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A profile of Senaptec strobe in young elite university athletes

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Abstract
Background: Stroboscopic visual training has shown improvement in cognitive skills and perceptual performance by performing motor tasks under situations of intermittent vision.
Aim: The aim of this study to compare the improvement of visuomotor skills in athletes after the Stroboscopic visual Training.
Methods: Thirty male Athletes were assigned for strobe group (EG n=15), and for control group (CG n=15). 15 Strobe group (SG) took part in SVT programme, and their performance on 6 measures of visual and perceptual skills was compared with 15 Control group (CG) Athletes. Whilst the EG wore Senaptec Strobe and control group CG continued to train with unimpaired vision. Post Training assessment were administered after 10 mins of SVT. Reaction test, Eye Hand coordination was administered pre and post SVT. This involves the Laptop for EHC and iPhone 6S for Reaction test using Reaction Test pro and PT Balance is used to evaluate balance.
Results: The strobic effect were absorbed at each time. Baseline performance was significant related to Post performance immediately 10 min, visual response time ($p = 0.001$), Reaction time ($p = 0.01$), Eye hand coordination ($p = 0.02$). No significant differences were found for NPA, NPC, Balance measures.
Conclusion: The analysis of the SVT programme in SG Athletes show consistent improvements in the visual response time at post-test, were the CG Athletes did not. The present research on Stroboscopic Visual Training has the potential to improve the visuomotor skills in the young athletes.

Keywords: Stroboscopic visual training, visuomotor skills, skill acquisition

Introduction

Stroboscopic visual training (SVT) is a new approach for enhancing visual and perceptual performance by requiring people to execute tasks while their vision is intermittent. It has been demonstrated in studies to help with visual memory, anticipation, and dynamic acuity [1]. Stroboscopic visual training (SVT) is the practise of subjecting people to intermittent vision, generally through the use of specialised eyewear, in order to improve their visual and perceptual skills [1].

SVT has quickly acquired popularity as a viable, user-friendly visual teaching method in sports and other fields. Given this development and the wider expansion of digital sports vision training tools, it is critical to think about how future uses of this technology and related research might be optimised [2, 3].

SVT has been reported to increase central-field motion sensitivity (3) short-term visual memory [5], anticipation [6], dynamic visual acuity [7], processing speed [8], and accommodation [3, 1].

Improvements in sport performance as a result of visual training interventions are investigated in this study [9]. Many sports demand athletes to react fast to visual information. As a result, swift and precise visual and neuromuscular processing is an important ability for athletes, and numerous tools have been developed to assess and enhance visual–motor reaction speed [10].

Athletes with an uninterrupted supply of accurate and reliable visual information perform better. While optimal conditions are normally required for peak performance, athletes have a long history of training in less-than-ideal situations [10].

Stroboscopic training has been shown to improve eye-hand reaction speeds, visual span, peripheral awareness, visualisation skills, and dynamic visual acuity [11]. The visual system and systems that interpret visual information account for about 80% of sensory input to the brain. Visual signals are processed by many pathways in the central nervous system to determine where and what the eyes view, allowing the brain to assess the placement and movement of visual objects in space.

Visual processing, visual fields, and visual reaction times are all important in a variety of sports, and they also play a part in athletic accidents. By increasing neuro visual processing, vision training, a technique that includes visual exercises as part of an organised sports conditioning programme, can be utilised to improve sports performance and prevent injury. The concept of "lighting up" complex brain networks is included into vision training. The objective is to "stress" or "train" certain pathways. Processing sensory information and synchronisation between the occipital lobe and motor cortex are required for visuomotor skills [12].

The goal of these stroboscopic glasses is to increase visual processing, particularly cooperation between the occipital and motor brain [12].

SVT differs from many other visual, perceptual, and cognitive training tools in that it allows athletes to train in natural environments. Instead of performing tasks outside of the sports field/court/pitch, athletes can practise their regular sports-specific drills while wearing the stroboscopic eyewear [2].

Extensive athletic training has been demonstrated to enhance performance on a variety of perception and cognitive tests, including covert attentional orienting, visual search and anticipation, motion speed and direction discrimination, and reaction inhibition [13-16].

Aim

The primary goal of this research was to see how an acute SVT training period affected the practised task of 10 minutes [9].

The idea of strengthening visual and perceptual skills to obtain an advantage has grown increasingly attractive in professional athletics, given the ongoing drive to identify marginal improvements [1, 17].

The current research is an investigation into the effects of SVT on various visual and perceptual skills of 30 young elite athletes from the cricket, football, and volleyball teams (1).

It is hypothesised that participants who complete the SVT will considerably enhance their performance on the visual and perceptual skills in the post-test, based on previous studies. When compared to the control group, the strobe group was significantly more likely to respond quickly following training [1, 9, 6].

Methodology

Participants: Following informed consent and institutional ethics approval, thirty university athletes took part in this study, with 15 receiving stroboscopic training and the remaining 15 serving as a control group. On the basis of age and pre-test visual and perceptual skills, participants were matched as closely as possible. The participants were from team of cricket, football, volleyball.

The athletes were all exceptional athletes who had undergone extensive training and ranged in age from 19 to 25 years old. The Faculty of A.C.S Medical Sciences Research Ethics Committee gave its approval to the project.

Apparatus

Participants completed the computer-based tests using a Lenovo laptop. The Reaction Test Pro app (version 4.0) was completed using a 16-GB Apple iPhone 6. This has a 4.7-in. LED display and a 1334 × 750-pixel resolution. All tests, excluding the Reaction Test Pro, were completed using a standard computer keyboard and wireless computer mouse.

Four tests of PT Balance were Single Leg (Eyes Open), Single Leg (Eyes Closed), Tandem Stance (Eyes Open), Tandem Stance (Eyes closed).

Participants used the Senaptec Strobe glasses [18] to create the stroboscopic effect employed in the training programme.

These glasses flicker from clear to opaque at eight different frequencies, ranging from 6 Hz (the easiest because it receives the most visual samples) to 1 Hz (level 8; deemed hardest due to receiving the fewest visual samples). The stroboscopic effect can also be changed in three modes: both eyes, left eye only, and right eye only (when in one-eye mode, the non-strobing lenses remain in the opaque state). The Senaptec Strobe eyewear that was used in most of the prior research, as well as other commercially available items like the MJ Impulse and Vision up Strobe Glasses, are comparable in design.

Procedure

This study has conducted between (SG and CG) Strobe group and Control group. The SG group was start to the test. Prior to testing, participants were given general optometric tests for static visual acuity, dominant eye, Stereo acuity and colour vision to determine their degree of eye care and appropriateness for the study. The tests took around 10 minutes to administer and were found to be broadly typical of the assessment approaches used by practising optometrists.

The pre testing measurement consisting of reaction test (Reaction test pro app) [21] and (Faculty Washington) [20], Eye hand coordination test [19], Near point of accommodation (NPA), Near point of convergence (NPC), PT Balance test that includes Single Leg (Eyes Open), Single Leg (Eyes Closed), Tandem Stance (Eyes Open), Tandem Stance (Eyes closed).

The eyewear was explained to the participants prior to training. All participants were debriefed about the study and given a report of the outcomes following the post-test.

The CG group have tested for optometric evaluation and performed the same training protocol without stroboscopic training.

Measures

The test consists of 1. Near point of accommodation (NPA) measures accommodation 2. Near point of convergence (NPC) measures convergence 3. The Reaction Test Pro app measuring visual response time. 4. Faculty Washington (F/W) measures visual reaction time 5.PT Balance test measures balancing. 6. Eye hand coordination measuring test.

Stroboscopic training

Stroboscopic training has taken several forms, ranging from the employment of strobe lights in otherwise dark environments to the use of digitally controlled eyeglasses in realistic practise conditions. The underlying premise behind these methods is that by intermittently disturbing vision, people are only able to view brief snapshots of their surroundings, forcing them to train under more difficult conditions than they would otherwise face [3].

Liquid crystal lenses alternate between transparent and opaque states in the eyewear. The transparent state displays total visibility, while the opaque state displays a grey tint that indicates a higher level of visual difficulties. Selecting the appropriate speed controls the rate at which the transparent to opaque transition occurs (8 levels). At replicate the same frequency level used in earlier studies, they were set to level 3, 100ms clear, 150 ms opaque [5]. It took 7–8 minutes to replicate a similar SVT exposure in earlier study, depending on individual performances [5].

Training sessions included a variety of skills ranging from simple catching drills with a tennis ball to specialist drills with a football for cricket and volley ball players (such as those in Wilkins and Gray 2015) [8].

Participants practised each drill for a short time without the glasses first, then for a lengthy time with the glasses on, and then for a short time without the glasses to complete the sessions, which followed the same format as earlier SVT research. Participants progressed through eight degrees of strobe difficulty and switched between different eye modes during the time they wore the glasses.

The CG group have tested for optometric evaluation. The pre testing measurement consisting of reaction test (Reaction test pro), Eye hand coordination, near point of accommodation and near point of convergence, PT Balance test.

Fig 1: Image of an SG participant performing drill in SVT

Result

Descriptive Analyses: To demonstrate the mean performance scores were provided in a descriptive manner.

Table 1: Descriptive performance data. Data presented as mean ± SD

Measurement	NPC		NPA			EHC	REACTION TEST		PT BALANCE			
CRICKET (SG)	Subjective	Objective	OD	OS	OU		F/W	RTP	SLO	SLC	TSO	TSC
Pre	7.8 ±0.89	8±1.22	7.2 ±0.44	8.4±1.14	6.4±0.54	46.2±11.56	0.364±0.150	0.342±0.078	0.968±0.452	0.308±0.124	1.466±0.742	0.702±0.316
Post	7±1	8±1.22	6.8±0.44	7.6±1.14	6.2±0.84	61.6±5.63	0.263±0.029	0.280±0.043	1.268±0.126	0.33±0.132	0.81±0.890	0.638±0.426
CRICKET (CG)												
Pre	8±0.70	8±1.22	9.4±3.50	9.8±1.93	8.6±1.67	54.6±5.94	0.361±0.145	0.390±0.064	1.6±0.411	0.61±0.279	1.69±0.571	0.456±0.390
Post	8±0.70	8.6±1.14	9.4±3.50	9.8±1.93	8.6±1.67	54.6±6.65	0.357±0.155	0.396±0.065	1.268±0.170	0.45±0.331	1.504±0.147	0.962±0.480
Measurement	NPC		NPA			EHC	REACTION TEST		PT BALANCE			
FOOTBALL (SG)	Subjective	Objective	OD	OS	OU		F/W	RTP	SLO	SLC	TSO	TSC
Pre	7.4±1.94	6.8±0.83	7.2±2.03	7.8±1.51	7.4±1.09	46.4±9.52	0.378±0.078	0.321±0.043	1.02±0.206	0.164±0.123	0.902±0.362	0.486±0.165
Post	7.4±1.94	6.8±0.83	7.2±2.03	7.8±1.51	7.4±1.1	46.4±9.52	0.298±0.100	0.258±0.034	1.17±0.264	0.242±0.244	0.69±0.385	0.548±0.089
FOOTBALL (CG)												
Pre	7.6±1.94	7.2±0.83	8.4±2.30	8.6±1.51	8.2±1.09	45.8±9.52	0.493±0.078	0.34±0.043	1.238±0.206	0.368±0.123	1.152±0.362	0.438±0.165
Post	7.6±1.94	7.2±0.83	8.4±2.30	8.6±1.51	8.2±1.09	44.8±9.73	0.493±0.100	0.358±0.034	0.578±0.264	0.396±0.244	0.554±0.385	0.256±0.089
Measurement	NPC		NPA			EHC	REACTION TEST		PT BALANCE			
VOLLEYBALL (SG)	Subjective	Objective	OD	OS	OU		F/W	RTP	SLO	SLC	TSO	TSC
Pre	8.6±0.89	7.6±0.54	7.4±0.54	7.2±0.83	8.2±0.83	41.2±8.87	0.525±0.217	0.357±0.082	0.918±0.597	0.242±0.203	1.212±0.911	0.404±0.199
Post	8.6±0.89	7.6±0.54	7.4±0.54	7±1.22	8.2±0.84	53.6±6.73	0.323±0.581	0.262±0.070	1.246±0.743	0.412±0.326	0.676±0.518	0.27±0.169
VOLLEYBALL (CG)												
Pre	8±1.22	9.8±0.83	6.8±1.48	7.6±2.07	7.8±1.78	41.2±8.87	0.389±0.055	0.319±0.069	1.456±0.736	0.204±0.105	1.538±0.484	0.876±0.489
Post	8±1.22	9.8±0.83	6.8±1.48	7.6±2.07	7.8±1.79	55±5.29	0.374±0.065	0.323±0.070	0.926±0.555	0.334±0.150	0.69±0.363	0.312±0.109

SG - Strobe Group CG - Control group NPC - Near point Convergence NPA - Near point Accommodation EHC - Eye Hand Coordination

F/W - Faculty of Washington RTP – Reaction Test Pro SLO - Single leg open eyes SLC - single leg closed eye TSO - Tandem stance open eyes TSC - Tandem stance closed eyes

For the 15 SG and 15 CG subjects, Table 1 displays the results of the visual and perceptual tests at pre-test and post-test.

Convergence, hand-eye coordination, response time, single leg open eyes balancing, and Tandem stance open eye were among the six measures in which participant CSG1 exhibited consistent improvements (i.e. from pre- to post-test).

In five of the ten metrics, participant CSG2 exhibited consistent improvements. Accommodation, hand-eye coordination, response time, and balancing on one leg with eyes open are all skills that can be improved.

CSG3 improved consistently on five of the ten metrics. Eye-Hand coordination, reaction time, Single leg open eyes balanced and single leg closed eye.

Participant CSG4 showed consistent improvements in 4 out of the 10 measures: hand-eye coordination, reaction time, single leg open eyes balancing and Single leg closed eye.

Participant CSG5 showed consistent improvements in 5 out of the 10 measures: hand-eye coordination, reaction time, single leg open eyes balancing and Single leg closed eye.

Participant FSG1 showed consistent improvements (i.e. from pre- to post-test and) in 5 out of the 10 measures: hand-eye coordination, reaction time, single leg open eyes balancing and Single leg closed eyes.

Participant FSG2 showed consistent improvements in 6 out of the 10 measures: hand-eye coordination, reaction time, Tandem stance open eyes balancing, Tandem stance closed eyes.

Participant FSG3 showed consistent improvements in 4 out of the 10 measures: hand-eye coordination, reaction time, single leg open eyes balancing.

Participant FSG4 showed consistent improvements in 5 out of the 10 measures: hand-eye coordination, reaction time, single leg open eyes balancing and Tandem stance closed eye.

Participant FSG5 showed consistent improvements in 6 out of the 10 measures: hand-eye coordination, reaction time, single leg open eyes balancing and Single leg closed eye, Tandem stance open eye.

Participant VSG1 showed consistent improvements (i.e. from pre- to post-test and) in 5 out of the 10 measures: hand-eye coordination, reaction time, single leg open eyes balancing and Single leg closed eyes.

Participant VSG2 showed consistent improvements in 5 out of the 10 measures: hand-eye coordination, reaction time, single leg open eyes balancing and Single leg closed eyes.

Participant VSG3 showed consistent improvements in 5 out of the 10 measures: hand-eye coordination, reaction time, single leg open eyes balancing and Single leg closed eyes.

Participant VSG3 showed consistent improvements in 4 out of the 10 measures: hand-eye coordination, reaction time, single leg open eyes balancing.

Participant VSG3 showed consistent improvements in 4 out of the 10 measures: hand-eye coordination, reaction time, single leg open eyes balancing.

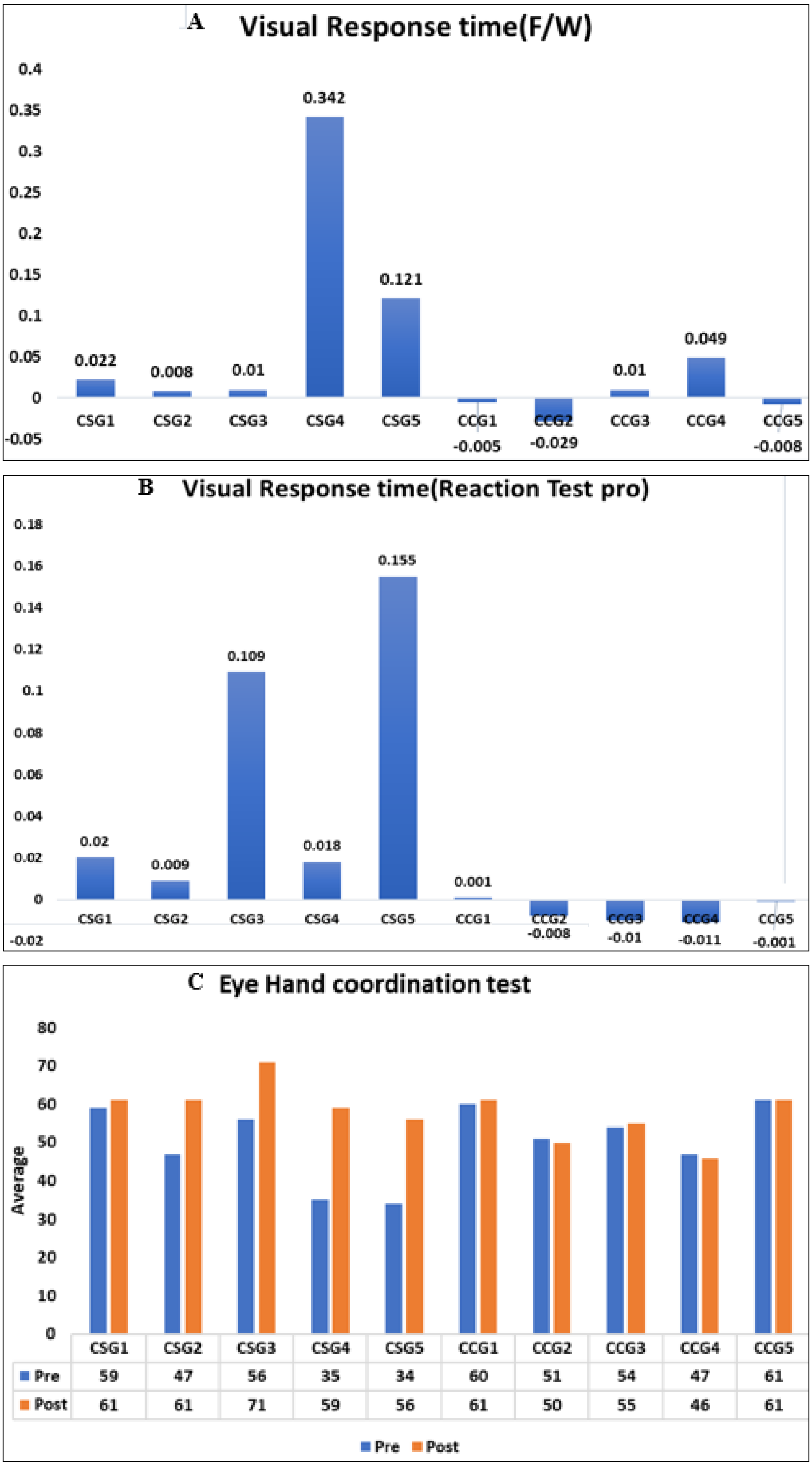

Fig 3: a) isal Response time (F/W) score variance between pre- and post-test for participants in CSG and CCG. b) Visual Response time (Reaction test pro) score variance between pre and post-test for participants in CSG and CCG. c) Eye hand coordination score variance between pre- and post-test for participants in CSG and CCG

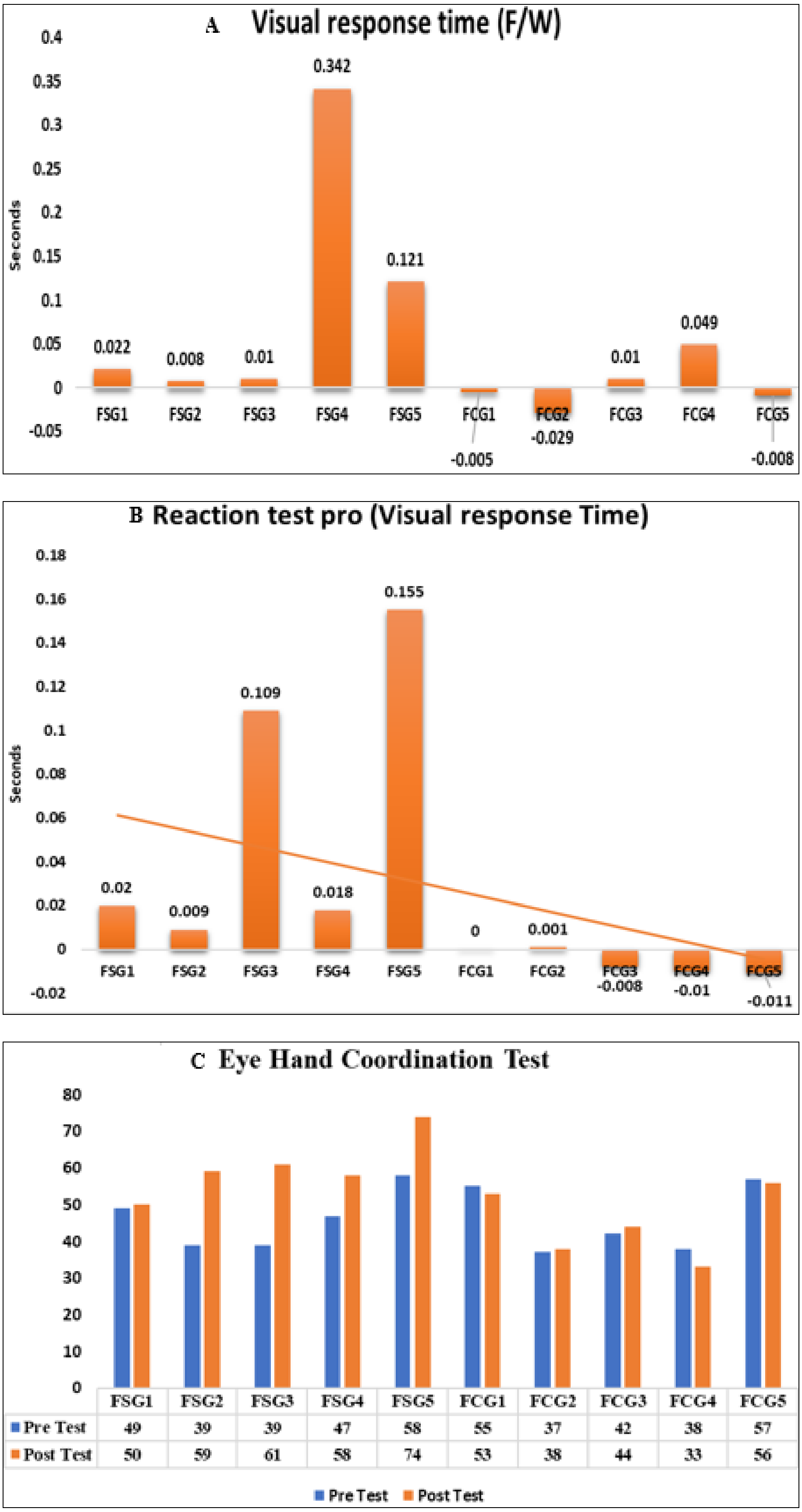

Fig 4: a) Visual Response time (F/W) score variance between pre- and post-test for participants in FSG and FCG. b) Visual Response time (Reaction test pro) score variance between pre and post-test for participants in FSG and FCG. c) Eye hand coordination score variance between pre- and post-test for participants in FSG and FCG

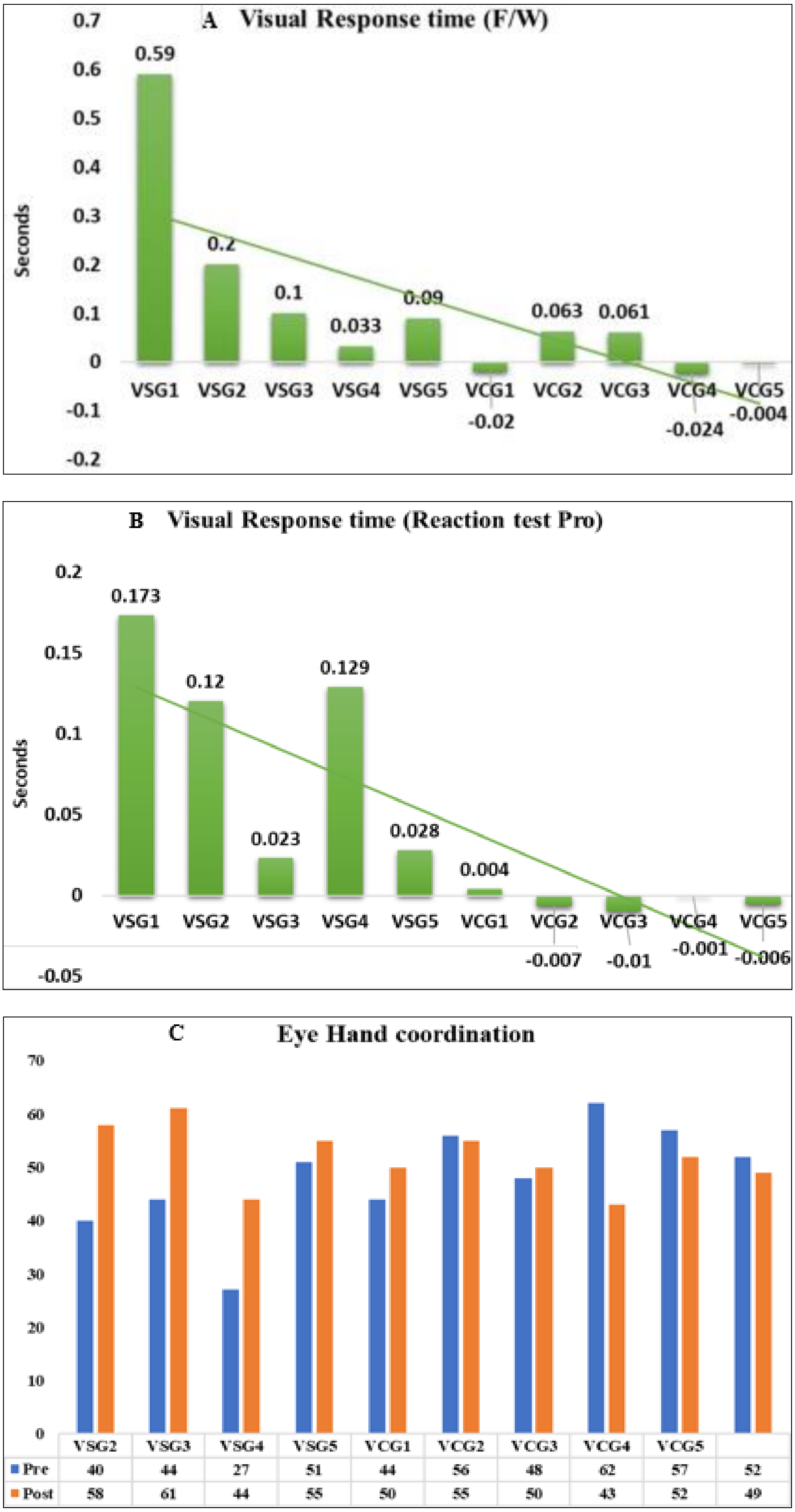

Fig 5: a) Visual Response time (F/W) score variance between pre- and post-test for participants in VSG and VCG. b) Visual Response time (Reaction test pro) score variance between pre and post-test for participants in VSG and VCG. c) Eye hand coordination score variance between pre- and post-test for participants in VSG and VCG

Statistical analyses

Significant difference after stroboscopic training between the two groups strobe group and control group (Cricket, football, Volleyball) was observed (Table 2). Eye Hand coordination (p=0.02), Visual Response - Reaction test pro (p=0.001) and Faculty Washington (p=0.01). When compared to the CG, the SG produced a significant improvement in performance.

Two methods of statistics are used to calculate the score from the pre-test baseline to the post-test for each experimental and control group. The shift from pre to post is mostly calculated by simply subtracting the scores for volleyball, football, and cricket players in order to evaluate individual changes between experimental and control groups. Along with population probability, which is provided by P value, odds ratios describe the better differences between athletes that have received SVT and athletes that have not undergone SVT. Athletes that underwent strobe training and testing to evaluate visual reactions like eye-hand coordination, reaction test (F/W and RPT), were found to have a strong significant relationship with this study's findings. Athletes who have undergone strobe training had a possibility of improving eye-hand coordination by 3% (OR = 0.0285, P = 0.02). For the F/W and RPT tests, athletes who had undergone strobe training had a 2% greater visual response than the athletes in the control group (OR = 0.0221,0.006), with significant population probabilities of P = 0.01, 0.001 for each test.

Table 2: Estimated Significance for strobe group and control group

Eye hand coordination						
Outcome	**Strobe group**	**Control group**	**Confidence Interval 95%**	**Z score**	**Odds ratio**	**P value**
Positive	15	7	0.0014,0,5618	2.339	0.0285	0.02
Negative	0	8				
Total	15	15				
Reaction test						
F/W						
Positive	15	6	0.0011,04379	2.2.502	0.0221	0.01
Negative	0	9				
Total	15	15				
RPT						
Positive	15	2	0.0003, 0.1357	3.214	0.006	0.001
Negative	0	13				
TOTAL	15	15				

Discussion

The goal of this study was to conduct research in the field of stroboscopic visual training. Thirty elite athletes from cricket, football, volleyball were took part. Fifteen undergoes SVT and other fifteen acts as a control group. The Strobe group and the control group are directly compared in the current study. Out of six measures NPA, NPC, Visual response time, Reaction Time, Eye Hand Coordination, and Balance Test. The quantitative data gathered indicates that SG performs better than CG. The SG experienced a significant improvement in visual response time (pre- to post-training) compared to the CG. For SG compared to CG, the improvement in eye-hand coordination was significantly greater. Visual response time, reaction time, and eye-hand coordination were the three metrics used to demonstrate the benefits of SVT, and they all showed improvement between the pre- and post-test for the Strobe group. Response time and eye-hand coordination were two metrics that indicated some improvement following stroboscopic visual training. This reveals a significant improvement between the pre-test and post-test. None of the CG participants improved between the pre- and post-test. However, the statistically significant variations in visual response time, eye-hand coordination, and reaction time had some beneficial effects on the strobe group's practise. This results in superior in performance. Furthermore, we measured reaction times using Faculty Wahington, which also reveals how the SG has improved, benefiting the SVT. A benefit in visual cognition, visual reaction, and performance anticipatory timing has been demonstrated in prior research using SVT [9].

The quantitative data are compatible with the existing literature on SVT, that implies that study participants improve their visual and perceptual skills. An empirical investigation on eye-hand coordination [9] and visual response [1] reported benefits of SVT. The Strobe group had shown that the timing improved immediately following training. The actual tests that were used to assess the skills were varied from those in the proposed investigation. The Reaction test pro test used in the earlier research [1] on visual response time matches the test utilised in the current research on visual response time. In comparison to the earlier research, the visual response time has improved further in the SG participants. In this study, there was no statistically significant difference between the pre- and post-training NPA, NPC, and balance test results. The conclusions of earlier studies [18] on balance parameters, which indicate the improvements of SVT in balance, are at contrast with the present results. In terms of exposure time, this Strobe exposure was comparable to the current study and the prior study (7–10 mins) [9].

Conclusion

The present research on Stroboscopic Visual Training has the potential to improve the Visual Response time in the young athletes. As per the present research, SVT may be able to help elite young athletes with their visual response times. Benefits of SVT on visual and perceptual skills, including eye-hand coordination and visual reaction time, have been found. The performance of eye-hand coordination and visual reaction time were dramatically improved by acute SVT exposure while wearing stroboscopic goggles. In this study, the generality of learning has board implications for theories of vision and how best to implement training protocols. At all post-test levels, statistically significant inferences were observed for the SG. Athletes that underwent strobe training and testing to evaluate visual reactions like eye-hand coordination, reaction test were found to have a strong significant relationship with this study's findings.

Conflicts of interest

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of this article.

References

1. Luke Wilkins, Carl Nelson, Simon Tweddle. Stroboscopic Visual Training: a Pilot Study with Three Elite Youth Football Goalkeepers. DOI 10.1007/s41465-017-0038-z.
2. Luke Wilkins & Lawrence Gregory Appelbaum: An early review of stroboscopic visual training: insights, challenges and accomplishments to guide future studies, International Review of Sport and Exercise Psychology; c2019. DOI:10.1080/1750984X.2019.1582081 To link to this article: https://doi.org/10.1080/1750984X.2019.1582081
3. Appelbaum LG, Erickson G. Sports vision training: a review of the state-of-the-art in digital training techniques. International Review of Sport and Exercise Psychology; c2016. p. 1-30. https://doi.org/10.1080/1750984X.2016.1266376
4. Appelbaum LG, Schroeder JE, Cain MS, Mitroff SR. Improved visual cognition through stroboscopic training. Frontiers in Psychology. 2011;2:276.
5. Appelbaum LG, Cain MS, Schroeder JE, Darling EF, Mitroff SR. Stroboscopic visual training improves information encoding in short-term memory. Attention, Perception, & Psychophysics. 201274(8):1681-1691.
6. Smith TQ, Mitroff SR. Stroboscopic training enhances anticipatory timing. International Journal of Exercise

Sciences. 2012;5(4):344-353.
7. Holliday J. Effect of stroboscopic vision training on dynamic visual acuity scores: Nike Vapor Strobe eyewear. All Graduate Plan B and other Reports, paper. 2013, 262.
8. Wilkins L, Gray R. Effects of stroboscopic visual training on visual attention, motion perception, and catching performance. Perceptual and Motor Skills. 2015;121:57-79.
9. Paul Ellison *et al*. -The effect of stroboscopic visual training on eye–hand coordination-Published online: 18 January 2020-https://doi.org/10.1007/s11332-019-00615-4.
10. Gregory Appelbaum L, Graham Erickson. Sports vision training: A review of the state-of-the-art in digital training techniques, International Review of Sport and Exercise Psychology; c2016. http://dx.doi.org/10.1080/1750984X.2016.1266376, DOI:10.1080/1750984X.2016.1266376
11. Lindsey Edgerton-The Effect of Stroboscopic Training on the Ability to Catch and Field -Approved November; c2018.
12. J Sports Perf Vis Vol 1(1):e8–e16; May 19, 2020. This article is distributed under the terms of the Creative Commons Attribution-Non Commercial 4.0 International License. ©Clark *et al*.
13. Improved visual cognition through stroboscopic training, L. Gregory Appelbaum Julia E. Schroeder, Matthew S. Cain and Stephen R. Mitroff, Front. Psychol., 28 October 2011 Sec. Perception Science, https://doi.org/10.3389/fpsyg.2011.00276
14. Mann DT, Williams AM, Ward P, Janelle CM. Perceptual-cognitive expertise in sport: a meta-analysis. J. Sport Exerc. Psychol. 2007;29:457-478.
15. Lum J, Enns JT, Pratt J. Visual orienting in college athletes: explorations of athlete type and gender. Res. Q. Exerc. Sport. 2002;73:156-167.
16. Savelsbergh GJ, Williams AM, Van Der Kamp J, Ward P. Visual search, anticipation and expertise in soccer goalkeepers. J Sports Sci. 2002;20:279-287.
17. Williams AM, Ford PR, Eccles DW, Ward P. Perceptual-cognitive expertise in sport and its acquisition: Implications for applied cognitive psychology. Applied Cognitive Psychology. 2011;25:432-442.
18. http://www.senaptec.com
19. https://www.arealme.com/eye-hand-coordination-test/en/
20. https://faculty.washington.edu/chudler/java/redgreen.html
21. https://apps.apple.com/us/app/reaction-test-pro/id493360516s