Effect of a maximal treadmill test on intraocular pressure and ocular perfusion pressure: The mediating role of fitness level

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Abstract

Objectives: We compared the impact of a maximal treadmill test on intraocular pressure and ocular perfusion pressure between trained and untrained individuals.

Methods: Based on the maximal aerobic capacity (relative VO₂ max), 31 military helicopter pilots were divided into groups of trained (n = 16; VO₂ max = 57.06 ± 1.66) and untrained (n = 15; VO₂ max = 43.42 ± 1.19) individuals. Intraocular pressure and blood pressure were collected before effort, just after volitional exhaustion and after 5 and 15 min of recovery.

Results: The maximal treadmill test induced significant changes on intraocular pressure (p < 0.001, η² = 0.52) and ocular perfusion pressure (p < 0.001, η² = 0.60). Intraocular pressure and ocular perfusion pressure increased just after volitional exhaustion (effect size = 0.88 and 1.59, respectively), and these values returned to baseline levels after 5 (effect size = 0.87 and 1.26, respectively) and 15 (effect size = 1.23 and 1.91, respectively) min of recovery. The untrained group exhibited higher intraocular pressure and ocular perfusion pressure values in comparison with the trained group just after volitional exhaustion (effect size = 1.43 and 0.11 for intraocular pressure and effect size = 2.81 and 0.96 for ocular perfusion pressure). Five minutes of recovery was insufficient to reach baseline intraocular pressure and ocular perfusion pressure values only for the untrained group (effect size = 0.91 and 0.72, respectively).

Conclusion: Our findings reveal that fitness level modulates the intraocular pressure and ocular perfusion pressure responses to a maximal treadmill test, being high fitness levels desirable in order to attenuate the impact of maximal efforts on these indices. These outcomes may be of clinical relevance for the management of glaucoma patients or those at risk, although future studies are needed to test these results in a clinical population.

Keywords

Glaucoma management, ocular physiology, rebound tonometry, cardiorespiratory fitness, ocular health

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Introduction

There is accumulated evidence on the influence of regular physical activity for overall health and cognitive function.¹–³ However, the physiological responses to exercise may vary depending on numerous factors such as fitness level, exercise intensity, health status or exercise mode among others. Therefore, the same exercise may lead to either positive or negative outcomes in two different individuals, being individualized exercise prescription the most recommended method to avoid undesirable effects.⁴

The practice of exercise has demonstrated to impact a wide variety of physiological mechanisms (e.g. hormonal
and cardiovascular), including the ocular physiology. In this regard, there have been several ocular indices such as the neural conductivity in the visual pathway, neuroretinal activity, tear osmolarity, intraocular pressure (IOP), and optic nerve and macular perfusion, among others, that have revealed to be sensitive to physical effort. In the last years, due to the positive association between mean levels and peaks of IOP and the risk of glaucoma, numerous researchers have focused on the short- and long-term effects of different types of physical exercise on IOP. Related investigations have reported that low-intensity exercise causes an IOP reduction, whereas highly demanding physical exercise (all-out cycling sprints or strength exercise) induces an acute IOP rise. In conjunction with IOP, ocular perfusion pressure (OPP) is considered a key factor to be evaluated in the management of glaucoma, and its instability with wide fluctuations would lead to optic-nerve-head injury. In this sense, higher levels of physical activity seem to have a beneficial impact on OPP, which may permit to reduce the prevalence of glaucoma.

Fitness level has shown to be an important modulator of the acute physiological responses to exercise. For example, high-fit individuals maintain a superior cardiovascular function during incremental exercise. Vera et al. found that trained individuals showed a more attenuated tear osmolarity rise after performing an incremental maximal test in comparison with untrained individuals. Also, the acute IOP response to all-out cycling sprints against different loads was modulated by participant’s fitness level, showing a more stable IOP response to the group with higher fitness level. In view of this, it seems relevant to test whether fitness level could have a potential impact on OPP, which may permit to reduce the prevalence of glaucoma.

To address these research gaps, participants performed a maximal treadmill test, while IOP and blood pressure (BP) measurements were taken after physical effort, just after volitional exhaustion and after 5 and 15 min of recovery. Specifically, the aims of this study were (1) to explore the acute impact of a maximal treadmill test on IOP, BP and OPP responses to a maximal treadmill test and, consequently, it would help to clarify the potential benefits of physical activity on the reduction of IOP and OPP fluctuations during strenuous physical effort.

Methods

This study complied with the Declaration of Helsinki and was approved by the University Institutional Review Board (IRB approval: 112/CEIH/2016). A total of 41 members of the Spanish Army participated in this study. They were physically active and free of any ocular or systemic disease. The following inclusion criteria were imposed: (1) to have a baseline IOP ≤21 mmHg which is considered as the upper limit for normal baseline values; (2) to present a baseline blood-pulse pressure (difference between systolic and diastolic BP) lower than 59 mmHg, since higher values are considered as an indicator of possible cardiovascular disorder; (3) to accomplish the criteria for maximal exercise test of a VO2 plateau prior to exhaustion, respiratory exchange ratio ≥1.10 and a maximal heart rate within 10 beats per minute (bpm) of age-predicted maximum (220 – age); and (4) to belong to the trained (relative VO2 between 45 and 55 mL min−1 kg−1) or untrained (relative VO2 <45 mL min−1 kg−1) group following the recommendations of De Pauw et al. First, participants were classified according to their fitness level, and 16 participants formed the trained group, 10 participants the recreationally trained group (relative VO2 between 45 and 55 mL min−1 kg−1), and 15 participants the untrained group. For analysis purposes, all participants from the recreationally trained group were discarded. Therefore, 31 participants (16 in the trained group and 15 in the untrained group, see Table 1 for descriptive characteristics) formed the experimental sample. An a priori power analysis using the GPower 3.1 software showed that a total sample size of 30 was required for our experimental design, with an assumed effect size of 0.25, alpha of 0.05 and power of 0.90. Participants were asked to avoid any strenuous exercise 2 days prior to each testing session, as well as alcohol and caffeine-based drinks 24 h and 12 h, respectively. Finally, they were instructed to sleep at least 7 h the night before testing and keep their regular diet the day of testing.

An h/p/COSMOS pulsar (Nussdorf-Traunstein, Germany) treadmill was used to conduct the maximal physical test. The warm-up consisted of running 3 min at 8 km/h with a 1% slope. Afterwards, initial treadmill speed was set up to 10 km/h with a 1% slope, and it was progressively increased in 0.25 km/h every 15 s until the participants reached volitional exhaustion. After exhaustion, participants walked at 4 km/h (0% slope) for 5 min (active recovery). Participants were fitted with the fall prevention system during the test. Pulmonary gas exchange and electrocardiography signal (Ultima CardiO2; Medical Graphics Corporation, St Louis, USA) were continuously recorded from the warm-up stage until the end of the active recovery period (i.e. 5 min after completing the test).

A rebound tonometer (Icare, Tiolat Oy, Inc., Helsinki, Finland), which has been clinically validated and commonly