Effect of stroboscopic training on the groundstroke in skilled youth tennis players

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ABSTRACT

Previous research suggested that training with stroboscopic glasses has a positive effect on visual processes like online control and transient attention in a laboratory setting. In this study the effect of six stroboscopic training sessions on the groundstroke in skilled youth tennis players was investigated. Controls participated in the same training sessions as the strobe group. The hitting accuracy of the groundstroke in the strobe group improved significantly after stroboscopic training compared to the control group ($p < 0.05$). Therefore, it is concluded that training with stroboscopic glasses has a positive effect on the groundstroke in tennis.

Keywords

Stroboscopic training, groundstroke, tennis, youth players, hitting accuracy.

INTRODUCTION

Elite tennis players have to perform under immense time pressure. The velocities of groundstrokes reach 130 kilometers per hour (Landlinger et al., 2011). Many training programs focus on the physical, technical and tactical skills of the players. Although visual skills seem to be play a key role in different kinds of sports, training programs do not always include visual training (Smith & Mitroff, 2012). One method to train visual skills is by training with stroboscopic eyewear. The glasses of stroboscopic eyewear alternate between transparent and dark or opaque, depending on the type of glasses. The frequency and duty ratio at which the glasses alternate can be manipulated. The duty ratio is the percentage of time that the glasses are closed during one cycle of opening and closing.

It has been suggested that when people get less visual feedback during training, they will improve when the task is performed with full vision (Appelbaum et al., 2011, Appelbaum et al., 2012, Holliday, 2013, Smith & Mitroff, 2012, Wilkins et al., 2014). Stroboscopic training improved visual processes like anticipatory timing, online control and dynamic visual acuity when tested in a computer-based assessment (Appelbaum et al., 2011, Appelbaum et al., 2012, Holliday, 2013, Smith & Mitroff, 2012, Wilkins, 2014). Anticipatory timing is the ability to predict a movement and online control is the ability to adjust a movement when it is already initiated. Dynamic visual acuity is the ability to track a moving object while there is relative movement between the object and the observer.

Few studies investigated the effect of training with stroboscopic eyewear on catching performance. These studies did not find a difference in catching performance after stroboscopic training (Holliday, 2013, Wilkins & Gray, 2015). Little research has been done to examine whether strobe training results in improvement in sport situations. Clark et al. (2012) included stroboscopic training in the in-season training program of University baseball players. The strobe training was one of eight methods of vision training that was used. An improvement in batting average and slugging percentage was found. However, it is not clear whether these improvements were due to the visual training, and even more specifically, to the strobe training. Mitroff & Friesen (2013) did a pilot study with professional ice hockey players. This study suggests that stroboscopic training could have a positive effect on performance in ice hockey.

All studies that implemented the strobe glasses in sport, did this in a sport with an interceptive task. Stroboscopic training could be effective in interceptive tasks, because visual processes like anticipatory timing, online control and dynamic visual acuity have an influence on the performance on these tasks (Appelbaum et al., 2011, Appelbaum et al., 2012, Holliday, 2013, Smith & Mitroff, 2012, Wilkins, 2014). Tennis is an interceptive sport in which visual processes are of importance. In this study, youth players who are in the Dutch national under sixteen tennis team trained the groundstroke with stroboscopic eyewear. The stroboscopic training was incorporated in the regular training regimen of the players. Before and after the training with the strobe glasses, a tennis test was conducted to assess whether the players improved on playing a groundstroke. Based on previous studies it is assumed that training with the strobe glasses improves the visual skills of the tennis players. Therefore the main question of this research was whether stroboscopic training could improve the groundstroke in skilled youth tennis players. It was hypothesized that stroboscopic training would improve the accuracy of the groundstroke of the players. Since there are no reported studies with the stroboscopic glasses in tennis published yet, this study explores the opportunities to implement this innovation in the sport of tennis.

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METHODS

Participants

Thirteen skilled youth tennis players who are in the Dutch national team under sixteen participated in this study. Six players participated in both the control and the strobe group. Three players were included as controls only and did not train with the strobe glasses. Four players were included in the strobe group only due to practical reasons. In total there were ten players in the strobe group and nine players in the control group. The results of all participants were included in the analysis. Characteristics of the participants are shown in Table 1.

	Mean (M) ± Standard Error (SE) Strobe	Mean (M) ± Standard Error (SE) Control	P-Value
Age (years)	13.66 ± 0.22	13.74 ± 0.27	0.81
Experience (years)	7.95 ± 0.44	8.12 ± 0.49	0.74
Training time per week (hours)	13.80 ± 0.88	13.17 ±0.83	0.61

Table 1. Characteristics of the participants.

Study design

The ten players were randomly divided into two groups that trained with the stroboscopic glasses; group A (six players) and group B (four players). During the first three weeks of the study, group A trained with the stroboscopic glasses. The controls performed the same training regimen, but without the stroboscopic glasses. Before the first training session, all players performed a pretest with full vision. Immediately after the last training session, the players performed a posttest with full vision. After a tournament participants performed a pretest again and group B started with the stroboscopic training. The controls performed the same training regimen as group B, but without stroboscopic vision. After the last training session, the participants performed a posttest again. The schedule is summarized in Figure 1.

Figure 1. Study design. S = strobe group, C = control group.

Pre- and posttest

The pre- and posttest consisted of 42 shots, 21 forehand strokes and 21 backhand strokes. The testing took place on an indoor hard court surface. The balls were projected by a ball machine (Miha 3000) to ensure repeatability of ball velocity and placement. The directions, effect and height were varied to prevent adaptation to the task. Players started just behind the middle of the baseline. The first shot was projected into the right side of the participant (for a right-handed player, this is the forehand corner). The next shot was hit into the other corner and the third shot was hit to the right-hand corner again. After this drill, players received five seconds of rest. Then a new drill was started. Players were instructed to hit the balls in the direction of the target areas as in Figure 2. Shots received a score of 0, 1, 2, 3 or 4 points. This method is based on the study of Rota et al. (2013). The hitting accuracy is calculated by dividing the sum of scores of the strokes in the test by the amount of strokes produced by the player in that test. Furthermore, the percentage of strokes with a score is calculated by dividing the number of balls landing within one of the target areas by the total number of strokes and multiplying this with 100%. The velocities of the strokes produced by the players are measured with the Pocket Radar PR1000-BC. The mean velocity of the balls with a point is reported in kilometers per hour.

Training regime

Participants trained five or six times with the stroboscopic glasses within a time period of three weeks, two times each week. In total, players trained 60 to 70 minutes with the stroboscopic eyewear. The training took place outside on gravel. Some training sessions were performed inside on hardcourt because of bad weather. Stroboscopic training was part of the regular training regimen, so no special designed drills were performed. The stroboscopic glasses that were used in this study were the Visionup Athlete VA10-FA. In this experiment the clear state was kept constant at 100 miliseconds, so the length of the opaque state varied across the sessions. The frequency and duty ratio varied between training sessions, as shown in Table 2.

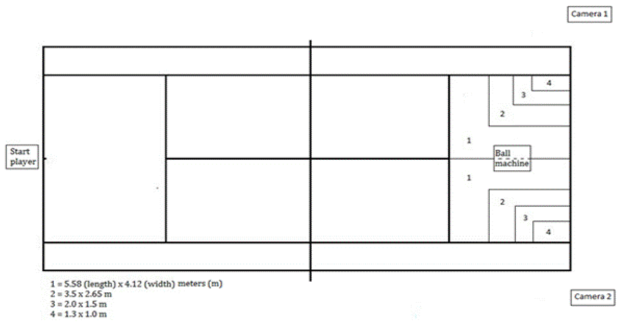

Figure 2. Representation of the test and division of the field in target areas.

Questionnaire

Immediately after the posttest, a questionnaire was filled in by the ten players who had trained with the strobe glasses to get an idea whether the players experienced a change in their groundstroke or not. Players were instructed to indicate on a scale of seven whether they totally disagreed (score of 1) or totally agreed (score of 7) with some statements. The statements were about whether they enjoyed the training with the strobe glasses or not and whether they felt like something had changed in their anticipation after training with the strobe glasses. Players answered four more statements about their timing and their strokes during the training with the strobe glasses and after the training with the strobe glasses. A score of 1 in these case meant ‘worse timing or quality of strokes’ and a score of 7 ‘better timing or quality of strokes’.

Session number	Duration (min)	Frequency (Hz)	Duty ratio (%)	Open-closed (ms)
1	10	7	30	100-43
2	20	6	40	100-67
3	20	6	40	100-67
4	10	5	50	100-100
5	10	5	50	100-100
6	*Variable per player*	*5*	*50*	*100-100*

Table 2. Settings of the stroboscopic glasses per session.

Statistics

One-tailed paired-samples t-tests were performed to compare the hitting accuracy of the pretest and the posttest for all participants in the control group and the strobe group. A one-tailed one-sample t-test was performed to find out whether the hitting accuracy of the strobe group changed differently than the control group. A one-tailed test is performed instead of a two-tailed test because the experimenters expected an effect in the positive direction. Two-tailed paired samples t-tests were performed to compare the mean velocity and the percentage of strokes with a score of the pretest and the posttest for both the control group and the strobe group. Two-tailed one-sample t-tests were performed to find out whether the increase or decrease in velocity or percentage of strokes was due to training with the strobe glasses. Effect sizes for all tests were reported.

RESULTS

The strobe group showed a higher hitting accuracy on the posttest compared to the pretest This difference, 0.2, BCa 95% CI [0.02, 0.35], was significant $t(9) = 2.57$, $p = 0.02$, and represented a large effect size, $r = 0.7$.

The control group showed the same hitting accuracy on the posttest compared to the pretest. There was no difference, 0.0, BCa 95% CI [-0.11, 0.16], so this was not significant $t(8) = 0.43$, $p = 0.34$, and represented a small effect size, $r = 0.2$. The increase in hitting accuracy in the strobe group was significant compared to the control group in which the hitting accuracy did not change. The difference in improvement of the hitting accuracy in the strobe group compared to the control group was 0.2, BCa 95% CI [0.00, 0.32] and was significant $t(9) = 2.23$, $p = 0.03$. The effect size was large, $r = 0.6$. The results for the hitting accuracy are shown in Table 3.

No significant difference of the percentage of strokes with a score and the improvement of the mean velocity from the strobe group was found compared to the control group.

Questionnaire

Players gave an average score of 4.1 out of 7 to how much they enjoyed training with the strobe glasses. Players agreed that their anticipation improved after stroboscopic training (M = 4.5). All players noticed that the timing (M = 1.8) and their strokes (M = 2.0) were worse during training with the strobe glasses. Players responded that the timing directly after the training was better (M = 5.0), just like their strokes (M = 4.5).

CONCLUSION AND DISCUSSION

The purpose of this study was to investigate whether training skilled youth tennis players with stroboscopic eyewear would lead to improvement of the groundstroke. It was hypothesized that players who trained with the stroboscopic glasses would improve more on a tennis test than the control group who performed the same training but without the strobe glasses. This hypothesis is confirmed by the findings in this study. The hitting accuracy of the strobe group improved significantly more than the hitting accuracy of the control group. This was likely due to the stroboscopic training, because the control group performed the same training but without the strobe glasses. Players experienced an improved timing after the training as well, as is found by the questionnaire. It is not possible to conclude which visual process caused the improvement of the hitting accuracy. However, it is suggested that by training with the strobe glasses, online control and anticipatory timing improved.

A limitation of this study was that six players participated in both the control as the strobe group. In future research it would be better to perform a randomized controlled trial. Because players had a tournament in the week between the two training periods, another pretest was performed before the second training period. Furthermore, it would be of value for the scientific knowledge to perform both a computer task that measures different visual processes and a sports task to be able to conclude which visual process is affected. Moreover, the amount of training and duration of the training sessions in sports practice could be investigated. The amount of training time, 60 to 70 minutes, was shorter than in previous studies (Appelbaum et al., 2011, Appelbaum et al., 2012, Holliday, 2013, Mitroff & Friesen, 2013, Wilkins & Gray, 2015). The retention of the effect could also be investigated. With this information the optimal training program with the strobe

	Pretest	Posttest	Difference pre- and posttest
Strobe group	M = 1.1, SE = 0.1*	M = 1.3, SE = 0.1*	M = 0.2, SE = 0.1**
Control group	M = 1.2, SE = 0.1	M = 1.2, SE = 0.1	M = 0.0, SE = 0.1**

Table 3. Results hitting accuracy. M = mean hitting accuracy. SE = Standard Error of the mean. * $p<0.05$, there is a significant difference between pre- and posttest. ** $p<0.05$, there is a significant difference between the change in hitting accuracy in the strobe and control group.

glasses could be estimated.

The frequencies and duty ratios of the strobe glasses were based on previous literature (Appelbaum et al., 2011, Appelbaum et al., 2012, Holliday, 2013, Mitroff & Friesen, 2013). However, in practice it was concluded that these settings were too difficult. It was decided to train with higher frequencies to prevent the task from being too hard. The frequencies were lowered in the same pattern across participants. In practice and further research it would be advised to adapt the settings per player according to the performance, like in Appelbaum et al. (2011), Wilkins & Gray (2015) and Holliday (2013). Different sports teams train with the strobe glasses, but a good foundation for using stroboscopic eyewear in sports situations was missing. Therefore, this study contributes to the knowledge about this type of training. The results discussed in this study could be of relevance for all people that work or compete in interceptive sports. An improvement from stroboscopic training on the groundstroke in tennis was found. Players involved in interceptive sports are advised to implement the stroboscopic glasses in their training regimen. Future research has to be conducted to support the evidence found in this research that stroboscopic training is effective in an interceptive sports task like tennis. More research has also to be done into the design of the stroboscopic training.

ROLE OF THE STUDENTS

Students did their research in cooperation with the Dutch Tennis Association (KNLTB). Sabine did her internship at the KNLTB under supervision of embedded scientist Aldo Hoekstra. He was looking for a way to implement stroboscopic training. Sabine and Lara were both interested in implementing scientific research in a practical situation and decided to investigate the effect of stroboscopic training on the tennis performance. David Mann was the supervisor at the VU University. The students defined the research question and designed the tennis test and training program together and discussed this with their supervisor and co-supervisor and visual skills expert Johan Koedijker. The KNLTB decided which group was training with the stroboscopic eyewear because other players were abroad for a tournament. Methodological problems were discussed with David, more practical issues were discussed with Aldo and Johan, as well as the trainers of the KNLTB. The whole research project was performed by both students. The work was equally divided, both the measurements and the writing of the report were done by both students in good cooperation.

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