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THE EFFECT OF ACUTE PHYSICAL ACTIVITY ON LEVELS OF STEREOACUITY

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Abstract

The effect of acute physical exercise on levels of stereoacuity was examined in 8 subjects. The subjects' ocular state was assessed by testing distance and near vision, contrast sensitivity, the near and distance deviation, convergence, near fusion range and stereopsis. This was followed by a bout of moderate exercise on a Monark bicycle ergometer and on completion the ocular tests were repeated. There were 8 subjects in a control group who underwent the same ocular assessment but did not participate in the exercise.

Key words: *Stereopsis, contrast sensitivity, vision, ocular muscle balance, fusion range, moderate exercise.*

INTRODUCTION

While it may be generally accepted that sportspersons must have good visual acuity for successful athletic performance, stereopsis is also considered to be necessary. In basketball, for example accurate stereopsis is considered to be an important factor in a player's ability to shoot for the basket[1], and Jolly and Jolly[2] found that successful competitive tennis players scored significantly higher on a stereoacuity test when compared to a normal population. They hypothesised that the natural selection which operates in sporting activities may be influenced by visual standards. The effect of accurate stereopsis has been questioned by Beals et al (cited by Sherman)[1], who suggested that the level of dynamic visual acuity (DVA) may be more important than depth perception.

DVA and kinetic visual acuity (KVA) are defined as "visual acuity for the moving target".[3] The distinction between DVA and KVA is the "difference in the direction of movement of the test object". DVA is tested when the test object is moved in horizontal and vertical directions. KVA is tested when the test object is moved from far to near. Suzumura[4] studied the effect of acute exercise on DVA and KVA. He found that KVA was decreased following an acute exercise bout. These results are in agreement with Watanabe.[3] Watanabe's study revealed that while KVA is decreased following an exercise bout, static visual acuity (SVA) remained unchanged immediately after exercise, but increased 7-9 minutes later and was maintained at that level until 21 minutes post exercise. This increase was statistically significant. He suggested that different physiological mechanisms may be involved in SVA and KVA in terms of visual perception. These results were not compared to those of a control group.

Visual acuity is only one component of stereoacuity. The other components which affect

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TABLE 1
Number and age of subjects

	No.	Mean Age	Range	Female	Male
Exercise group	8	33 yrs	22-48 yrs	4	4
Control group	8	32 yrs	17-48 yrs	6	2

the level of stereoacuity are ocular muscle balance and the fusion ability. As visual acuity has been found to alter with exercise, the aim of this pilot study was to investigate the effect of physical activity on stereoacuity, by examining stereopsis and its components, namely, vision, contrast sensitivity, and ocular muscle balance including convergence and fusion.

METHOD

Subjects

Sixteen subjects were randomly assigned to either the control or the exercise group. Subjects' details are summarised in Table 1. All subjects were non-orthoptist employees of the Lincoln School of Health Sciences. None had any previous ocular history or history of cardiorespiratory disease which limited their ability to participate in moderate physical exercise. Subjects were fully acquainted with experimental procedures and all signed a written consent form prior to participation in the study. The study was approved by the University's Ethics Review Committee.

Method of Visual Assessment

A number of visual tests were performed both prior to and following the experimental treatment. The tests chosen were those which gave a quantitative measure of function where possible. They were visual acuity at 6 metres and at 1/3 metre, contrast sensitivity at near, measurement of the near and distance deviation by prism cover test, ocular muscle balance, fusion range and stereoacuity.

Visual Acuity

This was tested uniocularly with a Snellen's Chart at 6 metres. The same chart was used for the pre and post tests. The maximum level possible was 6/4. No subject wore glasses for distance. Near vision was tested uniocularly at 1/3 metre using the Moorfields Bar Reading book. Reading glasses were worn by one subject in the control group.

Contrast Sensitivity

Contrast sensitivity was tested with the Vistech vision contrast sensitivity test system (VCSTS), Model 6000 designed for use at near. This test was chosen as it is considered to be a more sensitive test of visual function than a visual acuity test. The test was administered uniocularly. Reading glasses were worn by one control subject. The results were recorded by noting when a grating was visible and the orientation correct. Subjects were encouraged to attempt the grating beyond that at which they had originally stopped, as suggested in the manufacturer's instructions.

Measurement of the Deviation

Measurements were taken to quantify the amount of the deviation and any change post exercise. The type of deviation (ie whether the deviation was latent or intermittent) was not considered to be relevant. Measurements were taken by the prism cover test at 1/3 metre and at 6 metres while the subjects fixed on an accommodative target. The size was assessed as the strength of prism below that where a reversal of movement was noted.

Ocular Movements and Convergence

Ocular pursuit movements were assessed to detect any gross abnormality; no attempt was made to objectively measure pursuit or saccadic velocities. The convergence near point was measured with the RAF near point rule. The subjects were asked to maintain single vision while fixing on the vertical line with the dot as it was moved towards the nose. The convergence near point was assessed at the position where the subject indicated that the target had formed a double image. This was performed three times and an aggregate measurement was taken.

Fusion Range

The near convergence and divergence ranges were measured with the prism bar while the subject fixed on an accommodative target. The maximum convergence range was recorded at 45△, this being the largest prism on the bar.

Stereoacuity

Stereoacuity was tested in the near position using the TNO stereotest. The level recorded was the maximum level at which both plates were appreciated correctly.

PROCEDURE

The exercise group followed the first set of visual tests with a 15 minute bout of moderate exercise. Subjects cycled on a Monark bicycle ergometer at a work load selected to elicit a heart rate representing 70 to 75% of their predicted maximal heart rate as described by Astrand et al[5]. Heart rate was continually monitored throughout the exercise period using a heart rate monitor (PE 3000 Sport Tester). The control group followed the first set of visual tests with a 15 minute rest period. The second set of visual tests followed either the exercise or the rest period for the exercise and control groups respectively. This study employed a 2 x 2 design with one between-subjects factor (group) and one within-subjects factor (pre-post test). Analysis of differences between groups was performed using an independent groups t-test on the differences between pre and post-test scores in each group for each of the dependent variables except visual acuity. The significance level for each test was 0.05.

RESULTS

Visual Acuity

The majority of subjects in both groups had 6/6 vision or better in each eye. One subject in the exercise group had 6/9 vision in the left eye only. In each group, 2 subjects recorded a reduction of one line in one eye between the pre and post tests. Clearly there was no difference between the groups on pre and post testing.

Near Vision

All subjects in both the exercise and control groups had N5 vision at near. There were no differences at the post test.

TABLE 2
Measurement of the near deviation

	Exercise Group		Control Group	
Subjects	Pre	Post	Pre	Post
1	0	+1△	−10△	−10△
2	−10△	−4△	−8△	−14△
3	−4△	−4△	−1△	−1△
4	+14△	+18△	−16△	−12△
5	−6△	−4△	−4△	−6△
6	−6△	−4△	−14△	−10△
7	−2△	−1△	−1△	−1△
8	−2△	−2△	0	−1△

Contrast Sensitivity

Both groups were similar at the pre-test, and were similar for both left and right eyes. At the post-test, the control group had higher mean values at each of the five contrast levels while the exercise group showed a minimal increase in the lower and mid contrast levels. The contrast sensitivity results are shown in Figures 1 and 2. They are represented cumulatively, that is the values of each eye were totalled and the mean values are represented on the tables.

Measurement of the near deviation

The near prism cover test results are shown in Table 2. In the exercise group, 6 subjects showed a change in the deviation. Subjects 2, 5, 6 and 7 recorded slightly less divergent deviations, while subjects 1 and 4 recorded a slight increase in the convergent deviations. Only 2 subjects remained unchanged. In the control group, 3 subjects measured differently post test. Subjects 2 and 5 showed an increase in the divergent deviation. Subject 4 demonstrated an increase in the convergent deviation. The remaining 4 subjects were unchanged. While this change in the deviation of the experimental group is interesting it was not statistically significant.

Measurement of the Distance Deviation

The results of the distance measurement show no change between the pre and post tests in either group, except from one subject in the exercise group whose convergent deviation increased from 1△ to 2△. This was not statistically significant.

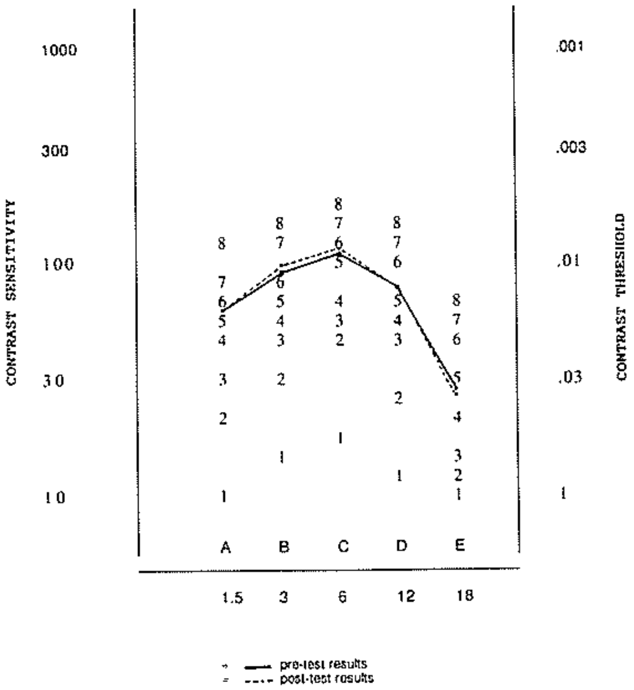

Figure 1: Cumulative results of both eyes of Experimental Group.

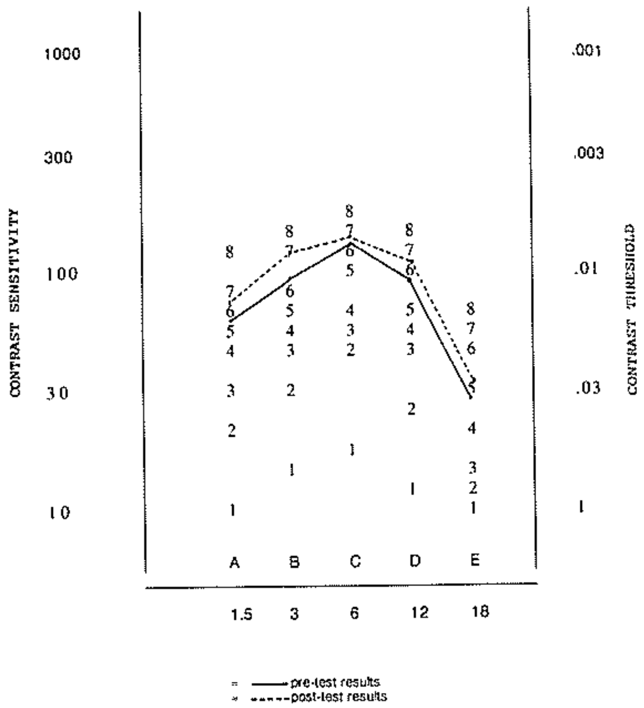

Figure 2: Cumulative results of both eyes of Control Group.

Ocular Muscle Balance
No subjects in either the exercise or control groups had any gross defect of smooth pursuit movements at the pre test. The equipment was not available to measure pursuit or saccadic velocities, but on gross assessment there were no changes post test. At pre test, the mean convergence near point of the exercise group was 6 cms, which was the same at the post test. The mean of the control group at pre test was 7cms and it too remained unchanged at post testing.

Fusion Range
Four subjects in the exercise group showed mild (average of 4△) increase in the fusion range, while one subject showed no change and one, a decrease of 1△ . The same changes were noted in the control group. These differences were not statistically significant. The fusion ranges are shown in Table 3.

Stereoacuity
The results of testing stereoacuity with the TNO pre and post testing is shown in seconds of arc in Table 4. The average score of the two groups was quite different at the pre test which was largely due to control subject 5. Without this subject, the groups showed less discrepancy at pre test and show similar decreases at post test. These differences were not statistically significant.

DISCUSSION

The effect of exercise on visual acuity.
There was no statistically significant difference between the results at pre and post testing. The mild reduction of vision of the 4 subjects cannot be explained except to suggest that it was most likely to be the effects of test-retest reliability.

The effect of exercise on contrast sensitivity.
The importance of the raised values is not clear. It may be that the raised values of the control group indicated merely random error as the group sizes were small. It may also be due to a problem with test-retest reliability, that is, on post-test the control group was more familiar with the test and so scored higher. It is not possible to ascribe a cause for these observed differences given the limitations of the study.

TABLE 3
Fusion Range

Subject	Exercise Group Pre-test Conv	Exercise Group Pre-test Div	Exercise Group Post-test Conv	Exercise Group Post-test Div	Control Group Pre-test Conv	Control Group Pre-test Div	Control Group Post-test Conv	Control Group Post-test Div
1	+45△	− 6△(51△)	+45△	− 6△(51△)	+30△	− 8△(38△)	+35△	− 6△(41△)
2	+45△	−10△(55△)	+45△	−12△(57△)	+45△	−10△(55△)	+45△	−12△(57△)
3	+35△	−13△(48△)	+45△	−12△(57△)	+35△	−16△(51△)	+35△	−16△(51△)
4	+45△	−11△(56△)	+45△	−14△(59△)	+20△	−14△(34△)	+20△	−14△(34△)
5	+25△	−16△(41△)	+25△	−15△(40△)	+45△	−12△(57△)	+40△	−18△(58△)
6	+18△	− 6△(24△)	+20△	−10△(30△)	+45△	−18△(63△)	+45△	−18△(63△)
7	+45△	−10△(55△)	+45△	−12△(57△)	+16△	−12△(28△)	+13△	−15△(28△)
8	+45△	−14△(59△)	+40△	−10△(50△)	+18△	−12△(30△)	+22△	−12△(34△)

(The figures in brackets are the total fusion range)

None of the differences were statistically significant.

The effect of exercise on the deviation.

While the changes in the deviation measured at near are not statistically significant, it is of clinical interest that there was an apparent increase in the esophoria and a decrease in exophoria amongst the exercise group, which was not evident in the control group. A possible explanation for these observations is that an increase in body temperature causes an increase in conduction velocity in muscles. This may be sufficient to cause an increase in convergence particularly when the eyes are already in that position, that is, the medial recti are in a state of contraction. This would explain why the increase was evident at near only.

The effect of exercise on ocular pursuit and vergence movements.

While there were some changes in convergence near point results, none of the differences were statistically significant. They may be due to the subjectivity of the test. Subjects were encouraged to maintain single vision for as long as possible, and it was impossible to ascertain if the effort to converge was equally applied at the pre and post tests. This possibly could be overcome by examining a larger group.

TABLE 4
Stereoacuity

Subjects	Exercise Group Pre	Exercise Group Post	Control Group Pre	Control Group Post
1	60″	60″	60″	60″
2	30″	15″	120″	60″
3	30″	30″	30″	30″
4	60″	60″	60″	30″
5	30″	30″	480″	240″
6	60″	30″	60″	60″
7	30″	30″	15″	30″
8	60″	60″	120″	60″

The effect of exercise on the fusion range.

As there was an apparent increase in the convergent deviation of the subjects in the exercise group at near, it might be expected that there would have been a corresponding increase in the fusion range at near. This was not found to be so. When the results of these subjects' fusion range was compared to the near deviation, in cases 2, 6 and 7, there was an increase in the fusion range and in case 5 there was a decrease. While this is interesting, the major increase was in case 3 who did not show any alteration in the near deviation. Unfortunately, convergence was only assessed to 45△ on the prism bar. It is conceivable that if convergence had been measured to its maximum, any increase would have been evident. However, there was no increase on convergence as measured on the RAF gauge except in 2 cases and that was only by 1cm in each case.

The effect of exercise on stereoacuity.

As there was no statistically significant difference found in any of the tests of the various aspects of visual function which combine to result in a person's ability to perceive depth, it was predictable that stereoacuity was not altered by exercise. However, it may be interesting in future experiments to examine differences in eso and exo disparity by appropriate changes in presentation of the tests, as it may change with alteration of the near deviation.

CONCLUSION

In conclusion, there were no statistically significant differences between either the exercise or control groups on pre and post testing for visual acuity, contrast sensitivity, ocular muscle balance, fusion range or stereoacuity. It is interesting, however, to speculate on the small differences which were found. Most may be due to subject error, to test-retest error, or to a learned response in cases of minor differences recorded in vision testing, convergence, fusion range and stereoacuity testing. If there had been a larger number of subjects some of these errors may have been minimised.

The results of the contrast sensitivity did not demonstrate as marked a learning curve tendency as in the control group. A larger group would help to explain whether this is test-retest error or whether contrast sensitivity is affected by acute exercise.

While the differences in the results of the measurements at the pre and post tests were not statistically significant, the fact that 6 of the 8 subjects in the exercise group showed an increase in the deviation in a convergent direction is interesting and may be an indication of increased conduction velocity in the medial recti muscles. More studies are necessary to prove this hypothesis.

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