REVIEW ARTICLE

# Effect of stroboscopic visual training in athletes: A systematic review

**Sudesan Jothi** ✉ **.** *Saveetha Institute of Medical and Technical Sciences (SIMATS)-(deemed to be university). Tamilnadu, India.*
**Jagadeswaran Dhakshinamoorthy.** *Saveetha College of Allied Health Sciences. Saveetha Institute of Medical and Technical Sciences (SIMATS)-(deemed to be university). Tamilnadu, India.*
**Kanmani Kothandaraman.** *Department of Ophthalmology. ACS Medical College. DR.M.G.R. Educational and Research Institute)-(deemed to be university). Chennai, Tamil Nadu, India.*

## ABSTRACT

Background : Visual abilities and motor performance are the key factor in athletes to improve their performance. One emerging technology to enhance athletes' visuomotor and cognitive abilities is SVT. This paper aims to show how SVT can be used as an intervention technique in athletics to enhance athletes' performance. Any research that examined the use of strobe glasses as a training aid for physically fit athletes was taken into consideration for this evaluation. Objectives : The purpose of this study is to investigate the impact of stroboscopic visual training on athletes. Methods: In January 2024, searches were conducted using a variety of databases, including PubMed, Scopus, Google Scholar, Springer, ProQuest databases. Screening publications that included strobe glasses as a training aid was done by two independent reviewers. 13 of the 25 full-text articles that were evaluated for inclusion and exclusion satisfied the requirements. Results: The results of the SVT intervention were: enhanced visual and visuomotor function; improved reaction time; enhanced eye-hand coordination; enhanced perceptual skills; enhanced short-term memory; enhanced central visual field motion; enhanced anticipatory timing; no improvement in peripheral field motion; some athletes reported feeling mentally exhausted and unable to identify colours. Conclusions: More research is necessary to establish the ideal strobe dosage and administration since there are no established guidelines for SVT intervention settings, duration, and outcomes in athletes. With future recommendations to athletes and coaches to incorporate SVT as part of sports training to improve their on-field performance, this review outlines the advantages of SVT intervention in athletes as well as the current research gaps addressing the usage of SVT.
**Keywords**: Strobe, Stroboscopic visual training, Athletes.

**Cite this article as:**
Jothi, S., Dhakshinamoorthy, J., & Kothandaraman, K. (2025). Effect of stroboscopic visual training in athletes: A systematic review. *Journal of Human Sport and Exercise, 20*(2), 562-573. https://doi.org/10.55860/vm1j3k88

✉ **Corresponding author.** *Saveetha Institute of Medical and Technical Sciences (SIMATS)-(deemed to be university). Tamilnadu, India.*
E-mail: sudesan.opto@drmgrdu.ac.in
Submitted for publication December 09, 2024.
Accepted for publication January 21, 2025.
Published February 10, 2025.
Journal of Human Sport and Exercise. ISSN 1988-5202.

**doi:** https://doi.org/10.55860/vm1j3k88

## INTRODUCTION

Sports vision training (SVT) and other performance training methodologies like strength, conditioning, speed and agility, nutrition, and sports psychology have a common objective of translating functional benefits to athletic performance. The relevant queries are whether it is possible to train one's visual abilities and whether an athlete's increased ability to see improves their performance in sports. Training is a possibility for many of the visual characteristics that have been found to be significant in sports.

The development of visual training devices was encouraged by the growing awareness of the role that visual and visuomotor talents play in determining performance in sports (Hülsdünker et al 2021).An increasing amount of study is looking into how using visual training interventions might improve athletes' performance (Ellison et al 2020).Generally speaking, the idea behind stroboscopic training is an activity that uses sporadic visual stimuli to increase the strain on visuomotor processing and improve performance under normal vision settings (Zwierko et al 2024).

Shutter glasses, sometimes referred to as stroboscopic eyewear, are becoming more and more common in sports-specific training because they enable athletes to practice in certain visual environments (Zwierko et al 2024). One example of contemporary technology that has helped with multimodal integration is strobe glasses (Vasile et al 2023). Products like Platino glasses, Nike SPARQ vapor strobes, and, more recently, Senaptec stroboscopic glasses made it easier to evaluate temporal occlusion and stroboscopic vision in practical contexts (Dunton et al2020).

A type of cognitive motor training known as "*strobe training*" involves performing motor tasks in dimly lit environments on occasion (Vasile et al 2023). Enhancing neuro visual processing vision training is a method that can be used to enhance athletic performance and reduce injury risk. This method incorporates visual exercise into a structured sports environment program (Sudesan et al 2023).

Top athletes in training and competition need to have excellent eyesight and perception in addition to a high degree of attention (Jendrusch et al 2023). The key to achieving peak athletic performance is seeing and then generating the proper motor response (Patrícia et al 2020). In order to prevent injuries, vision training is a simple and effective addition to regular pre-season training regimens (Clark et al 2020).

Generally speaking, the concept behind stroboscopic training is an exercise consisting of sporadic visual stimuli that increase the workload on the visuomotor system, improving performance under normal vision settings. The goal of many vision performance assessments and training programs for enhancement is to evaluate and enhance the overall processing of visual information. The majority of enhancement training programs aim to improve the visual abilities necessary for good sports performance in order to influence the perceptual process.

The main objective of visual improvement training programs is to prime the athlete's perception and effector mechanisms for future information while simultaneously focusing their ability to handle more information in less time. In the end, this increases the decision mechanism's speed and effectiveness, which is further improved by processes that offer feedback on visual attention and promote the formation and use of mental images. Even if there are still a lot of unsolved problems about how visual enhancement training affects sports performance.

The study's goal is to compile a list of every peer-reviewed study that looked into using SVT to enhance athletic performance. The review sought to: (1) Present the SVT results; and (2) Offer recommendations for further study

## METHODS

### *Search strategy*

A preliminary search was conducted in January 2024 across five databases—PubMed, Scopus, Springer, ProQuest, Google Scholar —using the search term ("*KEY WORDS: STROBOSCOPIC VISUAL TRAINING AND SPORTS*."). The scope of the search was restricted to complete English-language journal articles published between January 2010 to January 2024.The reviewer (SJ) removed duplicates and did a screen test after two separate reviewers (VS and SJ) examined the entire articles. If the study's eligibility for review was unclear from the title, full text articles were eliminated.

### *Inclusion and exclusion criteria*

Articles that employed stroboscopic visual training as a form of intervention were included. This study only included research articles with human subjects. Articles covered the effects of athletes' visual performance and whether or not strobe glasses were used during the training phase to induce intermittent vision. Any sport that uses stroboscopic visual training is included. Included were studies that looked at how stroboscopic visual training affected task performance right away. Excluded were studies that examined the effects of SVT in clinical patients rather than in healthy individuals, or that included SVT as a component of multiple visual training. SVT related abstracts, discussion papers, and review papers were not included.

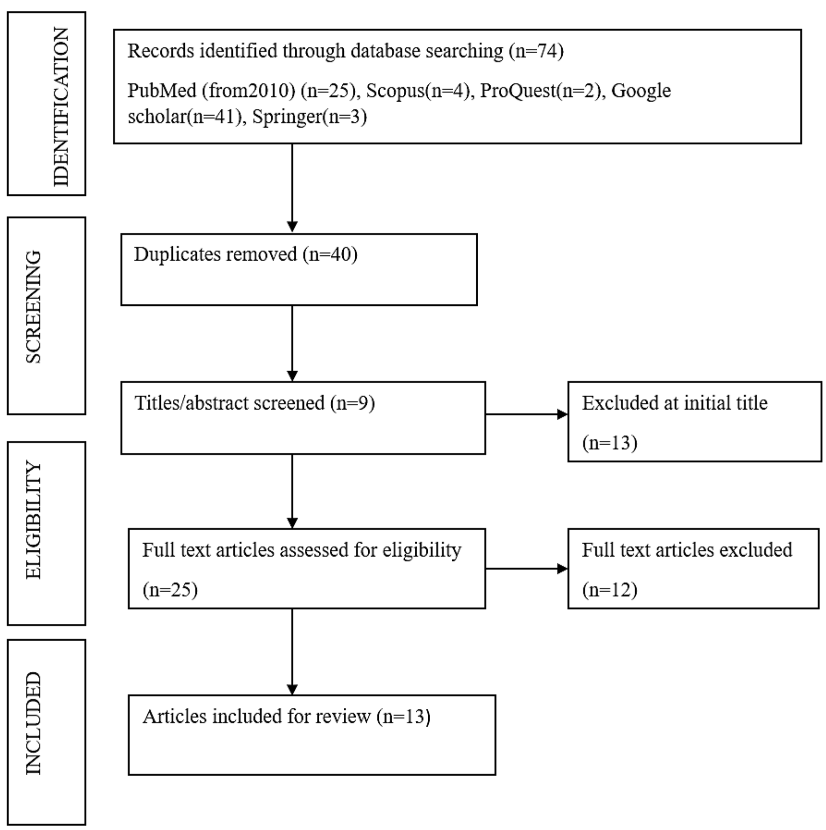


Figure 1. Prisma search strategy (search updated January 2024).

 

### *Data extraction*

A second reviewer (VS) verified the data entered after the first reviewer (SJ) extracted and synthesized the data into a tabular format (Table 1). Details such as the name of the participant, the characteristics, the eligibility requirements, the design, and the purpose of the study. Table 2 contained the participant group, kind of eyeglasses, study protocols, flash settings, and important findings.

Table 1. Participant characteristics, sports, inclusion and exclusion criteria, design and aim of the reviewed studies.

| Author | Participants | Sports | Inclusion criteria | Exclusion criteria | Study design and aim |
|---|---|---|---|---|---|
| Zwierko et al. (2023) | Initially 58 participants were recruited<br>50 volleyball athlete's participants (26 males,24 females)<br>Age 16-18 years<br>SVT group(n = 25)<br>Control group(n = 25) | Volleyball | a) volleyball training on a regular basis, at least 5 days a week, and (b) participating in official volleyball federation competitions during the season | H/O epilepsy, migraine, or injury. | Pretest and post-test study<br>Effect of SVT on visual, visuomotor and reactive agility. |
| Hülsdünker et al. (2021): Part 1 | 45 young badminton athletes participated<br>13 excluded illness (n = 5), missing data (n = 2), or insufficient training time (n = 6).<br>32 participants (21 male, 11 females, 27 left handed, 5 right handed; age, 13.7 ± 1.3 yr; height, 166.2 ± 10.9 cm; weight, 54.5 ± 11.4 kg) | Badminton | Competitive at national level badminton | H/O epilepsy, migraine, or neurological or psychiatric disorders | Longitudinal Pretest and post-test study<br>Long term and short-term effect of SVT on reaction time and on-court performance. |
| Ellison et al (2020) | 62 athletes a strobe group (SG; n = 31, age 20.82 ± 1.54 yrs.), or control group (CG; n = 31, age 21.34 ± 4.27 yrs.) | Not mentioned | Novice to eye hand coordination | H/O epilepsy | Pretest and post-test<br>Effect of SVT on eye hand coordination. |
| Luke Wilkins et al. (2018) | 6 elite young football goalkeeper's participants<br>Experimental group-3<br>Control group-3 | Football | Not recorded | Not recorded | Pilot pretest and post-test study<br>Effect of SVT on visual and perceptual skills. |
| Palmer et al. (2022) | 61 youth soccer players were recruited (aged 11.2 ± 1.3 years)<br>36 participants | soccer | Not recorded | Not recorded | Pretest and post-test study<br>Effect of SVT on dribbling performance of fast and slow dribbler. |
| Appelbaum et al. (2012) | 84 participants | Soccer, basketball | Not recorded | H/O seizures, migraines, or light sensitivity | Pretest and post-test study<br>Effect of SVT on visual memory |
| Teresa Zwierkoet al. (2024) | 22 highly experienced male handball players participants, including 20 right-handed and two left-handed, with a mean age of 24.59 years (±5.4) | Handball | Not recorded | Not recorded | Pretest and post-test study<br>Effect of SVT on conductivity of the visual pathway specifically related to their visual processing of retinal location and viewing conditions |
| Antonia Ioana Vasile et al. (2023) | 9 climbers with ages between 13 and 19 years (M = 16.59; SD = 2.00), of which 4 male and 5 female. | climbing | 1.age over 12 years old and lower than 20 years old<br>2. a frequency of at least three training sessions per week with their head coach<br>3. achieving at least one red-point lead route higher than 7a+ measured of French scale in the last year before enrolling into the study<br>4. active participation in national and international competitions and federal training camps for juniors. | Not recorded | Pretest and post-test study<br>Formulating preliminary model of training climber with strobe glasses explaining time of training, methods, materials, dosing, intensity, walls to use. We also explained the benefits of this method of training, disadvantages and adaptability. |
| Sudesan J. et al (2022) | 30 participants<br>ST group-15<br>Control group-15<br>Age 19 -25 | Football<br>Volleyball<br>cricket | Not recorded | Not recorded | Acute pretest and post-test study<br>Acute effect of SVT on visuomotor skills |

| | | | | | |
|---|---|---|---|---|---|
| Jendrusch et al (2023) | 22 tennis players participants (18m, 4f, mean age = 23.6, SD = ±2.7 years) | Tennis | Not recorded | Not recorded | Pretest and post-test study Analyses the effect of shutter glass on (image-)frequency or "*duty ratio*" (dark phase percentage) on target stroke accuracy in tennis |
| Appelbaum et al (2011) | 157 participants University students and athletes SG-16 CG-15 | Athletes | Not recorded | H/O Seizures Migraine Sensitivity to light | Pretest and post-test study Effect of SVT on Motion sensitivity peripheral vision and dual task attention Sustained attention |
| Smith and Mitroff (2012 | 30 athletes SG-15(Age 20 -27 years) CG-15(Age 20 -29 years) (Strobe: M = 22.80, SD = 2.11; Control: M = 23.60, SD = 2.82; t(28) = 0.88, *p* = .387) | Athletes | Not recorded | Not recorded | Pretest and post-test study Effect of SVT on anticipatory timing |
| Hülsdünkeret al.(2021): Part 2 | 45 young badminton athletes participated 13 excluded illness (n = 5), missing data (n = 2), or insufficient training time (n = 6). 32 participants (21 male, 11 females, 27 left handed, 5 right handed; age, 13.7 ± 1.3 yr; height, 166.2 ± 10.9 cm; weight, 54.5 ± 11.4 kg) | Badminton | Competitive at national level badminton | H/O epilepsy, migraine, or neurological or psychiatric disorders | Longitudinal Pretest and post-test study Effect of SVT on reaction time |

Table 2. Types of strobes, strobe settings, frequency and duration of the training total strobe time, intervention and key findings.

| **Author** | **Types of strobes** | **Strobe settings** | **Frequency/Duration of training** | **Total strobe time(Mins)** | **Intervention/Task** | **Key findings** |
|---|---|---|---|---|---|---|
| Zweirkoetal. (2023) | Senaptec strobe | Modulated frequency 15-9 Hz (duty ratio 50%-70%) | 6 weeks 18 sessions × 25-40 mins | 450-540 mins | Wall passing drills, partner passing drills, passing rotation drills. | Improved visual and visuomotor function |
| Hulsdunker et al (2021) part 1 | Senaptec strobe | Preprogrammed frequency (15hz-8hz) Duty ratio :50%-70% | 10weeks 10sessions ×10-15 mins | 100-150 mins | Drive drills, net drive drills, ball machine drills | Improved visuomotor reaction speed |
| Ellison et al (2020) | Nike vapor strobe eyewear | Fixed frequency of level 3 (4hz) | Single session ×7-8min | 7-8min | Sports vision trainer light board | Improved eye hand coordination performance |
| Luke Wilkins et al (2018) | Senaptec strobe | Modulated frequency of level 1-8(6hz-1hz) | 7weeks 14 sessions× 45mins and 1× 5 mins | 635 mins | Catching drills using tennis ball and goalkeeper specific drills using a football | Improved visual and perceptual skills |
| Palmer et al (2022) | Nike vapor strobe eyewear | Modulated frequency of level 3 -7(4hz-1.33hz) | 4weeks 4 sessions × 20 mins | 80 mins | Dribbling exercise | No persistent changes seen in soccer in situ dribbling performance |
| Appelbaum et al (2012) | Nike vapor strobe eyewear | In lab: Level 1-6 Training: Level 2-4 | In lab: 2 sessions ×27min Varsity soccer: 6or 7 sessions ×15-45 mins Varsity basketball: 5or 6 sessions × 15-40 mins | 54-315 mins | Catch, agility and ball handling drills | Improved short term memory and retention short term memory capacity |
| Teresa Zweirko et al (2024) | Senaptec strobe | Modulated frequency 5hz-9 Hz (50%-70%) | 6 weeks 18 sessions | Not mentioned | Ball catch drills partner passing drills, handball specific passing drills | Improved effect on early visual processing in short term |
| Antonia loanavasile et al (2023) | Senaptec strobe | Fixed frequency of level 1 and 2 | 6 sessions × 2 hours | 12 hours | Climbing on bouldering, lead, spray wall, and moon board | Improved motor-cognitive skills |

| | | | | | | |
|---|---|---|---|---|---|---|
| Sudesan J. et al (2022) | Senaptec strobe | Modulated frequency of level 1-8 | Single session × 7-8 mins | 7-8 mins | Catching drills and specialist drills with a football for cricket and volleyball players | Improved visual response time |
| Jendrusch et al (2024) | Nike vapor strobe eyewear | Preprogrammed frequency of level 2,5,and 8 | Single session | Not mentioned | Striking balls dispensed from a tennis ball machine | Improved the precision of the eye hand coordination in tennis |
| Appelbaum et al (2011) | Nike vapor strobe eyewear | Modulated frequency of level 1-6 | In lab:<br>2or 4 sessions × 27 min<br>Club ultimate Frisbee:<br>4 sessions × 20 -25 mins<br>Varsity football:<br>9or10 sessions ×15- 30 mins | 54-300 mins | Catch drills, Frisbee practice speed and agility drills | Improvement in central visual field motion |
| Smith and Mitroff (2012) | Nike vapor strobe eyewear | Fixed frequency of level 3 (4hz) | Single session ×5-7mins | 5-7mins | Anticipation training | Improved anticipatory training |
| Hulsdunker et al (2021) Part -2 | Senaptec strobe | Modulated frequency 15hz-8hz (Duty ratio 50%-70%) | 10 weeks<br>10 sessions ×10-15 mins | 100-150mins | Badminton drills | Improved visual perception skills |

## RESULTS

### *The evidence base*

A total of 74 papers were produced using the search method. We eliminated about forty duplicate articles from the search.34 articles of relevance were found after the first reviewer (SJ) did an initial scan of titles and abstracts. Nine publications were eliminated after an abstract assessment. The first and second reviewers (SJ and VS) have examined 25 full-text publications. Twelve papers were eliminated on the grounds of exclusion. There was agreement to include 13 articles for the study committee to review.

### *Study population*

*Participants*

The majority of participants were in their late teens or early twenties and were recruited through professional or elite sports teams or their university cohorts. Two studies looked at how SVT affected athletes right away (Sudesan et al 2023, Smith et al 2012). With the exception 1 study that exclusively enrolled male participants (Zwierko et al 2024), 5 studies were recruited all gender (Zwierko et al 2023, Hülsdünker et al 2021, Vasile et al 2023, Jendrusch et al 2023, Hülsdünker et al 2021). 7 studies did not report any particular gender traits (Ellison et al 2020, Wilkins et al 2018, Palmer et al 2024, Appelbaum et al 2012, Sudesan et al 2023, Appelbaum et al 2011, Smith et al 2012) (Table 1).

*Eligibility criteria*

Seven studies did not list any exclusion standards for their subjects (Wilkins et al 2018, Palmer et al 2024, Zwierko et al 2024, Vasile et al 2023, Sudesan et al 2023, Jendrusch et al 2023, Smith et al 2012). The remaining six studies listed migraines, a history of neurological disorders, and/or seizures/epilepsy as reasons why participants should not participate (Zwierko et al 2023, Hülsdünker et al 2021, Ellison et al 2020, Appelbaum et al 2012, Appelbaum et al 2011, Hülsdünker et al 2021) (Table 1).

*Cohort structure*

Sample size: The number of participants ranged from 6 (Wilkins et al 2020) in pilot research to 157(Appelbaum et al 2011) in the first study conducted by Appelbaum and colleagues, indicating a significant variation in participant sample sizes between the studies.

Control groups: A control group was a part of all 13 trials.

### ***Study protocols***

*Stroboscopic devices*

Throughout the 13 trials, two distinct brands of eyewear devices that are available for purchase were utilized to provide stroboscopic visual disruption (Table 2). The Nike Vapor Strobe (Ellison et al 2020, Palmer et al 2024, Appelbaum et al 2012, Jendrusch et al 2023, Appelbaum et al 2011, Smithet al 2012) (n = 6) and the more recent Senaptec strobe (Zwierko et al 2023, Hülsdünker et al 2021, Wilkins et al 2018, Zwierko et al 2024, Vasile et al 2023, Sudesan et al 2023, Hülsdünker et al 2021) (n = 7) was the most often used devices in the studies. Nike is located in Beaverton, Oregon.

*Strobe settings*

Out of the 13 research, 3 studies conducted their stroboscopic training at a single fixed frequency (Ellison et al 2020,8, Smith et al 2012),7 studies had modulated frequency (Zwierko et al 2023, Wilkins et al 2018, Palmer et al 2024, Zwierko et al 2024, Sudesan et al 2023, Appelbaum et al 2011, Hülsdünker et al 2021) and 2 studies had pre-programmed frequency (Hülsdünker et al 2021, Jendrusch et al 2023).

*Frequency and duration of interventions*

SVT sessions ranged in duration from five minutes (Smith et al 2012) to a maximum of 12 hours (Vasile et al 2023) in different trials. The remaining studies (n = 11) offered numerous SVT sessions for up to 10 weeks with 50 minutes and 2 studies didn’t mention any time duration (Zwierko et al 2024, Jendrusch et al 2023) (Table 2). Additionally, there was a notable variation in the length of training across studies.

### ***Training intervention***

When performing physical activities like wall passing drills, passing drills (Zwierko et al 2023, Zwierko et al 2024), drive drills, ball machine drills, catching drills (Wilkins et al 2018, Appelbaum et al 2012, Zwierko et al 2024, Sudesan et al 2023, Appelbaum et al 2011) and goalkeeper specific drills, dribbling exercise (Palmer et al 2024), climbing on bouldering (Vasile et al 2023) were done wearing strobe glasses.

*Post training test points*

Depicts those two studies (Sudesan et al 2023, Smith et al 2012) were conducted immediate post-test following training in all of the evaluated research, and 11 of those studies also recorded retention test data with delays of 10, minutes, 24 hours, 10 days, 4 weeks, and 6 weeks.

### ***Outcome measures***

Most research (n = 7) examined the relationship between SVT results and one or more specific visual abilities, such as visual processing, visual memory, or reaction time or eye hand coordination (Zwierko et al 2023, Hülsdünker et al 2021, Ellison et al 2020, Wilkins et al 2018,7, Sudesan et al 2023, Jendrusch et al 2023, Hülsdünker et al 2021). One study showed that SVT improved motor cognitive skills (Vasile et al 2023). Study by Smith and Mitroff explained acute SVT leads to improved anticipatory timing in athletes (Smith et al 2012). Hulsdunker and colleagues identified modulations in the participants' visuomotor performance and visual perception speed using neurophysiologic research. Improvement in short-term memory retention (Appelbaum et al 2012). SVT had a small impact on P100 amplitude and reduced the P100 implicit time for the dominant eye, especially in extra foveal vision. Additionally, under binocular seeing conditions, the stroboscopic intervention had a positive impact on extra foveal vision (Zwierko et al 2024). Focused attention, distributed attention, memory, visualization, selecting the best climbing pace, body placement on the wall, sensory reorientation on proprioception, central and peripheral vision, and intersegmental coordination were indicated as the competencies of the training approach. Athletes report feeling mentally exhausted, dizzy, and unable to discern colour following SVT (Vasile et al 2023). The study demonstrated that increasing the load of strobe frequency reduced target hit precision and eye-hand coordination in tennis players. It also established the necessary conditions for organizing and arranging stroboscopic visual training with shutter glasses and then carrying it out methodically over an extended length of time (Jendrusch et al 2023). Greater visual information in the central visual area and no change in the peripheral attention task were observed (Appelbaum et al 2011).

### *Interpretation of outcomes*

A number of distinct visual and motor performance outcomes, including central field motion sensitivity, short-term memory capacity (Appelbaum et al 2012), processing speed, eye-hand coordination (Ellison et al 2020, Smith et al 2012) anticipatory time, motor cognitive skills, and reaction speed, were positively impacted by SVT (Table 2). On the other hand, results based on longer-lasting visual stimuli or stimuli that appeared in the periphery of the visual field were found to be unaffected by SVT (Appelbaum et al 2011).

### *Safety and adverse events*

None of the studies in this analysis addressed reporting safety issues or adverse occurrences as one of their objectives. Participants using strobe glasses did not result in any safety concerns or unfavourable incidents, according to any of the research.

## DISCUSSION

The purpose of this structured review was to summarize the impact of SVT on visual and/or motor performance by looking at 13 research that described its use in healthy and fit athletes. Since all of the research studies included in this review have been completed since 2010, SVT is a relatively recent field of study. Nonetheless, the utilization of this approach in diverse training environments has resulted in notable variations both amongst and within treatments. We reviewed the literature to see what studies had been done with athletes; prior research indicates that visual skill training could help athletes perform better.

### *Protocols*

*Stroboscopic devices*

The two devices included in the research all had distinct manufacturer operating levels, so there was no standard way to record the "*blink rate*" or strobe effect frequency. To provide the stroboscopic effect used in the training program, Senaptec Strobe glasses (Appelbaum et al 2011, Hülsdünker et al 2021, Wilkins et al 2018, Zwierko et al 2024, Vasile et al 2023, Sudesan et al 2023, Hülsdünker et al 2021) were used. Eight distinct frequencies cause these glasses to flicker, from 1 Hz (level 8; considered toughest because it receives the fewest visual samples) to 6 Hz (the easiest because it receives the most visual data). At each frequency, the glasses change from transparent to opaque. Additionally, there are three settings to adjust the stroboscopic effect: both eyes, left eye alone, and right eye only (in one-eye mode, the non-strobic lenses stay opaque). Phase-wise stroboscopic occlusion of perception through frequency modulation and alteration of the dark phase ratio was achieved with the use of shutter glasses, namely the Nike SPARQ Vapor Strobe (Nike, USA). Depending on the (load) level selected, the Nike Vapor Strobe occludes from around 60ms dark phase (level I) to approximately 900ms dark phase (level VIII), with a constant 100ms light phase. As the ratio of dark to light increases from stage I to stage VIII, the frequency of images diminishes.

### *Strobe settings*

Regarding the frequency of strobe settings and the usage of fixed versus variable strobe frequency settings, there was a lack of standardization. Researchers Ellison and his colleagues looked at the effects of SVT given at a set frequency of 4 Hz (Nike Vapor Strobes: level 3, 100ms clear: 150ms opaque), and they discovered that right after just one SVT session, individuals in the intervention group showed noticeably improved anticipation. These results have since been used by other studies to support their choice of strobe rate setting.

Therefore, more research is needed to ascertain whether there is a strobe frequency that is ideal for both visual and motor learning, as well as whether or not participants' exposure to a fixed strobe frequency will result in a bigger (or even less) impact from SVT.

#### *Frequency and duration of interventions*

This evaluation shows that there was a great deal of variation in the frequency, length, and quantity of SVT treatments used in the trials. The interventions varied from one SVT session to several sessions spread out over a period of ten weeks. The paucity of detail offered in certain papers about the intervention protocols further complicates interpretation in our analysis.

#### *Post training test points*

In every study, post tests were conducted within a day, demonstrating the direct impact of SVT on various outcomes. We know less about the long-term efficacy of SVT in any population since retention-test data, which are perhaps more relevant to the practical application of SVT, were only obtained in 4 of the trials. Future research is necessary to ascertain whether the effects of SVT persist for longer than four to six weeks and whether the frequency and duration of SVT actually influences retention.

### *Outcomes*

Across the studies, the effectiveness of SVT was evaluated using a variety of outcomes, such as tests of motor function and visual skills (such as reaction time, visual memory, and processing speed). These results underline the necessity for future clinical trials to take into account their choice of outcomes in connection to the SVT tasks being offered, and they offer compelling evidence for the positive training effects of employing SVT for task-specific dynamic balancing training, at least in younger individuals. According to the Zweirko research, stroboscopic intervention significantly improved visuomotor and visual performance on three out of five measures, with visuomotor function being enhanced more than sensory processing. The study by Sudesan J showed that acute SVT exposure while wearing eye-hand coordination and visual reaction time significantly enhanced performance. The Appelbaum research demonstrates a noteworthy enhancement, indicating that stroboscopic training may enhance one's capacity to interpret visual information in the centre visual field more rapidly. In the peripheral attention task, neither group showed any differences. The stroboscopic training used here, according to research by Smith and Mitroff, decreased the timing mistakes' magnitude and variability when participants had to estimate when a moving visual stimulus would arrive at a certain spot. The only research that showed the drawbacks of SVT was that done by Antonia Loana Vasile. In her paper, she proposed that the skills of this training method include: intersegmental coordination, focused attention, distributive attention, memory, visualization, choosing an ideal climbing speed, body placement on the wall, sensory reorientation on proprioception, and central and peripheral vision. The athletes listed their increased mental exhaustion, increased vertigo, and impaired ability to discern hold colour as some of the drawbacks of training.

## CONCLUSION

This research aims to review the scientific literature that investigates the impact of SVT on athletes' motor and visual performance. Engaging in stroboscopic training can enhance both short-term and long-term memory retention of visual information. Athletes stand to benefit greatly from stroboscopic training as it can notably improve their visual memory, thus potentially boosting their sports performance. Stroboscopic training has been found to enhance motion detection and central attention, although it does not seem to have the same effect on sustained attention. Studies indicate that there are enduring advantages to stroboscopic vision training when it comes to perceptual processes. Stroboscopic training can expedite visuomotor reactions, consequently aiding athletes in their on-field performance. By training with stroboscopic vision, athletes may improve their anticipatory timing skills. Wearing stroboscopic eyewear can result in significant enhancements in both visual and visuomotor functions. Further studies are necessary before SVT is routinely used in sports training.

### *Future recommendations*

- There is no such proper research article regarding strobe usage published in underdeveloped and developing nations.
- Mention the mode of strobe used to maintain a proper protocol for future researchers.
- Include the effects of the strobe being retained after the retention period.
- Mention the experience of adverse effects or not regarding the usage of the strobe to have a safety protocol.
- A proper training intervention protocol should be mentioned according to the age criteria, which will be helpful for future researchers.
- Include the feedback or user experience from the participants regarding the strobe usage before and after the intervention, including both training experience and on-the-field experience.
- Include the test points after every single intervention of strobe to know the consistency improvement in performance.
- Perform studies regarding the effect of SVT on balance in healthy populations.
- Mention the effect and usage of each frequency in strobe settings, which was unclear to date.
- There is no proper protocol regarding the reintervention of strobe in the same healthy individuals and the total period of effect of strobe in the healthy individuals.

## AUTHOR CONTRIBUTIONS

Sudesan Jothi: writing – review & editing, writing – original draft, methodology, formal analysis, data curation, conceptualization, investigation. Dr. Jagadeswaran D.: supervision, methodology, Dr. K. Kanmani: review & editing, supervision.

## SUPPORTING AGENCIES

No funding agencies were reported by the authors.

## DISCLOSURE STATEMENT

No potential conflict of interest was reported by the authors.

**ACKNOWLEDGMENTS**

Researchers thankfully acknowledge TAC committee members and Research Department of Saveetha Institute of medical and technical sciences (SIMATS).

**REFERENCES**

Appelbaum, L. G., Cain, M. S., Schroeder, J. E., et al. (2012). Stroboscopic visual training improves information encoding in short-term memory. Attention, Perception, & Psychophysics, 74, 1681-1691. https://doi.org/10.3758/s13414-012-0344-6

Appelbaum, L. G., Schroeder, J. E., Cain, M. S., & Mitroff, S. R. (2011). Improved visual cognition through stroboscopic training. Frontiers in Psychology, 2, 276. https://doi.org/10.3389/fpsyg.2011.00276

Bennett, S. J., Hayes, S. J., & Uji, M. (2018). Stroboscopic vision when interacting with multiple moving objects: Perturbation is not the same as elimination. Frontiers in Psychology, 9, 1290. https://doi.org/10.3389/fpsyg.2018.01290

Clark, J., Betz, B., Borders, L., Kuehn-Himmler, A., Hasselfeld, K., & Divine, J. (2020). Vision training and reaction training for improving performance and reducing injury risk in athletes: Sports vision training. Journal of Sports and Performance Vision, 2, e8-e16. https://doi.org/10.22374/jspv.v2i1.4

Das, J., Walker, R., Barry, G., Vitório, R., Stuart, S., & Morris, R. (2023). Stroboscopic visual training: The potential for clinical application in neurological populations. PLOS Digital Health, 2(8), e0000335. https://doi.org/10.1371/journal.pdig.0000335

Dunton, A. B. (2020). The impact of spatial occlusion training on complex motor skills in sport. Theses. https://doi.org/10.34719/8jvp-pt85

Elliott, D., & Bennett, S. J. (2021). Intermittent vision and goal-directed movement: A review. Journal of Motor Behavior, 53(4), 523-543. https://doi.org/10.1080/00222895.2020.1793716

Ellison, P., Jones, C., & Sparks, S. A. (2020). The effect of stroboscopic visual training on eye-hand coordination. Sport Sciences for Health, 16, 401-410. https://doi.org/10.1007/s11332-019-00615-4

Hinton, J., Brantley, S., Berulava, E., et al. (2024). Use of stroboscopic goggles in suture training improves precision and accuracy. American Surgeon, 90(4), 502-509. https://doi.org/10.1177/00031348231216493

Hülsdünker, T., Fontaine, G., & Mierau, A. (2023). Stroboscopic vision prolongs visual motion perception in the central nervous system. Scandinavian Journal of Medicine & Science in Sports, 33(1), 47-54. https://doi.org/10.1111/sms.14239

Hülsdünker, T., Gunasekara, N., & Mierau, A. (2021a). Short- and long-term stroboscopic training effects on visuomotor performance in elite youth sports. Part 1: Reaction and behavior. Medicine and Science in Sports and Exercise, 53(5), 960-972. https://doi.org/10.1249/MSS.0000000000002541

Hülsdünker, T., Gunasekara, N., & Mierau, A. (2021b). Short- and long-term stroboscopic training effects on visuomotor performance in elite youth sports. Part 2: Brain-behavior mechanisms. Medicine and Science in Sports and Exercise, 53(5), 973-985. https://doi.org/10.1249/MSS.0000000000002543

Jendrusch, G., Binz, N., & Platen, P. (2023). Shutter glasses as a training tool in tennis - Influence of (image) frequency and dark phase ratio on eye-hand-(racket-) coordination. Optometry & Contact Lenses, 3, 359-367. https://doi.org/10.54352/dozv.ROFV4461

Lee, H., Han, S., & Hopkins, J. T. (2022). Altered visual reliance induced by stroboscopic glasses during postural control. International Journal of Environmental Research and Public Health, 19(4), 2076. https://doi.org/10.3390/ijerph19042076

 

Palmer, T., Coutts, A. J., & Fransen, J. (2022). An exploratory study on the effect of a four-week stroboscopic vision training program on soccer dribbling performance. Brazilian Journal of Motor Behavior, 16(3), 254-265. https://doi.org/10.20338/bjmb.v16i3.310

Rodrigues, P. (2020). Sports vision: Influence on athlete's performance. Acta Scientific Ophthalmology, 3, 10-18. https://doi.org/10.31080/ASOP.2020.03.0118

Smith, T. Q., & Mitroff, S. R. (2012). Stroboscopic training enhances anticipatory timing. International Journal of Exercise Science, 5(4), 344-353. https://doi.org/10.70252/OTSW1297

Sudesan, J., Priyadharshini, D., Padmapriyadarshini, S., Leena, K., Kowshika, K., & Lakshmi Priya, S. (2023). A profile of Senaptec strobe in young elite university athletes. International Journal of Physical Education, Sports and Health, 10(1), 375-382. https://doi.org/10.22271/kheljournal.2023.v10.i1f.2805

Symeonidou, E. R., & Ferris, D. P. (2022). Intermittent visual occlusions increase balance training effectiveness. Frontiers in Human Neuroscience, 16, 748930. https://doi.org/10.3389/fnhum.2022.748930

Vasile, A. I., & Stanescu, M. (2023). Application of strobe training as a motor-cognitive strategy in sport climbing. Journal of Educational Sciences & Psychology, 13(75), 131-138. https://doi.org/10.51865/JESP.2023.1.14

Wilkins, L., & Gray, R. (2015). Effects of stroboscopic visual training on visual attention, motion perception, and catching performance. Perceptual and Motor Skills, 121(1), 57-79. https://doi.org/10.2466/22.25.PMS.121c11x0

Wilkins, L., Nelson, C., & Tweddle, S. (2018). Stroboscopic visual training: A pilot study with three elite youth football goalkeepers. Journal of Cognitive Enhancement, 2, 3-11. https://doi.org/10.1007/s41465-017-0038-z

Zwierko, M., Jedziniak, W., Popowczak, M., & Rokita, A. (2023). Effects of in-situ stroboscopic training on visual, visuomotor and reactive agility in youth volleyball players. PeerJ, 11, e15213. https://doi.org/10.7717/peerj.15213

Zwierko, T., Jedziniak, W., Domaradzki, J., Zwierko, M., Opolska, M., & Lubiński, W. (2024). Electrophysiological evidence of stroboscopic training in elite handball players: Visual evoked potentials study. Journal of Human Kinetics, 90, 57-69. https://doi.org/10.5114/jhk/169443