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Correlating intraocular pressure, blood pressure, and heart rate changes after jogging

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PURPOSE. *To examine the effects of jogging on intraocular pressure (IOP), blood pressure (BP), and heart rate (HR).*
METHODS . *Twenty-nine healthy individuals–25 athletes and 4 untrained–were studied. IOP, systolic and diastolic BP, and HR were measured before and just after 20 minutes of jogging (submaximal – 70% – aerobic exercise).*
RESULTS. *IOP decreased after jogging. Only three individuals had unchanged IOP in one eye and one individual in both eyes. The IOP decrease (1 to 8 mmHg) was statistically significant ($p<0.001$). BP increased after jogging (systolic: 0 to 60 mmHg, statistically significant changes, $p<0.001$; diastolic: 0 to 15 mmHg, statistically significant changes, $p<0.001$). HR increased as well (15 to 80 pulses/min, statistically significant changes, $p<0.001$). However, there were individuals who presented a significant decrease of IOP and a mild BP rise and vice versa, and also individuals with mild IOP decrease and significant HR change and vice versa. The statistical analysis clearly showed that there are no linear quantitative correlations between BP or HR changes and IOP changes.*
CONCLUSIONS. *IOP decreases after jogging. Changes in BP and HR values have no linear quantitative correlation with IOP decrease. (Eur J Ophthalmol 2004; 14: 117-22)*

KEY WORDS. *Jogging, Aerobic exercise, Intraocular pressure, Blood pressure, Heart rate*

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INTRODUCTION

Aerobic exercise (such as running or walking) has a tendency to reduce intraocular pressure (IOP), whereas anaerobic exercise (such as weight lifting or horizontal bars) tends to increase it (1, 2). Blood pressure (BP) increases during physical exercise. This rise mainly concerns systolic pressure and, to a lesser degree, diastolic pressure. Individuals who are regularly trained with physical submaximal aerobic exercise tend to have lower BP before and after the exercise, as compared to untrained individuals (3).

The present study aims to evaluate the effect of jogging on IOP and to offer some new considerations on the possible mechanisms that are implicated, correlating these changes with BP variations and with heart rate (HR) changes before and after the exercise.

MATERIALS AND METHODS

We examined 29 healthy young individuals (18 males and 11 females). The age ranged from 13 to 18 years. Twenty-five of them exercised regularly (athletes) and four of them were physically untrained.

We measured IOP (applanation tonometry), systolic

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and diastolic BP, and HR before exercise and just after the completion of 20 minutes of submaximal – 70% – aerobic exercise (jogging). The individuals examined went on running inside the examination room until the initiation of the BP and HR measurements. The IOP measurements followed immediately.

RESULTS

The detected differences of the measured values as compared before and after jogging are shown in Table I.

In all examined subjects the IOP was reduced after the exercise and, in the great majority of them, the reduction concerned both eyes. The change in IOP values ranged from 0 to 8 mmHg. The two most serious reductions of 8 mmHg were measured in two untrained individuals; however, IOP decrease of 6 to 7 mmHg was also measured in athletes. Considering separately the right and left eyes, the results are as follows: right eye–before the exercise, mean IOP=13.586, SD=2.322, and after the exercise, mean IOP=10.275, SD=2.458 (statistically significant difference, $p<0.001$); left eye–before the exercise, mean IOP=13.448, SD=2.045, and after the exercise, mean IOP=10.500, SD=2.405 (statistically significant difference, $p<0.001$). Three individuals had unchanged IOP in one eye and one individual in both eyes. There was no

TABLE I - MEASURED DIFFERENCES OF SYSTOLIC AND DIASTOLIC BLOOD PRESSURE (BP), HEART RATE (HR), AND INTRAOCULAR PRESSURE (IOP), IN RIGHT EYE (OD) AND LEFT EYE (OS), AFTER JOGGING

Subjects	Systolic BP increase (mm Hg)	Diastolic BP increase (mm Hg)	HR increase (pulses/min)	IOP (OD) decrease (mm Hg)	IOP (OS) decrease (mm Hg)
1.A	40	5	70	1	2
2.A	30	5	68	4	0
3.A	25	10	73	0	2
4.A	20	0	72	2	2
5.A	20	5	62	2	0
6.A	25	5	80	2	2
7.A	35	10	76	4	3
8.A	10	10	78	4	5
9.A	40	0	80	3	5
10.A	10	0	75	4	3
11.A	55	10	76	1.5	3.5
12.A	0	20	76	2	2
13.A	15	0	76	3	3
14.A	10	10	79	5	6
15.A	10	10	79	4	3
16.A	30	10	15	2	0
17.A	25	10	58	6	6
18.A	15	5	72	1	1
19.A	35	20	76	2	2
20.A	20	10	77	7	4
21.A	20	0	73	0	0
22.A	35	5	74	4	3
23.A	15	0	76	6.5	3
24.A	20	5	78	2	2
25.A	5	15	77	1	2
26.U	25	0	42	8	8
27.U	60	15	62	2	4
28.U	10	0	75	5	4
29.U	10	0	73	8	5

A = Athlete; U = Untrained

statistically significant difference (p>0.5) between the two eyes.

The maximum systolic BP that was measured after the exercise was 190 mmHg. The mean systolic BP before the exercise was 127.000, SD=13.846, and after the exercise was 149.138, SD=17.272 (statistically significant difference, p<0.001). The diastolic BP also changed significantly after jogging and the maximum measured value was 105 mmHg in an untrained subject, who had 90 mmHg before the exercise. The mean diastolic BP before the exercise was 76.724, SD=8.374, and after the exercise was 83.275, SD=9.753 (statistically significant difference, p<0.005).

HR also increased after the exercise (before exercise mean=65.965, SD=5.596, and after exercise mean= 136.586, SD=10.527). These changes are also statistically significant, p<0.001.

There were 11 individuals (8, 10, 13, 14, 15, 17, 20, 23, 26, 28, 29) who presented a rather strong reduction in IOP (3 to 8 mmHg) and a mild increase in systolic BP (≤25 mmHg) and 3 individuals (1, 16, 19) who presented a mild decrease of IOP (≤2 mmHg) and a significant increase of systolic BP (>30 mmHg). There are also 9 individuals (3, 4, 5, 6, 12, 18, 21, 24, 25) presenting a mild decrease of IOP (≤2 mmHg) and a mild increase of systolic BP (≤25 mmHg) and 6 individuals (2, 7, 9, 11, 22, 27) presenting significant IOP reduction (≥3 mmHg), at least in one eye, and significant systolic BP rise >30 mmHg. Consequently, no obvious direct quantitative correlation was detected between the systolic BP changes and the IOP decrease.

Additionally, a similar correlation concerning the diastolic BP and the HR changes gives conflicting considerations, as shown in the statistical analysis that follows. In order to compare the higher and lower changes for statistical reasons, critical differences of the BP and HR were considered those that approximately divided our material in half.

Comparing the IOP reduction between the individuals who had an increase of systolic BP >20 mmHg after 20 minutes of jogging and those who had an increase ≤20 mmHg, we found that the mean IOP reduction (resuming the values of both eyes) of the first group was 6.153847, SD=4.038279, and of the second group was 6.343750, SD=3.815402 (not a statistically significant difference, p>0.5).

Comparing the IOP reduction between the individuals who had an increase of diastolic BP <10 mmHg after 20 minutes of jogging and those who had an increase ≥10 mmHg, we found that the mean IOP reduction (resuming the values of both eyes) of the first group was 6.156250, SD=4.233670, and of the second group was 6.384616, SD=3.477031 (not a statistically significant difference, p>0.5).

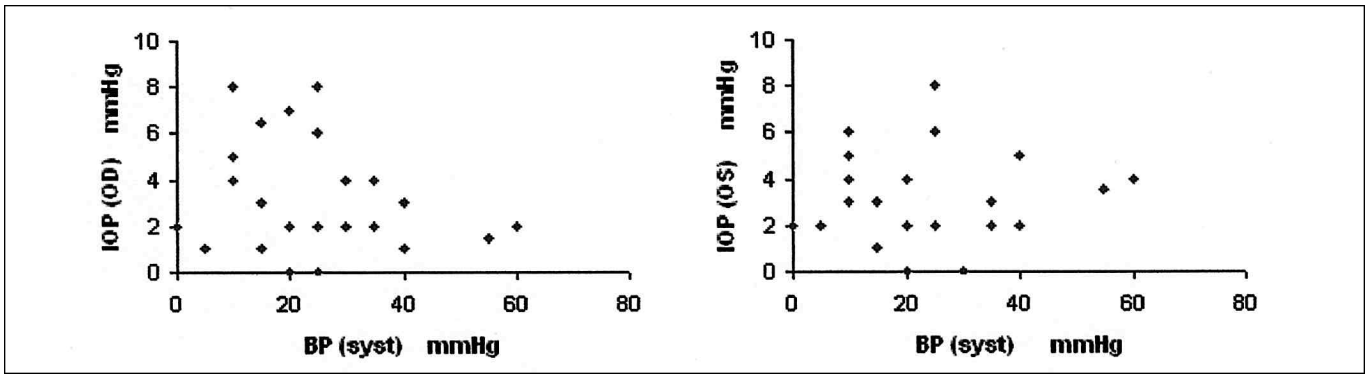
Comparing the IOP reduction between the individuals who had an increase of HR >75 pulses/min after 20 minutes of jogging and those who had an increase ≤75 pulses/min, we found that the mean IOP reduction (resuming the values of both eyes) of the first group was 6.607143, SD=2.746877, and of the second group was 5.933334, SD=4.727831 (not a statistically significant difference, p>0.5).

Additionally, the statistical analysis was extended with the creation of scatter diagrams, comparing the following pairs: systolic BP and IOP separately for right and left eyes, diastolic BP and IOP (right and left eyes), HR and IOP (right and left eyes). In these scatter diagrams (Fig. 1), it is clearly indicated that there is no linear correlation between the differences of the values of these pairs after jogging.

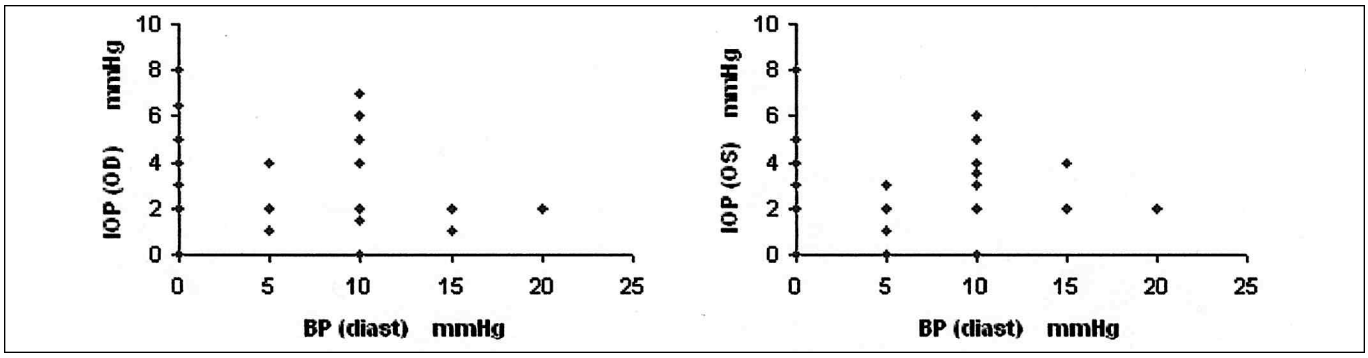
DISCUSSION

The influence of different kinds of exercise on IOP was determined in different studies and the possible implicated mechanisms for this particular IOP behavior were investigated in various ways and are still under investigation.

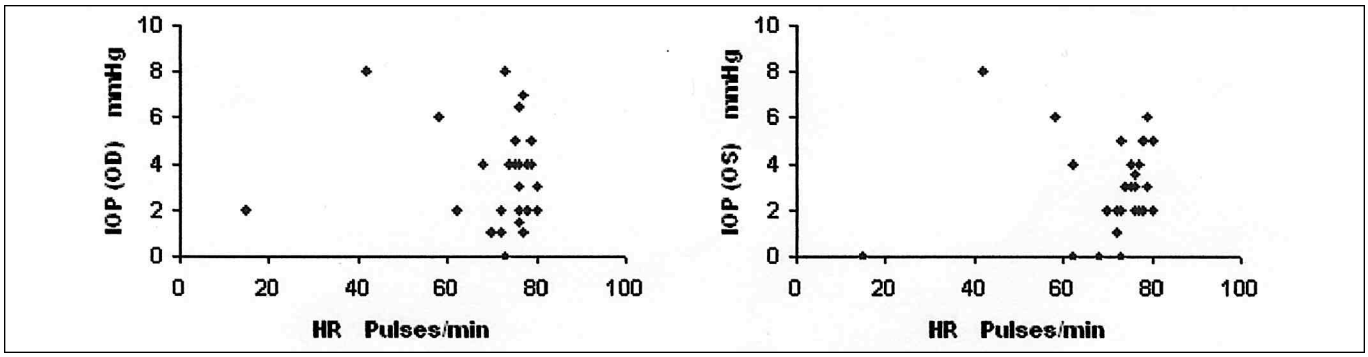
Era et al (4) studied the effects of the bicycle ergometer test and concluded that this kind of exercise has a moderate, if any, effect on IOP. They did not find significant relation to the intensity and the duration of exercise. Qureshi et al (5-10) concluded in different studies that physical fitness reduces IOP and causes significant attenuation in the IOP response to physical exercise. They proposed that it would seem reasonable not to discourage patients who have glaucoma from light exercise; on the contrary, perhaps, they should be encouraged. However, certain precautions should be kept in mind, concerning the BP and the HR increase, because, as is clearly shown in the present study, the BP and the HR show a significant increase due to exercise. Passo et al (11) reported decrease of IOP (5.9 ± 0.6 mmHg) after maximal aerobic exercise and also noticed that the decrease and



a) *Correlation between the systolic BP increases and the IOP decreases (OD and OS separately)).*



b) *Correlation between the diastolic BP increases and the IOP decreases (OD and OS separately).*



c) *Correlation between the HR increases and the IOP decreases (OD and OS separately).*

Fig. 1 - *Scatter diagrams correlating the differences of the values (before and after jogging) of the following pairs:* **a)** *systolic blood pressure (BP) and intraocular pressure (IOP) of right eye (OD) and left eye (OS) separately* **b)** *diastolic BP and IOP of OD and OS separately,* **c)** *heart rate (HR) and IOP of OD and OS separately. The distribution of the values clearly shows that there are no linear correlations.*

the baseline of IOP were lower after 4 months of training. It is known that physically trained individuals, in general, tend to have lower BP as well (3). Qureshi et al (12) found that the intensity of exercise seems responsible for the magnitude of the initial IOP decrease after short-term exercise and that other factors, such as duration or quantity of exercise, BP, and body mass index, are not related to the amount of the initial fall of IOP. Martin et al (13) concluded that acute dynamic exercise and isosmotic fluid ingestion each seem to change IOP through changes in colloid osmotic pressure. However, such changes are influenced by the

BP and HR rate changes as well. Furthermore, Moura et al (14), studying the effects of submaximal exercise with water ingestion, concluded that IOP was not affected by exercise and that water ingestion increased IOP as expected. Harris et al (15) reported decrease of IOP after acute dynamic exercise and concluded that the reduction of IOP correlated with the increase of blood lactate. They did not find correlation with the plasma osmolarity or the Pco_2. They also reported that beta-blockers, which also have a lowering effect on BP, might have an additive effect on the exercise-mediated IOP decrease. Stewart et al (2) tried to correlate the norepinephrine blood concentration by applying norepinephrine topically in one eye of the examined individuals, but did not observe any significant difference in IOP behavior between the two eyes after exercise. The autonomous nervous system is implicated with BP and HR changes as well. Orgul and Flammer (16) reported that moderate exercise (six deep knee bends) lasting only seconds reduces IOP and correlated this with the changes in HR, concluding that the IOP reduction was the result of sympathetic activity. In a similar way, Lanigan et al (17) reported IOP responses as a result of systemic autonomic stimulations. They correlated them with the increase in diastolic BP after sustained isometric muscle contraction as a response mediated by the sympathetic nervous system and also with HR responses to Valsalva maneuver as a response mediated by the parasympathetic nervous system.

There is ongoing interest in the mechanisms of exercise-mediated IOP reduction. The innovative element of the current study is the effort to correlate quantitatively the detected changes of BP and HR with changes in IOP before and after jogging in a substantial number of individuals in an attempt to offer insights into the possible mechanisms of this IOP behavior. The current study failed to reveal quantitative correlation between increase in BP or HR and reduction of IOP.

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