why are we discussing this topic?
• What lifestyle modifications may influence IOP?
• Is lifestyle modification a therapeutic tool in the prevention/management of glaucoma?
• What lifestyle recommendation can you start making for your patients with glaucoma today?
Why Are We Discussing This Topic?

- Glaucoma is the second leading cause of blindness worldwide
  - 37 million people worldwide (WHO)

- POAG is managed by lowering IOP

- OHTN treatment can slow (prevent?) development of glaucoma

- With emerging technologies, POAG will likely begin to be diagnosed in younger, healthier patients, who may be averse to using medication for the rest of their lives

- Glaucoma in a chronic disease

- Management of many chronic diseases, such as diabetes and hypertension, includes lifestyle modifications, so lifestyle modifications that can reduce IOP represent an exciting research area in eye care.
Patients may inquire how lifestyle or emotions may influence their intraocular pressure or risk for developing chronic open-angle glaucoma.

Currently, little modification of lifestyle (including diet, drugs, emotion, activity, or risk factors for cardiovascular disease or diabetes) can be advised to reduce the risk of developing chronic open-angle glaucoma.
What Lifestyle Modifications May Influence IOP?

- Diet
- Sleeping/Head Position
- Caffeine
- Exercise
- Others
Diet

- Higher intake of fruit, especially fresh or canned peaches, associated with decreased odds of glaucoma in healthy subjects

- Vegetables, such as fresh carrots, green collards, kale, and iceberg or romaine lettuce may also be associated with a decreased risk of glaucoma in some populations
  - Green collards or kale may be more protective in African Americans than Caucasians.

- Mechanism? ↑ Vitamins A, B2, flavonoids, isothiocyanates, fiber, antioxidant

- Higher consumption of walnuts and fatty fish (omega-3s) reduced risk for glaucoma
  - Improved vascular perfusion, neuroprotection
Diet

• Consumption of orange juice, fresh oranges, spinach, and higher intake of lutein/zeaxanthin tended to **increase** risk of glaucoma
  • Higher daily intake of cryptoxanthin, one major nutrient component of orange juice, was correlated with high risk for glaucoma

• Supplementation with magnesium, iron, and calcium may increase the risk of glaucoma
Other Risk Factors...

- These large scale nutritional studies found that, after adjusting for IOP, increased risk of glaucoma/OHTN with:
  - Male gender
  - Older age
  - First-degree relative with glaucoma
  - Occupational exposure to pesticides
    - Also associated with higher risk of PD/AD (neuro-degenerative)
  - Unmarried marital status
  - Unemployed work status
Diet

Mutolo et al. (2016)

Twenty-two POAG patients (9 women, 13 men), mean age 58.5 – 6.7 years, followed x 1 year

- Control group
- Food supplement group which was given two tablets a day:
  - Homotaurine (neuroprotective in AD)
  - Coleus forskohlii root extract (↓IOP, ↑ GC survival)
  - L-carnosine (neuroprotective in PD: antioxidant, pH buffering, heavy metal chelating)
  - Folic acid
  - Vitamins B1, B2, B6
  - Magnesium

- Control group: no significant change in IOP
- Treatment group: 2mmHg reduction (p<0.01)
- Significant improvement of pattern ERG amplitude (p < 0.01) and VF foveal sensitivity (4.8 dB, p < 0.05) in treated patients, but not in controls

Synergic neuroprotective effects on GC both in vitro and in vivo in a mouse model of hypertensive retinal ischemia.

FIG. 2. Intraocular pressure variation during the course of the study in treated (A) and control (B) patients. RE, right eye; LE, left eye; *P<0.05; **P<0.01.
Thirty-four POAG patients were followed x 2 months

- **Control group**
  - Oral aqueous saffron extract for 1 month
  - Powerful free radical scavenging, anti-oxidative and anti-tumor properties

- **Saffron** has been widely used for many years in traditional Asian medicine and in Persian medicine in particular to treat depression.

Both groups were then followed for an additional month

- **Control group:** from 14.0 ± 2.5 to 13.8 ± 2.2 mmHg
- **Treatment group:** from 12.9 ± 3.7 to 10.6 ± 3.0 mmHg vs. control; \( P = 0.001 \)

IOP values returned to baseline at 1 month follow up after treatment was discontinued.

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**Figure 1** Mean IOP change during 4 weeks after initiation of saffron or placebo in addition to conventional timolol and dorzolamide therapy in primary open angle glaucoma and after one month of wash-out (Arrows indicate where mean IOP levels were significantly different between the two study groups).
Cannabidiol (CBD)

- CBD is a cannabis compound without psychoactive effect heavily marketed as an OTC therapy for many conditions: Chronic pain, arthritis, seizures, PTSD, depression

Initial cannabis studies (1970s/80s) showed IOP lowering effect (~20-25%) peaking at 60-90 minutes and lasting 3-4 hours.

Is the IOP lowering effect of marijuana derived from THC or CBD?

**FIGURE 1.** Intraocular pressure (mean ± standard error) in glaucomatous eyes after smoking marijuana or placebo.
What Lifestyle Modifications May Influence IOP?

• Diet
• Sleeping/Head Position
• Caffeine
• Exercise
• Others
Sleeping Position

- Diurnal variation
  - IOP lowest ~9:30 PM
  - IOP highest ~5:30 AM
  - Rises steadily during nocturnal periods, on average, 4.0 mmHg

- Supine position causes IOP to rise
  - Posture changes trigger hydrostatic responses in the episcleral venous pressure and the distribution of body fluid

- Head position during sleep may help to mitigate IOP rise due to postural changes
Sleeping Position

Lee et al (2013)

- 20 healthy Korean subjects had IOP measured via iCare tonometer
- Randomized for 20 minutes into:
  - Seated
  - Supine
  - Right lateral decubitus
  - Left lateral decubitus
  - Prone with right head turn
  - Prone with left head turn
## Sleeping Position

Lee et al (2013)

<table>
<thead>
<tr>
<th>Position</th>
<th>Right Eye (mean ± SD)</th>
<th>Left Eye (mean ± SD)</th>
<th>P*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sitting</td>
<td>14.2±1.1</td>
<td>14.2±1.0</td>
<td>0.722</td>
</tr>
<tr>
<td>Supine</td>
<td>16.2±1.5</td>
<td>16.1±1.5</td>
<td>0.375</td>
</tr>
<tr>
<td>Right lateral decubitus</td>
<td>17.7±2.0</td>
<td>16.3±1.7</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Left lateral decubitus</td>
<td>15.8±1.9</td>
<td>17.2±1.8</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Prone with right head turn</td>
<td>16.9±1.7</td>
<td>18.1±2.5</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Prone with left head turn</td>
<td>19.4±3.2</td>
<td>17.9±2.7</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

SD = standard deviation.
*Wilcoxon signed-rank test.
Sleeping Position

Lee et al (2013)

- IOP significantly higher in all recumbent positions vs seated (all $P<0.001$).

- “Down” eye significantly higher than “up” eye in both lateral decubitus and prone positions with head turns (all $P<0.001$)

- Among IOPs measured in the recumbent positions, mean IOP of the down eye was significantly higher in both lateral decubitus and prone positions than in the supine position (all $P<0.0001$)

- Conclusion: IOP rises significantly in all recumbent positions, but adopting a supine position may mitigate the rise in IOP; do not sleep on the side of the worse eye

  - ~1/3 of patients preferred a lateral sleeping position
  - ~2/3 of those habitually sleep on the worse eye-dependent side.
Sleeping Position
Park et al (2016)

- 71 patients with POAG, measured IOP (via Tonopen Avia) in different randomly assigned positions after 10 minutes
  - Seated position (control)
  - Supine position (head flat)
  - Supine with 30-degree head elevation via bed head elevation (BHE)
  - Supine with 30-degree head elevation via multiple pillows (MP)
### Sleeping Position

- Park et al (2016)

<table>
<thead>
<tr>
<th>Position</th>
<th>Right eye (n = 71)</th>
<th>Left eye (n = 71)</th>
<th>Mean value of both eyes (n = 71)</th>
<th>p value*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sitting</td>
<td>15.0 ± 3.3</td>
<td>15.0 ± 3.2</td>
<td>15.0 ± 3.1</td>
<td>0.751</td>
</tr>
<tr>
<td>Supine flat</td>
<td>17.6 ± 3.9</td>
<td>17.3 ± 3.9</td>
<td>17.5 ± 3.8</td>
<td>0.251</td>
</tr>
<tr>
<td>Supine 30° head-up</td>
<td>15.6 ± 3.7</td>
<td>15.4 ± 3.4</td>
<td>15.5 ± 3.4</td>
<td>0.151</td>
</tr>
<tr>
<td>Supine 30° head-up with BHE</td>
<td>16.8 ± 3.8</td>
<td>16.8 ± 3.8</td>
<td>16.8 ± 3.7</td>
<td>0.939</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Positions</th>
<th>Mean value of both eyes (n = 71)</th>
<th>p value*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sitting vs. supine</td>
<td>−2.5 ± 1.9</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Sitting vs. BHE</td>
<td>−0.5 ± 2.2</td>
<td>0.284</td>
</tr>
<tr>
<td>Sitting vs. MP</td>
<td>−1.8 ± 2.6</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Supine vs. BHE</td>
<td>2.0 ± 2.0</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Supine vs. MP</td>
<td>0.7 ± 2.3</td>
<td>0.081</td>
</tr>
<tr>
<td>BHE vs. MP</td>
<td>−1.3 ± 1.4</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>
Sleeping Position

Park et al (2016)

- IOP significantly higher in supine position vs seated position
- IOP was significantly lower with head 30 degrees up by BHE compared to supine or head elevation with MP (average reduction~2.0 mmHg)
- IOP levels with head 30 degrees up by BHE were similar to seated

Yeon et al (2014): 24 healthy young subjects found a significant drop (2.8 mmHg) when measured in a 30-degree head-up position with BHE compared with the flat supine position.

- Conclusion: Physiological IOP increase from laying in supine position during sleep may be mitigated by bed head elevation.
What Lifestyle Modifications May Influence IOP?

- Diet
- Sleeping/Head Position
- Caffeine
- Exercise
- Others
Caffeine

- World’s most widely consumed psychoactive drug
- Found in variety of beverages, food products, supplements, and medications
- Small studies have demonstrated caffeine consumption equivalent to one cup of coffee elevates IOP about 1–2 mmHg for several hours in both healthy patients and those affected by POAG
- Caffeine ↓ phosphodiesterase, ↑ cyclic adenosine monophosphate (cAMP) in ciliary body, ↑aqueous humor formation
- Also ↓ tone of smooth muscle and closure of TM thereby ↓ aqueous outflow
Caffeine

Jiwani et al (2012)

- Prospective, double-masked, crossover, randomized controlled trial with 106 subjects:
  - 22 with high tension POAG
  - 18 with normal tension glaucoma
  - 20 with ocular hypertension
  - 21 POAG suspects
  - 25 healthy participants.

- Subjects ingested either 237 ml (~8oz/1 cup) of caffeinated (182mg caffeine) or decaffeinated (4mg caffeine) coffee for the first visit and the alternate beverage for the second visit.

- IOP measured at baseline (prior to caffeine or sham), then 60 minutes and 90 minutes later
<table>
<thead>
<tr>
<th></th>
<th>HTG</th>
<th>NTG</th>
<th>POAG Suspect</th>
<th>OHTN</th>
<th>Healthy</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>22</td>
<td>18</td>
<td>21</td>
<td>20</td>
<td>25</td>
</tr>
<tr>
<td>IOP Baseline</td>
<td>15.98 (2.71)</td>
<td>14.12 (1.82)</td>
<td>16.76 (2.84)</td>
<td>17.37 (2.39)</td>
<td>15.45 (2.37)</td>
</tr>
<tr>
<td>Δ At 60 min&lt;sub&gt;caffeinated visit minus decaffeinated visit&lt;/sub&gt;</td>
<td>0.19 (1.09)</td>
<td>0.94 (1.23)</td>
<td>1.51 (1.53)</td>
<td>1.61 (1.85)</td>
<td>0.81 (1.46)</td>
</tr>
<tr>
<td>Δ At 90 min&lt;sub&gt;caffeinated visit minus decaffeinated visit&lt;/sub&gt;</td>
<td>0.68 (1.11)</td>
<td>1.44 (1.61)</td>
<td>1.48 (1.74)</td>
<td>0.84 (1.88)</td>
<td>0.95 (1.89)</td>
</tr>
</tbody>
</table>

<sup>a</sup> Baseline calculated as the average of the caffeinated and decaffeinated visit baseline values before beverage consumption.

<sup>b</sup> NTG vs POAG suspect $P < 0.05$, NTG vs OHTN $P < 0.001$.

<sup>c</sup> HTG vs POAG suspect $P < 0.05$, HTG vs OHTN $P < 0.05$. 
Caffeine

Jiwani et al (2012)

- Mean changes (±SD) in IOP as compared with decaffeinated, coffee consumption at 60 and 90 min were, respectively, in mmHg: 0.99 (±1.52, P<0.0001) and 1.06 (±1.67, P<0.0001)

- Effect of caffeine may be stronger in patient’s with already elevated pressure (OHTN, POAG suspect)

- 80% of Americans drink coffee

- Average American coffee consumption: 3.5 cups/day
Caffeine

Okimi (1991)

- 12 young, healthy, non-glaucomatous subjects were randomly assigned to receive each of three treatments over a 3 day period:
  - Caffeinated coffee-946 ml (~32oz/4 cups) of coffee within 60 min
  - Hot water-946ml
  - No fluid

- IOP measured via NCT
Table 2. IOPs of Subjects After Ingestion of Caffeinated Coffee, Ingestion of Hot Water, and No Fluid

<table>
<thead>
<tr>
<th>Measurement Time</th>
<th>Coffee (mm Hg)</th>
<th>Water (mm Hg)</th>
<th>No Fluid (mm Hg)</th>
<th>F (2,22)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline</td>
<td>12.84</td>
<td>12.55</td>
<td>12.29</td>
<td>.75</td>
</tr>
<tr>
<td>1st hour</td>
<td>15.74</td>
<td>13.58</td>
<td>11.77</td>
<td>19.94*</td>
</tr>
<tr>
<td>2nd hour</td>
<td>14.30</td>
<td>12.46</td>
<td>12.03</td>
<td>13.70*</td>
</tr>
<tr>
<td>3rd hour</td>
<td>14.37</td>
<td>12.31</td>
<td>12.15</td>
<td>17.21*</td>
</tr>
<tr>
<td>Total</td>
<td>14.31</td>
<td>12.72</td>
<td>12.15</td>
<td>21.45*</td>
</tr>
</tbody>
</table>

* P = .0001.
Caffeine

Okimi (1991)

- Mean IOP significantly higher following coffee consumption than the same subjects consuming hot water or no fluid
- Significant IOP increase maintained for 3 hours
Caffeine


- 91 POAG on topical antiglaucoma drugs given direct face to face questionnaire on the frequency of coffee intake
- Complete ophthalmic exam and 2 consecutive, reliable Humphrey visual fields were completed following recruitment and compared to baseline VF at time of diagnosis
- No significant association between coffee drinking and the disease severity ($P = 0.863$)
- Frequency of coffee intake was significantly associated with disease progression ($P = 0.001$).
- In this small cross-sectional study daily coffee consumption was associated with an eightfold increase in the risk of progression
- “Perhaps, glaucoma patients should minimize or avoid coffee intake”
What Lifestyle Modifications May Influence IOP?

- Diet
- Sleeping/Head Position
- Caffeine
- Exercise
- Others
Exercise

• More fit individuals typically have lower resting IOP than sedentary individuals
• Aerobic exercise such as jogging, cycling, and walking reduces IOP transiently (~1 hour)
• This pattern has been demonstrated in healthy adults, elderly subjects, sedentary subjects, trained athletes, and in those with elevated IOP or glaucoma.
• A greater reduction in IOP occurs in subjects with a higher resting IOP (including those with glaucoma/OHTN)
• Sedentary subjects experience a greater reduction in IOP than trained/fit individuals
• The reduction in IOP correlates with exercise intensity rather than duration
Exercise

Qureshi (1995)

- 14 subjects (7 healthy, 7 with POAG) 40-50 years old
- IOP measured via GAT during and after 3 test conditions
  - Walking for 1 hour
  - Jogging for 1 hour
  - Running to volitional exhaustion
- For first 2 conditions, IOP measured at baseline, then at time 5 min, 20 min, 40 min, 60 min
- For 3rd condition, IOP measured at baseline, then after completing task
- Post-exercise, IOP measured at 10 minute intervals until IOP returned to baseline +/- 1mmHg
<table>
<thead>
<tr>
<th>Post-exercise mean recovery time (min)</th>
<th>Walking</th>
<th>54.28±8.41</th>
<th>42.86±8.08</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Jogging</td>
<td>71.43±11.43</td>
<td>57.14±5.22</td>
</tr>
<tr>
<td></td>
<td>Running</td>
<td>84.29±13.43</td>
<td>62.86±8.08</td>
</tr>
</tbody>
</table>

Table 1.

<table>
<thead>
<tr>
<th>Time (min)</th>
<th>Glaucoma patients</th>
<th></th>
<th>Normal subjects</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>IOP</td>
<td>% decrease</td>
<td>p value*</td>
<td>IOP</td>
</tr>
<tr>
<td>Effect of walking</td>
<td>0</td>
<td>33.43±2.19</td>
<td></td>
<td>15.29±0.81</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>29.14±1.77</td>
<td>12.83</td>
<td>&lt; 0.01</td>
</tr>
<tr>
<td></td>
<td>20</td>
<td>27.43±1.53</td>
<td>17.95</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td></td>
<td>40</td>
<td>26.14±1.32</td>
<td>21.81</td>
<td>&lt; 0.01</td>
</tr>
<tr>
<td></td>
<td>60</td>
<td>25.71±1.23</td>
<td>23.09</td>
<td>&gt; 0.05</td>
</tr>
<tr>
<td>Effect of jogging</td>
<td>0</td>
<td>33.29±2.24</td>
<td></td>
<td>15.14±0.74</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>26.71±1.04</td>
<td>19.77</td>
<td>&lt; 0.01</td>
</tr>
<tr>
<td></td>
<td>20</td>
<td>25.71±0.87</td>
<td>22.77</td>
<td>&lt; 0.01</td>
</tr>
<tr>
<td></td>
<td>40</td>
<td>23.57±1.11</td>
<td>29.20</td>
<td>&gt; 0.05</td>
</tr>
<tr>
<td></td>
<td>60</td>
<td>22.43±1.04</td>
<td>32.62</td>
<td>&gt; 0.05</td>
</tr>
<tr>
<td>Effect of running</td>
<td>Before</td>
<td>32.86±2.13</td>
<td></td>
<td>15.14±1.01</td>
</tr>
<tr>
<td></td>
<td>After</td>
<td>20.60±0.82</td>
<td>39.14</td>
<td>&lt; 0.001</td>
</tr>
</tbody>
</table>
Exercise

Qureshi (1995)

- Mean before/after differences in healthy subjects
  - Walking -2.43 mmHg
  - Jogging -3.85 mmHg
  - Running -4.00 mmHg

- Mean before/after differences in POAG subjects
  - Walking -7.72 mmHg
  - Jogging -10.86 mmHg
  - Running -12.86 mmHg

- Significant IOP reduction after just 5 minutes of walking and jogging

- POAG patients can achieve ~20-40% (!!) IOP reduction with exercise, depending on intensity
Exercise

Najmanova (2016)

- Forty-one healthy, but sedentary, volunteers between the ages of 19 and 25
  - Resting (reference) values IOP and HR were measured after 30 min of resting time
  - Subjects then performed 30 min of moderate intensity cycling exercise on a bicycle ergometer.
  - Intraocular pressure was remeasured immediately after the end of exercise and subsequently repeated 5, 10, 20, and 30 min after exercise.
Time after the exercise [min]

IOP [mm Hg]
Exercise

Najmanova (2016)

• Significant IOP reduction immediately following moderate intensity cycling
• IOP reduction was maintained at 5 and 10 minutes post-exercise
• IOP returned to baseline levels at 20 minutes post-exercise
• Higher baseline IOP associated with larger IOP reduction from exercise
• Higher resting HR (i.e. being less physically fit) associated with larger IOP reduction from exercise
Exercise

Bulson et al (currently in review)

• Twenty-five healthy participants with normal intraocular pressure (17.17 ± 3.85 mmHg)
• Each participant completed a standardized step test to estimate VO2 max, which was used to prescribe individualized treadmill speeds representing three exercise intensities (45%, 65%, and 95% maximal oxygen uptake)
• In a random and repeated design, participants completed 2.0 km at each intensity. This experimental design isolated power (exercise intensity) as the variable of interest, while holding total work constant for each condition (2.0 km)
• Baseline intraocular pressure, heart rate, and blood pressure were measured prior to each exercise intensity and again at time 0, 5, 10, and 20 minutes post-exercise
Figure 1: Effect of Exercise Intensity on IOP

- Baseline
- 95% VO2 max
- 65% VO2 max
- 45% VO2 max

Intraocular Pressure (mmHg)
Exercise

Bulson et al (currently in review)

• Mean IOP
  • Baseline IOP: 17.17mmHg
  • 95% VO2max: 12.87mmHg (25% reduction)
  • 65% VO2max: 14.96mmHg (12.9% reduction)
  • 45% VO2max: 15.69mmHg (8.6% reduction)

• Aerobic exercise **significantly reduced IOP for all intensities** relative to baseline (p<0.01)

• The 95% intensity showed a more significant IOP reduction than either the 65% and 45% intensities (p<0.001)

• Further study is needed to determine the duration of intraocular pressure reduction following exercise at different intensity levels
Exercise

Vieira (2006)

• 29 healthy male subjects 18-40yo performed 4 repetitions of a bench press (80% of 1 rep max) exercise in 2 ways:
  • Mode I-breath was held during the last repetition
  • Mode II-subjects exhaled normally during the last repetition

• IOP measured via tonopen before task and during 4th repetition in both modes
Figure 2. Histogram of intraocular pressure (IOP) variations in the 30 subjects in exercise mode I. Mean±SD was 4.3 ± 4.2 mm Hg.

Figure 3. Histogram of intraocular pressure (IOP) variations in the 29 subjects in exercise mode II. Mean±SD was 2.2 ± 3.0 mm Hg.
Exercise

Vieira (2006)

• Mean IOP with breath holding increased by 4.3±4.2mmHg ($P<0.001$, paired $t$ test; range, −3.6 to 17.7mmHg)
  • IOP increased in 90% of subjects
  • IOP increase of >5.0mmHg observed in 30% of subjects
  • In 2 subjects, IOP was markedly increased (>10.0 mm Hg).

• Mean IOP with normal breathing increased by 2.2±3.0 mmHg ($P<0.001$, paired $t$ test; range, −6.0 to 8.7mmHg)
  • IOP increased in 62% of subjects
  • IOP increase of >5.0mmHg observed in 21% of subjects
Exercise

Jasien et al

- Methods: 10 subjects with POAG and 10 normal individuals performed the yoga postures downward dog, forward bend, plow and legs up wall) for two minutes each.
  - IOP measured in seated position (baseline)
  - Immediately at the start of the pose
  - Two minutes into the pose
  - Immediately after assuming a seated position
  - Ten minutes later in a seated position
**Fig 4.** Least squares means and mean values of the covariates of the changes in IOP in the Adho Mukha Svanasana position over time. The X axis represents each time point an IOP measurement was taken (0 = Baseline seated; 1 = Immediate position; 2 = 2 minutes position; 3 = Post position seated; and 4 = 10 minutes post position seated). The Y axis represents the IOP in mmHg after adjusting for the covariates. Subjects with glaucoma diagnosis are depicted ‘Glaucoma = 1’; controls are ‘Glaucoma = 0’.

<table>
<thead>
<tr>
<th>Glaucoma=No</th>
<th>Glaucoma=Yes</th>
</tr>
</thead>
<tbody>
<tr>
<td>16.6 ± 2.8</td>
<td>28.1 ± 4.2</td>
</tr>
<tr>
<td>16.9 ± 3.2</td>
<td>27.3 ± 4.3</td>
</tr>
</tbody>
</table>

Maximal Difference in Intraocular Pressure between Baseline and Holding the Pose:

- mmHg: 12.6 ± 3.5% 79 ± 31%
- %: 11.6 ± 3.2% 72 ± 29%
Fig 5. Least squares means and mean values of the covariates of the changes in IOP in the Uttanasana position over time. The X axis represents each time point an IOP measurement was taken (0 = Baseline seated; 1 = Immediate position; 2 = 2 minutes position; 3 = Post position seated; and 4 = 10 minutes post position seated). The Y axis represents the IOP in mmHg after adjusting for the covariates. Subjects with glaucoma diagnosis are depicted ‘Glucoma = 1’; controls are ‘Glucoma = 0’.

Table: Maximal Difference in Intraocular Pressure between Baseline and Holding the Pose

<table>
<thead>
<tr>
<th>mmHg</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>8.4</td>
<td>48 ± 21%</td>
</tr>
<tr>
<td>9.8</td>
<td>61 ± 26%</td>
</tr>
</tbody>
</table>
Fig 6. Least squares means and mean values of the covariates of the changes in IOP in the Halasana position over time. The X axis represents each time point an IOP measurement was taken (0 = Baseline seated; 1 = Immediate position; 2 = 2 minutes position; 3 = Post position seated; and 4 = 10 minutes post position seated). The Y axis represents the IOP in mmHg after adjusting for the covariates. Subjects with glaucoma diagnosis are depicted ‘Glaucoma = 1’; controls are ‘Glaucoma = 0’.

<table>
<thead>
<tr>
<th>mmHg</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>17.8 ± 2.7</td>
<td>4.7 ± 3.1</td>
</tr>
<tr>
<td>18.2 ± 2.6</td>
<td>5.7 ± 2.6</td>
</tr>
</tbody>
</table>
Fig 7. Least squares means and mean values of the covariates of the changes in IOP in the Viparita Karani position over time. The X axis represents each time point an IOP measurement was taken (0 = Baseline seated; 1 = Immediate position; 2 = 2 minutes position; 3 = Post position seated; and 4 = 10 minutes post position seated). The Y axis represents the IOP in mmHg after adjusting for the covariates. Subjects with glaucoma diagnosis are depicted ‘Glaucoma = 1’; controls are ‘Glaucoma = 0’.

<table>
<thead>
<tr>
<th>Glaucoma</th>
<th>Time</th>
<th>mmHg</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>No</td>
<td>0</td>
<td>17.2 ± 2.8</td>
<td>4.0 ± 2.2</td>
</tr>
<tr>
<td>No</td>
<td>1</td>
<td>20.7 ± 2.4</td>
<td>25 ± 16%</td>
</tr>
<tr>
<td>No</td>
<td>2</td>
<td>20.1 ± 2.6</td>
<td>20 ± 15%</td>
</tr>
<tr>
<td>No</td>
<td>3</td>
<td>17.0 ± 3.2</td>
<td>13 ± 12%</td>
</tr>
<tr>
<td>No</td>
<td>4</td>
<td>16.6 ± 2.2</td>
<td>9 ± 14%</td>
</tr>
<tr>
<td>Yes</td>
<td>0</td>
<td>17.6 ± 3.8</td>
<td>4.0 ± 2.2</td>
</tr>
<tr>
<td>Yes</td>
<td>1</td>
<td>21.0 ± 3.4</td>
<td>37 ± 16%</td>
</tr>
<tr>
<td>Yes</td>
<td>2</td>
<td>20.4 ± 3.5</td>
<td>22 ± 15%</td>
</tr>
<tr>
<td>Yes</td>
<td>3</td>
<td>17.8 ± 3.2</td>
<td>18 ± 14%</td>
</tr>
<tr>
<td>Yes</td>
<td>4</td>
<td>17.2 ± 3.2</td>
<td>11 ± 13%</td>
</tr>
</tbody>
</table>
Exercise

Jasien et al

- IOP increased significantly for all 4 yoga positions
  - IOP increase greatest in downward facing dog
- Once in the pose, IOP did not change significantly after 2 minutes
- Increase in IOP did not differ significantly between control and glaucoma group
- IOP returned to baseline immediately after exiting pose
- Since elevated IOP is the most important known risk factor for development/progression of glaucoma, the rise in IOP after assuming the yoga poses is of concern for glaucoma patients.
Exercise

Baskaran et al

- 75 subjects (50 Asian Indian, 25 Caucasian) had intraocular pressure measured using Tonopen before, during, and after the Sirsasana. The recordings were done:
  - Before the posture (baseline sitting IOP)
  - Immediately after assuming the headstand
  - At 5 minutes into the headstand
  - Immediately after resuming the sitting posture.
  - Induced IOP = Inverted IOP – Sitting IOP
<table>
<thead>
<tr>
<th>Parameters</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subjects (n)</td>
<td>75</td>
</tr>
<tr>
<td>Men</td>
<td>24 (32%)</td>
</tr>
<tr>
<td>Women</td>
<td>51 (68%)</td>
</tr>
<tr>
<td>Asian Indians vs. Caucasians</td>
<td>50:25</td>
</tr>
<tr>
<td>Mean age (yrs)</td>
<td>48.9±13.7 (19–86)</td>
</tr>
<tr>
<td>&lt;40</td>
<td>17 (22.7%)</td>
</tr>
<tr>
<td>≥40</td>
<td>58 (77.3%)</td>
</tr>
<tr>
<td>Time of Sirsasana/day (min)</td>
<td>7.5±3.9 (3–20)</td>
</tr>
<tr>
<td>Yoga practice time (mos)</td>
<td>174±146.7 (12–864)</td>
</tr>
<tr>
<td>Mean baseline sitting IOP (tonopen) (mmHg)</td>
<td>14.2±2.9 (7–24)</td>
</tr>
<tr>
<td>Asian Indians</td>
<td>14.6±2.9</td>
</tr>
<tr>
<td>Caucasians</td>
<td>13.5±2.9</td>
</tr>
<tr>
<td>Average corneal curvature (diopters)</td>
<td>43.4±1.6 (40.4–47.6)</td>
</tr>
<tr>
<td>Central corneal thickness (μm)</td>
<td>532.2±30.1 (454–596)</td>
</tr>
<tr>
<td>Axial length (mm)</td>
<td>23.2±1.0 (21.2–25.4)</td>
</tr>
<tr>
<td>Vertical cup-to-disc ratio</td>
<td>0.4±0.2 (0.1–0.8)</td>
</tr>
<tr>
<td>Postural changes in IOP (mmHg)</td>
<td></td>
</tr>
<tr>
<td>IOP immediately after assuming headstand</td>
<td>29.3±4.4 (18–41)*</td>
</tr>
<tr>
<td>IOP after 5 min of headstanding</td>
<td>30.1±4.8 (21–44)*</td>
</tr>
<tr>
<td>IOP immediately after resuming sitting position</td>
<td>17.5±4.1 (10–32)*</td>
</tr>
<tr>
<td>Induced IOP immediately after assuming headstand</td>
<td>15.1±3.5 (8–23)</td>
</tr>
<tr>
<td>Induced IOP at 5 minutes of headstanding</td>
<td>15.8±4.6 (6–33)</td>
</tr>
</tbody>
</table>

IOP= intraocular pressure.
Numbers in parenthesis represent the range of values.

*P<0.001 when compared with baseline sitting IOP.
Figure 3. Baseline sitting intraocular pressure (IOP) versus IOP immediately after assuming headstand shows significant positive correlation.
Exercise

Baskaran et al

- IOP doubled immediately following entering the inversion posture
- IOP elevation was maintained after 5 minutes but changed minimally from initially entering the inversion posture
- Caucasians showed a slightly lower increase in IOP compared to Asian Indians
- IOP did NOT return to baseline immediately after ceasing the posture
  - How long does an elevated IOP persist?
Exercise

2 new studies: Nov 2018

• Lee et al (2018)
  • Higher rates of physical activity (walking or more moderate) associated with slower rates of VF loss in a treated population of glaucoma patients
  • If confirmed, “this would mark physical activity as a novel modifiable risk factor for preventing glaucoma damage”

• Meier et al (2018)
  • Subjects who got 150 minutes activity per week had a 50% lower risk of glaucoma compared to sedentary
  • Subjects at highest fitness level had 40% lower risk of glaucoma compared to lowest fitness levels
What Lifestyle Modifications May Influence IOP?

• Diet
• Sleeping/Head Position
• Caffeine
• Exercise
• Others
Other Effects on IOP

- Corticosteroids (topical, oral, inhaled) can increase IOP, especially when used chronically

- Conflicting evidence that tobacco smoking increases glaucoma risk
  - Smoking is associated with an immediate rise of IOP (5mmHg in patients with POAG)
  - Vasoconstriction (increased episcleral venous pressure), reduces aqueous outflow thereby increasing IOP
  - People who stop smoking for a month display a decrease in IOP of 2-5 mmHg

- Marijuana: initial studies in the 1970s showed IOP lowering effect (~20-25%) peaking at 60-90 minutes and lasting 3-4 hours; effects of CBD inconclusive

- Alcohol: Alcohol in every form (250 ml of wine, 250 ml of sparkling wine, 500 ml of beer, 42 ml of 38% alcohol) significantly reduces IOP
  - Ingestion of “socially tolerable quantity” (1L 5% ABV beer or 120ml/4oz 86 proof whisky) demonstrated transient (~2-5 hour) reduction of 5-6mmHg in healthy subjects
  - Stronger reduction effect in eyes with higher IOP
  - Isolated subject dropped 30mmHg (starting IOP 46mmHg)
  - EtOH believed to reduce aqueous production
  - “A ban on alcoholic beverages is therefore unnecessary”
  - Parikh & Parikh: ‘Have Wine, keep your nerve healthy and prepare yourself for liver transplant.’
Other Effects on IOP

• Lysergic acid diethylamide ("Acid") increases IOP 1-3 mmHg for 2-4 hours

• Heroin reduces IOP 2-3 mmHg peaking at 1-4 hours then slowly increasing

• Heavy fluid consumption (1L within 1 hour) can increase IOP by 8 mmHg

• Swimming goggles: can increase IOP by up to 4.5 mmHg

• Wearing a tight necktie: increase IOP by 2.6 mmHg

• Playing wind instruments: intensity dependent increase in IOP (into 30-40 s)

Figure 1. Simultaneous pneumatonometry and ultrasound biomicroscopy is performed while the musician plays his instrument (trumpet) in a supine position.
Pharmacology Without Drugs?

• Melanopsin
  • Receptor protein that captures light without being involved in the formation of images
  • Involved with control of circadian rhythm by controlling synthesis of melatonin
  • Present in a subset of retinal ganglion cells that connects to the pineal gland where melatonin is synthesized when light is absent
    • Stimulation of melanopsin located within the lens epithelium with white light, in particular by the blue component of white light (460-485 nm), resulted in **inhibition** of local synthesis of melatonin within the lens
    • Lack of light, or light with wavelengths distant from blue color, produced a marked **stimulation** of melatonin synthesis
  • Melatonin present in the aqueous results in decreased IOP
    • Does blue light from screens influence IOP?
    • Will blue light filters help facilitate normal melatonin release thereby reducing IOP and being protective against glaucoma?
Fig. 1  Light-mediated effect on the lens. (A) White light, and in particular its blue component, stimulates the melanopsin receptor blocking the local synthesis of melatonin in the lens. (B) When a filter eliminating blue light component (λ 460–485 nm) is used, melanopsin is not stimulated and the local synthesis of melatonin in the human lens epithelium occurs. Since melatonin is released to the aqueous humour, this substance can act on melatonin receptors present in the ciliary body reducing intraocular pressure.
Conclusions

There is evidence to suggest the following lifestyle modifications reduce IOP and thereby the development/progression of glaucoma:

- Adopt a high fiber diet containing more fruits and vegetables
- Perhaps consider supplements (more study needed)
- Changing sleeping positions
  - Sleeping on back preferred over side or stomach sleeping
  - Do not sleep on the side of the worse eye
  - Elevating head
- Moderating caffeine intake
- Moderate aerobic exercise (higher intensity provides stronger, longer IOP reduction)
- Avoid Valsalva maneuver during weightlifting (or perhaps avoid completely)
- Limit head down yoga positions; avoid inversion postures
- Avoid tobacco smoking
- Blue light filters?
- Marijuana/Alcohol use...in moderation? (but not before an appointment)
Conclusions

- Each intervention discussed in this review may only provide a modest reduction in IOP or a reduction for a modest period of time
  - If diet reduces IOP 2–3 mmHg
  - If exercise reduces IOP 2-3 mmHg
  - If caffeine restriction reduces IOP 1–2 mmHg
  - If sleeping with a head elevation reduces 1–2 mmHg
  - Cumulative effect might be significant

- Early Manifest Glaucoma Trial
  - 10% decrease in risk of glaucoma progression with each 1mmHg IOP reduction
References


References


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