Intraocular Pressure Variation During Weight Lifting

Geraldo Magela Vieira, MD; Hildeamo Bonifácio Oliveira, MSD; Daniel Tavares de Andrade, MSD; Martim Bottaro, PhD; Robert Ritch, MD

Objective: To evaluate the effect of weight lifting on intraocular pressure (IOP).

Methods: Subjects performed 4 repetitions of a bench press exercise in 2 ways: in mode I (right eyes), the breath was held during the last repetition; in mode II (left eyes), subjects exhaled normally during the last repetition. The IOP was measured with an electronic tonometer during the fourth repetition in both modes while the subject sustained the exercise.

Results: Mean IOP during exercise in mode I increased by 4.3±4.2 mm Hg ($P<.001$, paired t test; range, −3.6 to 17.7 mm Hg). In mode II, mean IOP increased by 2.2±3.0 mm Hg ($P<.001$, paired t test; range, −6.0 to 8.7 mm Hg). The IOP increased in 90% of subjects in mode I and in 62% in mode II. An increase in IOP greater than 5.0 mm Hg was observed in 9 subjects (30%) in mode I and in 6 (21%) in mode II. In 2 subjects, IOP during exercise mode I was markedly increased (>10.0 mm Hg).

Conclusions: The IOP increases significantly during a bench press exercise. Breath holding during the exercise leads to a greater IOP increase.

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EXERCISE TRAINING LEADS TO A decrease in intraocular pressure (IOP) after either aerobic[1-6] or anaerobic exercise.[7-9] This decrease is proportional to the strength and to the length of the exertion.[10-14] Static isometric exercises[15-17] and weight lifting training[18,19] lead to a decrease in IOP from preexercise levels. To our knowledge, however, the variations in IOP that occur during weight lifting have not been investigated. Elevated IOP during the Valsalva maneuver and during maximal isometric contraction have been reported,[20,21] and the similarities between weight training exercise and the performance of a Valsalva maneuver led us to suppose that an increase in IOP could occur during weight training exercise. We studied IOP during weight lifting exercise in healthy subjects.

METHODS

This prospective study was approved by the ethics committee of the Catholic University of Brasília, and participants signed a detailed informed consent form. We enrolled 30 healthy male volunteers aged 18 through 40 years, with best-corrected visual acuity of 20/40 OU or greater, who were regular exercise practitioners at the Catholic University of Brasília health club. Each underwent a full ophthalmic examination, including slitlamp evaluation, IOP measurement by means of Goldmann applanation tonometry, gonioscopy, stereoscopic optic disc examination, and analysis of visual fields (Humphrey SITA 24-2; Allergan Humphrey, San Leandro, Calif). Subjects were excluded if they had any physical disability that would prevent performing the required exercise, refractive error more than ±4.00 diopters, astigmatism greater than 3.00 diopters, seated IOP greater than 21 mm Hg at Goldmann applanation tonometry, glaucoma, any eye infection or inflammation, any eye condition other than those already cited that could lead to glaucoma or interfere with measurement of IOP, use of systemic or topical medications that influence IOP, or inability or refusal to sign the consent form.

All subjects had IOP less than 21 mm Hg according to Goldmann applanation tonometry, normal and open angles at gonioscopy, and normal optic discs and achromatic automated perimetry results. Normal optic disc appearance was defined as vertical cup-disc ratio asymmetry less than 0.2; cup-disc ratio not greater than 0.6; and an intact neuroretinal rim without peripapillary hemorrhages, notches, localized pallor, or nerve fiber layer defect. Achromatic automated perimetry indices showed a mean defect within 95% confidence limits and a glaucoma hemifield test result within normal limits. Subjects were excluded if they had either cup-disc ratio asymmetry between the eyes of 0.2, rim thinning, notching, excavation, or nerve fiber layer defect.

A bench press set was used to perform the exercise. This set is composed of a bench that

Author Affiliations: Institute of Specialized Ophthalmology and UNIPLAC School of Medicine (Dr Vieira), Department of Physical Education, Catholic University of Brasília (Messrs Oliveira and de Andrade), and Departments of Physical Education and Ophthalmology, University of Brasília (Dr Bottaro), Brasília, Brazil; Department of Ophthalmology, New York Eye and Ear Infirmary, New York (Dr Ritch); and Department of Ophthalmology, New York Medical College, Valhalla (Dr Ritch).

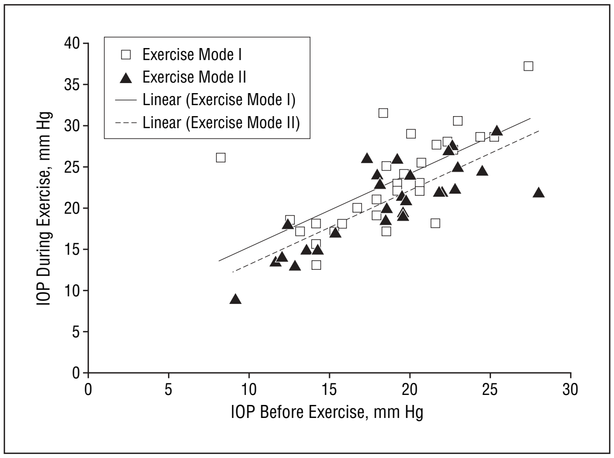

Figure 1. Scatterplot of the distribution of intraocular pressure (IOP) variations in exercise modes I and II.

has a pair of small, hook-shaped poles (in which the bar with weights fits) at its head. An 80% of 1 maximum repetition (the maximum weight a person can lift at 1 attempt) was standardized for each subject. The 1 maximum repetition value was determined from 1 week to 1 day before the start of the IOP measurements.

An electronic tonometer (Tono-pen XL; Medtronic Solan, Jacksonville, Fla) was used to measure IOP. Only valid measures (within a 95% confidence interval) were accepted. The instrument was calibrated daily before use. Special care was taken to fit the covering latex membrane neither too loosely nor too tightly. At least 4 measurements were obtained in the right eye in each subject before and during exercise, as well as before, during, and after exercise in the left eye, and the averages were computed. One experienced examiner (G.M.V.) obtained all measurements. Subjects lay supine on the bench press bank and remained still for 5 minutes. Before starting the exercise, a drop of proparacaine hydrochloride 0.5% (Alcon, Ft Worth, Tex) was instilled in the eye that was to be assessed.

Two exercise modes were tested. Both eyes of each subject were enrolled so that right and left eyes were chosen to evaluate modes I and II, respectively. In mode I, the subjects performed 4 repetitions, exhaling when lifting the weight and inhaling when lowering it. At the last repetition, however, subjects were instructed not to exhale but to keep holding the breath and to hold the bar elevated long enough for the examiner to obtain 1 or 2 reliable measurements (around 8 seconds) in the right eye. In mode II, subjects were asked not to hold the breath at the last repetition but to continue to exhale while lifting the bar for the IOP measurements in the left eye. The IOP was checked again in the left eye 1 minute after subjects finished the exercise. A 1-hour rest period was interposed between exercise modes I and II.

Statistical analyses were performed by using SPSS 12.0 (SPSS Inc, Chicago, Ill). The IOP measurements were subjected to paired *t* tests. $P < .05$ was considered significant.

RESULTS

We enrolled 60 eyes of 30 healthy subjects (mean ± SD age, 25.8 ± 6.1 years; range, 18-40 years). The mean 1 maximum repetition top load was 66.1 kg (range, 40-112 kg). The mean exercise load was 52.6 kg (range, 31-90 kg).

Mean ± SD IOP before exercise in the right eye of subjects who performed exercise in mode I was 18.6 ± 4.2 mm Hg and during exertion was 23.0 ± 5.6 mm Hg. Mean IOP increased by 4.3 mm Hg (median, 3.8 mm Hg) during mode I ($P < .001$). The IOP increased in 27 (90%) of 30 individuals. An increase in IOP greater than 5.0 mm Hg was found in 9 individuals (30%). Two subjects had marked elevation of IOP to 13.1 and 17.7 mm Hg. In 3 subjects (10%), IOP decreased during exercise in mode I (**Figures 1** and **2**).

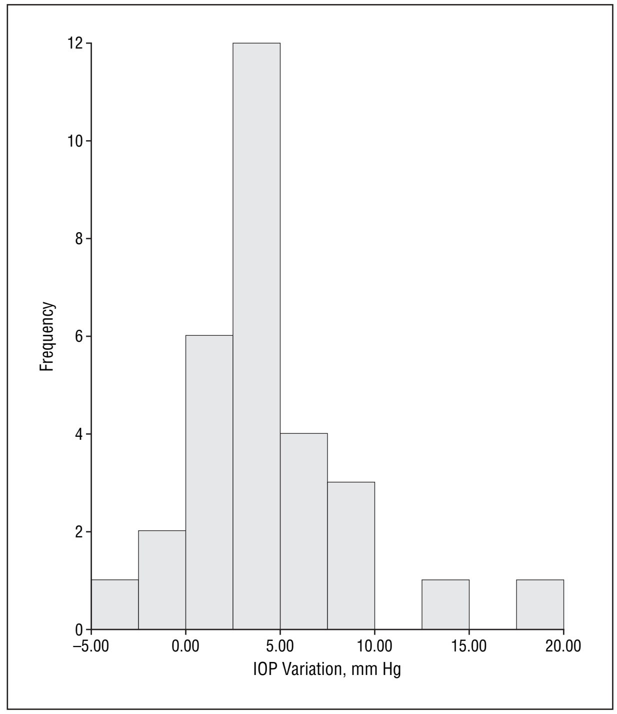

Figure 2. Histogram of intraocular pressure (IOP) variations in the 30 subjects in exercise mode I. Mean ± SD was 4.3 ± 4.2 mm Hg.

We tested 29 eyes in 29 subjects in mode II. One subject was excluded because of inability to keep his eye open for a reliable IOP measurement. Mean ± SD IOP before exercise in the left eye of subjects who performed mode II was 18.8 ± 4.6 mm Hg and during exercise was 21.0 ± 5.1 mm Hg. There was a small but significant increase of 2.2 ± 3.0 mm Hg in mean ± SD IOP (median, 1.6 mm Hg) during mode II ($P < .001$). The IOP increased in 18 (62%) of 29 individuals. Six subjects (21%) in mode II exhibited an increase in IOP of at least 5.0 mm Hg. None of the subjects had an elevation greater than 10.0 mm Hg. Five subjects (17%) showed a decrease in IOP. In 4 of them, there was only a small decrease of less than 1.0 mm Hg. In 3 individuals, mean IOP did not change during the exercise in mode II (Figure 1 and **Figure 3**). There was no significant correlation between IOP change in both modes and age.

Mean ± SD IOP measured 1 minute after finished exercise was 17.5 ± 3.6 mm Hg. A small but significant decrease of 1.3 ± 2.9 mm Hg was observed ($P = .02$). Exercise in mode I led to an IOP increase greater than that of exercise in mode II (4.3 ± 4.2 mm Hg [range, −3.6 to 17.7 mm Hg] vs 2.2 ± 3.0 mm Hg [range, −6.0 to 8.7 mm Hg]), and that difference was statistically significant ($P = .006$).

COMMENT

Few studies have been conducted on IOP variation during weight lifting. Biro and Botar[20] demonstrated an IOP increase when a belt was tightened firmly around the waist, simulating a Valsalva maneuver that occurs during weight lifting. However, this does not accurately depict the real situation. We tested subjects performing a bench press, a popular exercise in health clubs. To standardize the effort exerted independent of the physical attributes of each subject, we preestablished an 80% top load for each one so that the exertion was approximately the same for all.

The mean IOP increased significantly during weight lifting, greater in mode I than in mode II. In mode I, 90% of subjects had an IOP increase, compared with 62% in mode II. An IOP increase greater than 5.0 mm Hg occurred in 30% of subjects during mode I vs 21% during mode II. An IOP increase greater than 10.0 mm Hg occurred in 2 subjects in mode I and in none in mode II. Conversely, 28% of subjects in mode II had decreased or maintained constant IOP during exercise vs 10% in mode I.

To perform a proper Valsalva maneuver, a forced exhalation against a closed glottis leading to a sudden increase in intrathoracic pressure, one must exhale against a constant pressure of 40 mm Hg. Valsalva maneuvers occur during coughing, vomiting, lifting heavy objects, and playing wind instruments. The increase in IOP during weight lifting may be the result of a Valsalva maneuver,[22] which, in association with contraction of abdominal and thoracic muscles, causes an extra increase in intrathoracic venous pressure and compression of the intrathoracic venous system. The increase in intrathoracic venous pressure is transmitted through the jugular, orbital, and vortex veins to the choroid, bringing about vascular engorgement, an increase in the choroidal volume, and an increase in IOP.[23,24] The greater IOP increase during exercise mode I may be due to greater intrathoracic pressure caused by the air retained in the lungs when the subjects held their breath during IOP measurement. Another possible mechanism for the IOP increase is an increase in episcleral venous pressure, which increases at a much slower rate than does choroidal engorgement.[21]

A marked IOP increase during exercise was found in a study in which 11 athletes produced maximal isometric contractions, holding their breath while seated.[21] A mean ± SD IOP of 28.0 + 9.3 mm Hg was observed during contraction, with a mean elevation of 15.0 mm Hg from preexercise levels. One subject reached an IOP of 46 mm Hg. Two individuals were excluded because of large subconjunctival hemorrhages that had occurred during weight lifting practice 2 days before. In our study, the mean IOP increase was much smaller. The nature of the exercise tested and the use of 80% maximal load in our study may account for this difference. Also, the use of a power belt around the subjects' waists exacerbated the abdominal pressure, contributing to a further increase in IOP levels in the study by Dickerman et al.[21]

Three individuals showed a small decrease in IOP during exercise in mode I, and 5 showed a decrease during exercise in mode II. Rosen and Johnston,[23] studying the variations in IOP during the Valsalva maneuver in healthy subjects and patients with glaucoma, described a "negative pattern response" in a minority of patients, more common in patients with glaucoma than in healthy subjects, in which IOP decreases during the Valsalva maneuver. They hypothesized that decreased systemic arterial pressure during the Valsalva maneuver could have led to decreased intraocular blood volume that overshadowed the increase in thoracic venous pressure, the net result being a lower IOP.

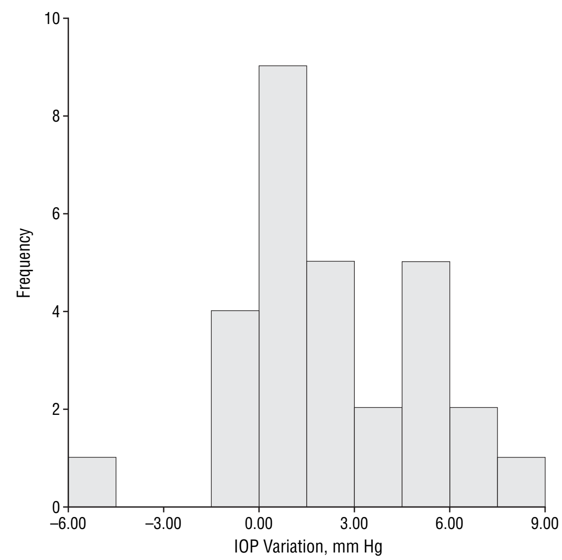

Figure 3. Histogram of intraocular pressure (IOP) variations in the 29 subjects in exercise mode II. Mean ± SD was 2.2 ± 3.0 mm Hg.

After the exercise, a small but significant decrease in IOP was observed in the left eye of the participants in mode II in the present study. This finding confirms the results obtained by other authors.[18,19]

Normal-tension glaucoma is more common in patients with exposure to potential transient increases in IOP caused by intrathoracic and intraabdominal pressure, such as lifting weights regularly, playing high-resistance wind instruments, or having asthma or chronic urinary tract obstruction or intestinal obstruction.[25] Normal-tension glaucoma is more common in those who play high-resistance wind instruments compared with those who play low-resistance wind instruments.[24]

Prolonged weight lifting could be a potential risk factor for the development or progression of glaucoma. Intermittent IOP increases during weight lifting should be suspected in patients with normal-tension glaucoma who perform such exercises. The subjects in our study were all 40 years or younger and had no history of glaucoma. Individuals with glaucoma generally have reduced outflow facility, so they may endure a larger IOP increase than those without glaucoma. Further studies are under way in older subjects, those with many years of weight lifting experience, and those with glaucoma. Patients with normal-tension glaucoma should be questioned as to a history of regular weight lifting.

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Correspondence: Robert Ritch, MD, Glaucoma Service, Department of Ophthalmology, New York Eye and Ear Infirmary, 310 E 14th St, New York, NY 10003 (ritchmd@earthlink.net).
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