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Effect of exercise on intraocular pressure

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ABSTRACT: To determine the effect of physical exercise on intraocular pressure (IOP), twentyfive (25) healthy Adults aged between 18 – 32 years with mean age of 23.80±3.77yrs were examined. The participants were selected from five busy gymnastic centers in Benin metropolis. They were all Emmetropes, with good physical conditions and had no history of any ocular or systemic disease. The IOP for each participant was measured between the hours of 3pm–6pm with the Perkins Hand-Held Tonometer after the application of topical anesthesia (0.5% tetracaine). The IOP was measured before and immediately after each exercise (tread-mill Jogger and Skipping). Thereafter, it was measured at intervals of 30minutes and 60mins respectively. The result obtained showed that the observed mean IOP before the exercise was 14.55 ± 2.35 mmHg, and the mean IOP immediately after treadmill jogging and Skipping exercises were 8.66 ± 1.98 mmHg and 11.18 ± 1.915 mmHg respectively. Also, the IOP readings 30mins and 60mins after treadmill jogging was 12.61±1.797 mmHg and14.97 ± 2.71 mmHg respectively while that after skipping was 13.19 ± 2.235 mmHg and 14.75 ± 2.08 mmHg respectively. Statistically, there was significant decrease in mean IOP immediately after treadmill jogger and skipping exercise using one way analysis of variance ANOVA (F= 1.813, F=16.951, P<0.05).The IOP value returned to normal after 60mins of the exercise. Thus, physical exercise results in a decrease in IOP. Patients with increased IOP may benefit from regular exercise in order to enhance aqueous outflow to avoid the development of glaucoma.

Keyword: Intra ocular pressure; Aqueous secretion; Perkins hand-held tonometer; Treadmill jogging; Skipping.

Introduction

Intra ocular pressure (IOP) is the pressure within the eye which enables it maintain its normal physiological functions. The amount of pressure which the eye can tolerate without compromising it's integrity ranges between 10- 20mmHg with an average value of 16 mmHg . Intraocular pressure is generated by constant secretion of aqueous at the rate of 3µl/min. This is by the non-pigmented ciliary epithelium via an active metabolic process that is dependent on a number of enzymatic (Na+-K+ ATPase and carbonic anhydrase) activity. This account's for about 80% of aqueous secretion while the remaining 20%, is secreted by passive diffusion and ultra filtration process. This process depends on the level of blood pressure in the ciliary capillaries and the plasma oncotic pressure [(1,2)].
Aqueous is a colourless fluid which is similar to blood plasma except for its high concentration of ascorbate (antioxidant), pyruvate, lactate and reduced concentration of protein and urea. It provides nutrient (amino acid and glucose) for the surrounding avascular tissues such as posterior cornea, trabecular meshwork, lens, anterior vitreous, etc. and also help in the removal of waste metabolic products from the tissues [(1,2,3,)]. For normal IOP to be maintained, the rate of production of aqueous must be equal to the rate of drainage i.e. there must be a state of equilibrium between the rate of secretion of aqueous and the rate of its outflow.

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The mechanism of production involves the secretion of aqueous into the posterior chamber by the ciliary epithelium before it flows through the pupil into the anterior chamber. From the anterior chamber, it is filtered through the Trabecular meshwork which has sieve-like connective tissues namely: uveal, corneoscleral and endothelial meshwork. Then it is emptied into the the schelmn's canal which drains it into the collector channels, the episclera veins the vortex vein. Thus, the two main routes of aqueous drainage are: the conventional trabecular meshwork, which is responsible for 90%, and the unconventional uveosclera route which is responsible for 10% of aqueous drainage [2,3].

Many physiological factors have been found to influence IOP. Some of these include: age, exercise, temperature and diurnal variation which ranges from 4 mmHg in a normal eye to as high as 10 mmHg in a glaucomatous eye [2,4,5,6]. Other factors include blood pressure, blood osmolarity, external factors such as body position , pressure on eye globe, forced closure of eye lids and contraction of rectus muscle [,7,8,9,].

Physical exercise is a body-based activity which is primarily performed to change and control the body physiological and biochemical function. This is because it helps to increase the transportation of oxygen to all parts of the body cells and tissues, where it is used to metabolize the glucose to produce energy needed for other physical activities. During rest period, the blood flow through skeletal muscles at an average rate of 4-5ml/min/100grams of muscles. But this could increase to as much as 12-18 fold, rising to 50-75ml/min/100grams, during exercise. In such situation, all capillaries open up and blood flow increases thereby decreasing the distance from which oxygen and nutrient diffuse into the muscular fibresd[10] . Exercise also increases muscular activity during which the muscle rapidly utilizes dissolved oxygen thereby decreasing it's concentration in the tissue fluid. This leads to vasodilatation either because their walls cannot contract due to oxygen deficiency or because of the release of some vasodilator materials which include: Adenosine, K+, Ach, ATP, lactic acid and carbondioxide. And these materials help to increase muscle blood out flow. Also skeletal muscles are provided with sympathetic vasoconstrictor/vasodilator nerves which secrete neurotransmitters norepinephrine and epinephrine. The vasoconstrictor nerve secretes norepinephrine which causes the constriction of vessel by exciting alpha receptors and consequently decreases the blood flow to about one quarter of a normal. The vasodilator nerve secretes epinephrine which causes dilation because it excites the beta receptors and consequently increases blood flow. These nerve fibres are activated by special nervous stimulation beginning in the cerebal cortex which is in close association with the motor area for control of muscular activity and transmitted via hypothalamus and brain stem into the spinal cord. Readjustment begins with mass discharge of systemic nervous system throughout the body with consequent stimulatory effect on the circulation. Increase cardiac output and increase arteriole pressure occurs as a result of vasoconstriction of most blood vessel and subsequently increase in mean arterial pressure. This activities produces heat and increases the body temperature thereby stimulating thermoregulatory mechanism which dissipates the excess heat in form of sweat. This activity could lead to increase in blood lactate, blood pyruvate, blood pressure and pulse rate. There could also be increase in blood plasma osmolarity, as well as increase acidosis leading to decrease in blood pH and consequent decrease in intraocular pressure [10,11,12,13].

Exercise can either be strenuous or non-strenuous e.g. karate, skipping, jogging, cycling, mill-reading, etc. Strenuous exercise affects the physiological activity of the body more than the non-strenuous[14,15,16]. Tread mill jogging is a type of exercise that involves maintaining an average distant run while skipping involves a slight forward movement and quick jumps with each step. Studies have shown that exercise cause reduction in IOP [17,18,19,20,21,19,20,21,22,23,24,25,] . Also exercise increases blood pressure, and consequently increase the episcleral pressure and thus increase outflow of aqueous [27,28]. Other factors that affects intraocular pressure body position during the exercise [6,7,8].

Materials and Methods

A prospective study was carried out on twenty five (25) volunteers who routinely go for exercise daily. The subjects who were aged between 18 – 32 years with mean age of 23.80±3.77 were all healthy emmetropes with good physical condition and had no history of ocular/systemic pathology. The baseline IOP for each subject was first measured before the commencement of the exercise. Each subject was made to complete the exercise (treadmill joggers and skipping) for 5minutes and the IOP was then measured first, immediately after and then atinterval of 30 & 60 minutes. The study was in two phases: phase 01 which involved the treadmill exercise and phase 02 which involved the skipping exercise. The first phase lasted for one week and the second phase which started the next day also lasted for one week. The procedure for IOP measurement involved first, desensitizing the cornea with two (02)

drops of topical anesthesia (1% tetracaine hydrochloride). With the subjects in a supine position, the Perkins Tonometer was held with the right hand and the probe gently placed on the central cornea of the patient as he looks up direct at the ceiling. The mires of the instrument which are two (02) arcs were made to torch at the inner tips and the reading in mm recorded. The equivalent of the value in mmHg then gave the value of the IOP (1 mm = 10 mmHg). All the measurements were taken between the hours of 3.00pm- 5.oopm. The first week was allotted for treadmill joggers exercise while the second week was for skipping exercise. Each measurement was repeated twice and the average value noted.

Results

Table 1 shows that there was a decrease in mean IOP immediately after the exercise. However the IOP returned to its original baseline value 60minutes after the exercise. The mean IOP before treadmill jogging was 14.551±2.317, immediately after was 9.132±1.411, and 30mins and 60mins later were 12.60±1.797 and 14.97±2.271 respectively. Statistically there was a significant decrease before and immediately after treadmill jogging using One Way Analysis of Variance ANOVA ($F=1.813, P<0.05$). Also it was still statistically significant both at 30minutes and 60minutes later ($F=3.063$, $F=4.688, P<0.05$)

Table 1: Age Distribution of mean IOP, before and immediately, and then 30mins and 60mins after Treadmill joggers exercise in the sample population.

Age range	**Mean IOP**			
	Before	Immediately	30 mins After	60 mins After
18 – 20	13.74±1.59	8.15±2.05	8.46±1.65	12.86±1.82
21 – 23	14.43±2.94	7.70±1.47	9.48±1.37	15.25±1.75
24 – 26	15.04±1.89	8.77±1.57	9.14±1.46	14.25±2.89
27 – 29	14.94±3.39	8.92±1.67	9.73±2.00	15.93±1.39
30 – 32	15.25±0.91	8.31±2.14	10.05±2.14	13.75±5.02

Table 2 shows that the observed mean IOP immediately after the exercise decreased in all the age groups immediately after the exercise. However, this value started to increase and returned to baseline value 60minutes after the exercise. The mean IOP before skipping was 14.658±2.224, immediately after was 11.049±1.943, and 30mins and 60mins later were 13.19±2.235 and 14.75±2. respectively. Statistically there was a significant decrease before and after treadmill jogging using one way analysis of variance (Statistically there was a significant decrease before and immediately after treadmill jogging using one way analysis of variance ANOVA ($F=16.951>0.05$). Also it was still statistically significant both at 30minutes and 60minutes later ($F=7.326$, $F=19.635, P<.05$)

Discussion

Tables 1 and 2 showed that the observed mean IOP values before and immediately after decreased in both exercises (treadmill jogging and skipping). However this value started to increase and returned to baseline value after 60minutes. The reason for this is that during exercise all capillaries open up and blood flow increases, thus there is rapid utilization of dissolved oxygen from the tissue fluid. This lead's to the depletion of oxygen from tissue fluid, and subsequently vasodilatation of the vessel resulting in increase blood flow. There is also rise in blood lactate and plasma osmolarity thereby leading to decrease in blood pH. The consequence of this change in blood chemistries leads to decrease in intraocular pressure [10,11].

Table 2: Age distribution of Mean IOP, before and immediately, and then, 30 and 60minutes after skipping exercise in the sample population.

Age range	**Mean IOP**			
	Baseline	Immediately	30mins After	60mins After
18 – 20	13.74±1.59	9.64±0.98	10.82±1.79	12.86±1.82
21 – 23	14.43±2.94	11.08±2.27	12.44±1.09	15.25±1.78
24 – 26	15.04±1.89	10.82±1.87	11.77±2.03	14.22±2.89
27 – 29	14.94±3.39	10.96±1.80	11.90±1.57	15.93±1.35
30 – 32	15.25±0.91	10.32±2.61	11.95±0.35	13.75±5.02

Treadmill jogging (Table 1) showed a higher decrease than skipping (Table2). The reason for this is that tread mill jogging is a more strenuous exercise than skipping. thus, had greater demand for oxygen utilization. This led to increased heart rate, vasodilatation of blood vessels , and consequent increase in blood flow and body temperature. This will in turn stimulate thermoregulatory mechanism of the hypothalamic centre for the dissipation of the excess heat in form of sweat (dehydration) [12,13]. This may lead to accumulation of potassium ion and osmotically active metabolites at a more rapid rate than they can be carried away. This results in increased plasma osmolarity, blood lactate (acidosis), and subsequent decrease in blood pH leading to increase systemic blood pressure and intraocular pressure. Also exercise leads to physiological changes in drainage tissues of the ocular system by causing the opening of the sclera spur leading to increase aqueous outflow and consequent decrease in IOP [14,15,16].

The tables also showed that the IOP for those of ages 30-32years took a slightly longer period to return to baseline value and this is because the physiological activity of the muscular cells and tissue decreases with increase in age[4,5,6]. The result also showed that the decrease in IOP immediately after and the consequent increase afterwards were statistically significant. The reason for this is because as soon as exercise is anticipated cardiovascular changes takes place as a result of vagal inhibitions and a generalized sympathetic discharge. This will result in increase in heart rate and myocardial contractility leading to the dilation of the vessels that supply the muscles whilst those supplying the kidneys, abdominal viscera and the skin constrict. The overall effect of this is to increase cardiac output and specifically, the blood supply to the muscles. With the onset of the exercise further dilation of muscular arterioles and capillaries occurs and venous return is augmented by the pumping action of the muscles. This action increases both the systolic and diastolic blood pressure, resulting in the distension of the arteries within the eye. This increases the filtrated fraction of the aqueous humour and consequently causes a decrease in the intraocular pressure. Increase in systemic blood pressure could also cause an increase in ciliary artery pressurethereby causing more aqueous to be secreted by ultrafiltration.It is worthy of note that the effect of exercise depends on the type and duration of the exercise[30,31,32],.

Conclusion

Exercise is found to cause a decreases intraocular pressure and the amount of reduction is dependent on the type of exercise. The more strenuous exercise would cause a greater decrease than the non strenuous type. Thus would recommend that exercise be included in the management of patients with ocular hypertension and acute glaucoma attack. Also individuals with a family history of glaucoma should be advised to have regular exercise to help them with the maintenance of average intraocular pressure. Also patients who are been managed for glaucoma especially young adults should be encouraged to exercise on a daily basis.

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