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Research Articles

An exploratory study on the effect of a four-week stroboscopic vision training program on soccer dribbling performance

TIM PALMER[1] | AARON J. COUTTS[1] | JOB FRANSEN[1,2]

[1] University of Technology Sydney, Faculty of Health, Human Performance Research Centre, Moore Park, Australia.
[2] University Medical Centre Groningen, Department of Human Movement Sciences, Groningen, The Netherlands.

Correspondence to: Job Fransen. Address: Cnr of Moore Park Rd & Driver Avenue, Moore Park NSW 2021. 0295145203.
email: job.fransen@uts.edu.au
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HIGHLIGHTS
- In concordance with previous research findings, dribbling with stroboscopic vision glasses teporarily impairs soccer dribbling performance
- The findings from this study do not support the existence of beneficial training effects of soccer training with stroboscopic glasses on dribbling performance and retention

ABBREVIATIONS
Strobe3 Stroboscopic level 3
Strobe7 Stroboscopic level 7

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BACKGROUND: Perceptual-cognitive skill is a crucial component of expert performance in sport as expert athletes rely on the integration and processing of sensory information to execute complex actions. One of the topics of interest to skill acquisition researchers is therefore how the perceptual cognitive system can be trained, and how that affects sport skill performance. One of the methods suggested to be able to aid in the training of perceptual-cognitive skill is restricted visual feedback training. Recently, stroboscopic vision glasses have been proposed as a tool that can restrict visual feedback during sport training and may therefore provide a useful tool for training sport-specific skills. However, despite its use in practice, evidence for the beneficial effect of stroboscopic vision on sport-specific performance across youth athletes with a range of performance levels is currently lacking.
AIM: Therefore, this study aimed to investigate the effect of a four-week soccer training program with (experimental group) or without (control group) stroboscopic vision on the dribbling performance of relatively fast and slow dribblers.
METHOD: To measure dribbling performance, this study used the Ugent Soccer dribbling task.
RESULTS: A Repeated Measures MANOVA revealed that four weeks of stroboscopic vision training did not improve soccer dribbling skill measured through the time taken to complete the dribbling task as well as the number of touches of the ball while dribbling.
CONCLUSION: While stroboscopic vision can likely lead to short term changes in perceptual-cognitive skill, it is likely not related to persistent changes in soccer dribbling performance in youth soccer players.

KEYWORDS: Visual restriction | Football | Perceptual-cognitive training | Expertise | Technical skill

INTRODUCTION

A relationship exists between perceptual-cognitive ability and sport performance, which may suggest that improvements in the performance of the perceptual-cognitive system could lead to improvements in sport skill performance [1,2]. Accordingly, in the pursuit of sporting excellence, there has been a growing interest in the use of perceptual-cognitive training as a means to improve sport performance [3-6]. Many of these training programs are underpinned by the theory that practice under perceptually and cognitively demanding circumstances can lead to superior performance in normal conditions by training participants to pick up and process relevant information quicker, in order to turn it into an appropriate motor response [7]. However, these claims have not been substantiated across a variety of perceptual-cognitive training modalities.

Historically, sports vision training methods have used temporal or spatial occlusion paradigms [8], the training of selective visual attention allocation processes (e.g. [9]) and video-based training tasks (e.g. [10]), which are often conducted in controlled laboratory settings (for a more detailed explanation of these and other methods consult [2]). As such, whether these same training programs could be used in sport practice is a source of contention in the literature. While Hadlow and colleagues [5] provide an expansive overview of sports vision and perceptual-cognitive training tools that have emerged with recent technological advancements, they also state that for these tools to be effective, the perceptual function targeted in training, the training stimuli and the response type should correspond maximally to the competition environment. These observations concord with those made by Travassos and colleagues [11] who concluded from their meta analysis that the superior perceptual-cognitive skills demonstrated by expert versus novice performers were negatively related to the similarity between actions completed during tasks involved in research studies and those observed in sport. This was further echoed by Broadbent and coworkers [12] who concluded that "high levels of task functionality and action fidelity seem to be required for researchers examining the processes and mechanisms that underpin expert performance in sport. However, a suitable balance is required between the need to maintain ecological validity, on the one hand, and the desire for internal validity and experimental control, on the other". In conclusion, for perceptual-cognitive training to be effective, it should be performed in an environment that closely replicates the perception and action demands of the competition environment [5,13]. Nonetheless, in order for researchers to be able to evaluate the effectiveness of practice, it should be done in a context in which experimental control is not unnecessarily sacrificed [12]. Therefore, research should explore the training of perceptual-cognitive skills through engagement in sport-relevant tasks that reflect those used in competition, but still allow researchers sufficient control to ensure experimental rigour and precision of measurement.

Stroboscopic vision training is an increasingly prominent domain of sports vision training [5,14]. Previous studies have shown detriments to short-term performance in complex soccer-related motor skills such as dribbling [15] and passing, controlling and receiving [16] under conditions of stroboscopic vision. Both these studies also observed that performance decrements were positively related to skill level. With regards to dribbling, Fransen et al. [15] concluded this could be the result of the fact that under higher dribbling velocities, high performing dribblers lose sight of the ball for longer as the ball displaces further under the intermittent periods of no vision, forcing the dribblers to keep the ball closer than they are used to. Beavan et al. [16] studied this same phenomenon, but hypothesised that the fact that more expert players have more exposure to training, and may therefore paradoxically be more reliant on their vision (i.e. the Specificity of Practice Hypothesis [17]) leading to greater performance decrements when visual feedback is reduced. Regardless of the specific mechanisms at work, it is clear that the inclusion of stroboscopic vision stresses the perceptual-cognitive system and elicits, at least in the short term, adaptations in soccer-specific behaviours. However, the extent to which these short-term adaptations can lead to longer term changes in soccer-specific skill is unknown.

It is proposed that intermittently disturbing visual information during the execution of a skill will help the performer adapt to the limited visual information available during match or game play, leading to a transfer from the practice environment to competition [18]. Wilkins and Appelbaum [14] hypothesise that when practising under conditions of rapid and repeated interruptions of visual input, two things may occur. First, the player may utilise the limited visual information they receive in a more efficient manner, or second, they develop an increase reliance on other sensory information such as kinaesthetic awareness or auditory information. They argue that regardless of the mechanism at play, the individual, through stroboscopic vision training, engages in potentially advantageous strategies that they otherwise wouldn't were they to experience full vision. This could then ultimately lead to more skilful behaviours as a result of engaging in stroboscopic vision training, Many peer-reviewed studies demonstrate improvements in perceptual skills, including central motion sensitivity [18], short-term memory retention [19], anticipatory timing [20] and dynamic visual acuity [21], among many more, as a result of a practising under conditions of intermittently restricted feedback. However, evidence on whether and how these improved perceptual-cognitive skills lead to improvements in on-field performance is severely lacking [5,12]. Some studies have investigated the effect of stroboscopic vision training on sport-specific performance. For example, Mitroff et al. [22] showed that after 16 weeks of stroboscopic vision training, passing (defenders) and shooting (attackers) precision was improved. Furthermore, Hülsdünker et al. [23] showed that 4 weeks of stroboscopic vision training lead to improved smash-defence performance in badminton players. However, the risk of bias in these studies due to very low sample sizes and methodological design issues is substantial. In response, Hülsdünker et al. [24] studied the perceptual-cognitive and badminton field performance chances that resulted from a 10 week stroboscopic training program and concluded that while changes in visuomotor reaction speed were observed, no changes in on-field performance could be attributed to the stroboscopic vision training program.

Evidently, more studies are needed that investigate the effect of stroboscopic vision on the performance of sport-specific skills which can add to the body of literature supporting or refuting the value of stroboscopic vision training for the improvement of sport-specific skills. Therefore, the aim of this study is to examine the effect of a stroboscopic vision training program on the performance and short-term retention of dribbling performance in youth soccer players using an on-field dribbling test. Due to the relatively scarce literature examining the far transfer between skill training using stroboscopic vision glasses and skill performance, the problem posed in this study is relatively ill-defined. As such, this study can only be considered an exploratory study. An exploratory study is useful when the problem posed to the researchers is not well defined and when the researchers do not intend to provide conclusive evidence as a result of the study's findings. Hence, no hypothesis on the efficacy of our training intervention is provided to allow for non-directional exploration of the study's findings.

METHODS

Participants

A priori sample size calculation (G*power, version 3.1) revealed a sample size of 62 athletes is required given the following parameters: Repeated measures MANOVA with within and between-subjects factors, Cohen's f effect size of 0.50 based on previous research examining the effect of stroboscopic vision on dribbling performance [15], power = 0.8 and an alpha level of $p<0.05$. This a priori sample size calculation is based on the only other research using soccer dribbling performance as the outcome variable, and the largest effect size reported (partial eta squared [η_p^2]= 0.45 for differences between stroboscopic frequency conditions). Therefore, this study must be viewed as exploratory, and any results should be viewed in light of its sample size restrictions, especially as more research and updated effect sizes become available. Finally, a convenience sample of 61 youth soccer players (aged 11.2 ± 1.3 years) was recruited from Australian representative club soccer teams for the initial part of the study, which was reduced to a convenience sample of 36 players for the training study. Before the commencement of the study, parents and/or guardians were familiarised with the testing procedure and requirements, and written consent was obtained from all participants and their parents or guardians. The Institutional Ethics Committee approved all experimental procedures.

Materials and Procedure

Soccer dribbling ability was assessed using an adapted version of the Ghent University Dribbling Test. It largely followed the procedure of Vandendriessche et al. [25], who reported that an intra-class correlation analysis (single measure) indicated high reliability values for dribbling with the ball in a sample of 40 adolescents (ICC = 0.81). To complete the dribbling task, participants could use any foot to guide a soccer ball as quickly as possible in a set pattern through eight cones marked by training cones on a dry grass field pitch (Figure 1), after which the ball was stopped inside a 1 m by 1 m square, stopping the time. Dribbling time (time to complete the dribbling course) was recorded to the nearest 0.01 s on two occasions based on a video recording sampled at 60Hz. When the player was unable to keep control of the ball (ball travels further than 2m from the course) or altered the position of a cone through a collision with their body or the ball, they received a warning and were asked to stop and repeat the assessment. Each trial was filmed on a JVC camcorder (Model No.GZ-RX120BAA, Yokohama, Japan, 60 Hz sampling rate) mounted on a SLIK F153 tripod. For each video, the time (to the nearest 0.01 s, using a handheld stopwatch) and the total number of foot-to-ball contacts made by each player from start to finish was recorded by the same person on two separate viewings. The stopwatch was started when the player crossed the starting line and time was stopped when the player stopped the ball inside the finish square. The average time taken to complete the dribbling course and the average number of touches needed on both viewings was subsequently calculated and recorded.

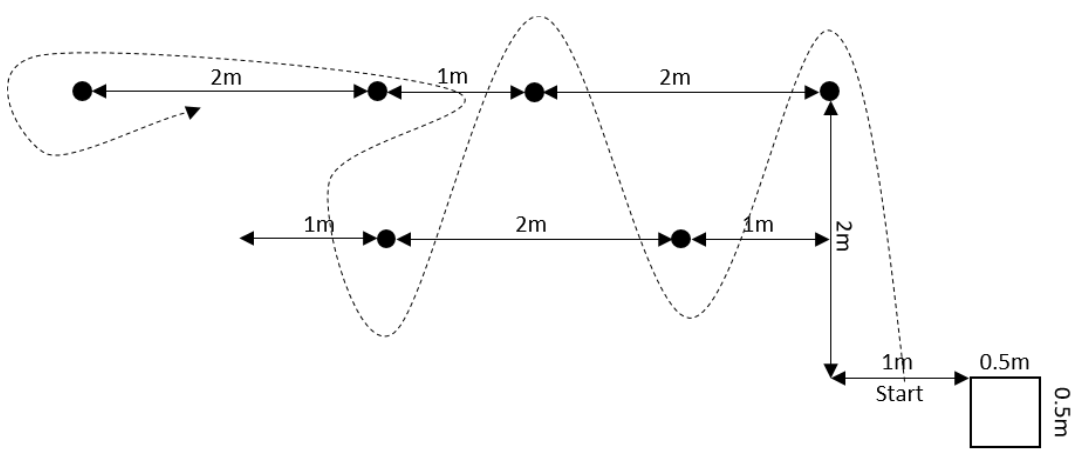

Figure 1. Outline of the adapted version of the UGent Dribble Test

Following a familiarisation period (two practice runs through the course without the ball), each participant performed three separate assessments under three conditions of visual feedback in a randomised order. One condition involved no visual restriction, whereas the other two conditions involved intermittent restriction of visual feedback using the Nike Vapor Strobe stroboscopic glasses (Nike Inc., Beaverton, Oregon, USA). These conditions were set at stroboscopic level 3 (Strobe3, stroboscopic frequency of 4 Hz, clear vision for 0.1s, opaque vision for 0.150s) and stroboscopic level 7 (Strobe7, stroboscopic frequency of 1.33 Hz, clear vision for 0.1s, opaque vision for 0.650s), as per the methods used by Fransen et al. (2017). These stroboscopic glasses intermittently restrict (opaque) and allow (clear vision) a full visual flow of an object and the performance environment, meaning that continuous tracking of objects for example may be more complicated with than without stroboscopic vision. Additionally, in the conditions used in this study, stroboscopic level 3 yielded less visual restriction than stroboscopic level 7 due to a higher stroboscopic frequency (4Hz vs 1.33Hz respectively) and resultingly shorter periods of visual restriction.

Training Study

A convenience sample of thirty-six participants were recruited following the baseline assessments to complete a training program aimed at improving soccer-relevant skill. This sample size was much lower than the required sample size based on an a priori sample size calculation (n = 62) but represented two conveniently accessible teams of relatively similar ages who trained and competed together. These participants were randomly allocated using a random number allocator to two equally sized control and intervention groups (n = 18). Both control and intervention groups completed four training sessions over four weeks, each of a 20 minutes duration. Training sessions were standardised for both groups and conducted concurrently. Instructions were given at the commencement of each exercise on how to complete the task. No performance or feedback instruction was given during a training exercise. Training involved participants performing dribbling exercises either under normal visual conditions (control) or restricted visual conditions (intervention). For the intervention group, visual conditions were restricted at Strobe3 for the first training session, with all intervention participants progressing to level 4, 5 and 6 for training session 2, 3 and 4 respectively. The control group completed the same training drills under normal visual conditions. Following the last training session, all participants completed a post-test and a one-week retention test. The post-test followed the same protocol as the pre-test with all participants completing three dribble test assessments under the three varying conditions of visual feedback. During the retention period, players did not engage in structured team training. During the one-week retention test, participants completed one assessment of the dribble test, only under normal visual conditions since the aim of the study was to investigate the effect of stroboscopic training on *in-situ* dribbling performance. An outline of the experiment can be found in Figure 2.

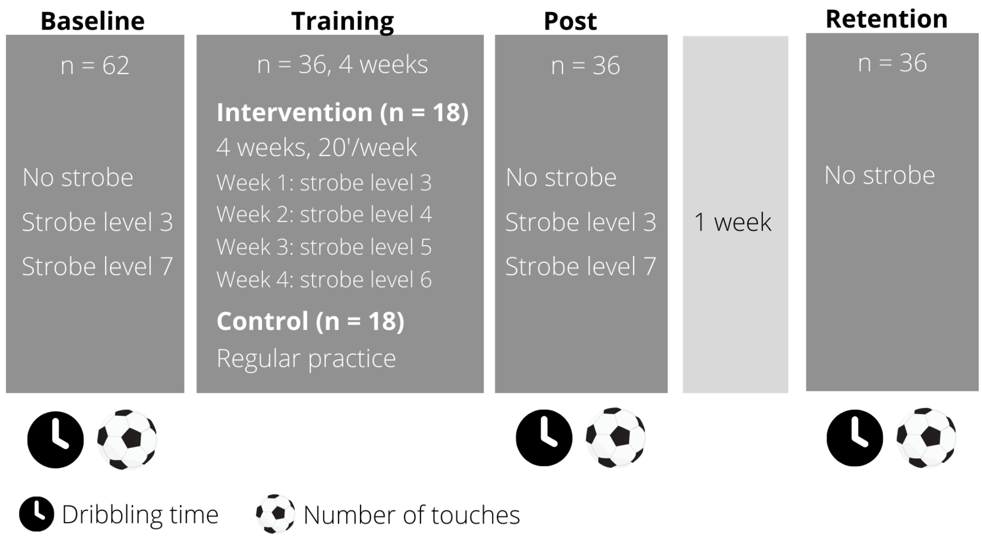

Figure 2. Experimental overview.

Statistical Analysis

Before analysis, players were divided into relatively fast or slow dribblers using a median split. This would allow for exploratory analyses into whether differential training effects could be observed for faster or slower dribblers. The use of this within-task subdivision according to dribbling proficiency was based on previous findings [15,16] which revealed that more skilled soccer players' skill performance is more substantially affected by visual restriction using stroboscopic vision than that of less skilled players. Before analysis, a Kolmogorov-Smirmov test and visual representations of the data sample determined normal distributions of the variables used in these analyses. To examine if different levels of visual restriction were associated with dribbling performance, similar to previous research [15], a repeated measures MANOVA using the stroboscopic condition (no strobe, strobe level 3 and strobe level 7) as a within-subjects factor and dribbling proficiency (relatively fast or slow dribbler) as a between-subjects factor was executed, where the dependent variables were the amount of touches and the time required to complete the dribbling course. To investigate the effect of training under stroboscopic conditions on dribbling performance, a second repeated measures MANOVA was used with time (pre, post and retention test) as a within-subjects factor, dribbling proficiency (fast or slow) and experimental group (control or intervention) as between-subjects factors and dribbling time and the amount of touches required to complete the course as dependent variables.

In all analyses, Bonferroni corrections were used for multiple comparisons, and partial eta squared (η_p^2) effect sizes (0.01-0.06, small; 0.06-0.14 moderate; >0.14 large [26]) were used to investigate the magnitude of effects. Data analysis was conducted using SPSS 25. The alpha criterion level for significance was set at $p < 0.05$.

RESULTS

Cross-sectional analysis

A repeated measures MANOVA showed no significant multivariate main interaction dribbling proficiency*stroboscopic condition ($F_{(4, 56)} = 0.472$, $p = 0.756$, ES = 0.03). However, significant, large multivariate main effects were found for stroboscopic condition ($F_{(4, 56)} = 16.674$, $p < 0.001$, ES = 0.54) and dribbling proficiency ($F_{(2, 58)} = 14.857$, $p < 0.001$, ES = 0.34). Further univariate analysis revealed a significant large main effect of stroboscopic condition on time taken ($F_{(2,118)} = 38.972$, $p < 0.001$, ES = 0.40) and number of touches ($F_{(2,118)} = 22.658$, $p < 0.001$, ES = 0.28) regardless of whether the participant was classified as fast or slow. Specifically, dribbling times were the slowest in Strobe7 condition (Strobe7 Time [95% CI] = 23.4 ± 3.1s [22.7-24.2s], Strobe3 Time = 22.6 ± 2.9s [22.0 – 23.3s], No Strobe Time = 20.9 ± 2.2s [20.5 – 21.4]) and the number of touches was highest in the Strobe7 condition (Strobe7 touches [95% CI] = 40.1 ± 4.0 touches [39.1 – 41.1 touches], Strobe3 = 38.8 ± 3.6 touches [37.9 – 39.7 touches], No Strobe = 36.8 ± 3.6 touches [35.9 – 37.7 touches]). Table 1 details the descriptive statistics (mean ± (SD), F-values and partial eta squared effect sizes) for fast and slow dribblers for each visual condition.

Table 1. Dribbling time and number of touches for fast and slow dribblers under different conditions of stroboscopic vision

	Fast			**Slow**			**Strobe**		**Dribble speed**		**Interaction**	
	No Strobe	**Strobe3**	**Strobe7**	**No Strobe**	**Strobe3**	**Strobe7**	**F**	**ES**	**F**	**ES**	**F**	**ES**
Time (s)	19.44 ± 0.97	21.39 ± 2.5	22.37 ± 2.49	22.41 ± 2.17	23.9 ± 2.67	24.55 ± 3.33	38.972**	0.40	23.274**	0.28	0.917	0.01
Touches (n)	36 ± 3	38 ± 3	39 ± 4	38 ± 4	40 ± 4	41 ± 4	22.658**	0	10.454**	0.15	0.158	0.00

Note: Data is means ± SD. * = p < .05: ** = p < 0.01. ES = partial eta squared. No Strobe = normal visual conditions. Strobe3 = stroboscopic frequency of 4 Hz, clear vision for 0.1s, opaque vision for 0.150s). Strobe7 = stroboscopic frequency of 1.33 Hz, clear vision for 0.1s, opaque vision for 0.650s.

Effect of stroboscopic training

A repeated measures MANOVA showed that changes in dribbling performance between pre, post and retention tests was not significantly affected by whether dribblers were assigned to a relatively fast or relatively slow dribbling group (Time*Dribbling proficiency*CI: $F_{(4.29)} = 0.959$, $p = 0.445$, ES = 0.12). Based on the lack of a three-way interaction effect players were no longer assigned to a relatively fast or relatively slow dribbling group for subsequent analysis of the training effects and hence the effect of stroboscopic vision training was analysed on all participants collectively. A repeated measures MANOVA demonstrated no significant Time*Intervention group ($F_{(31, 4)} = 2.650$, $p = 0.052$, ES = 0.26) interaction effect or Intervention group ($F_{(33, 2)} = 0.346$, $p = 0.71$, ES = 0.02), or Time ($F_{(31, 4)} = 2.135$, $p = 0.100$, ES = 0.216) main effects on dribbling performance. Despite the absence of significant multivariate main and interaction effects, the large effect size for the Time*Intervention group effect warranted further univariate analysis. Univariate analysis found no significant Time*Intervention group interaction effect on dribble time ($F_{(2,68)} = 0.087$, $p = 0.916$, ES = 0.00) but did reveal a significant moderate time*intervention group effect on the amount of ball touches ($F_{(2,68)} = 4.308$, $p = 0.017$, ES = 0.11). Further investigation of the interaction effect on the amount of touches on the ball revealed that in the control group the amount of touches remained steady from pre to post (Δpre-post control = 0.1 touches) test but decreased from post to retention test (Δpost-ret control = 1.0 touches) while in the intervention group there was a large decline in the number of touches required from pre to post (Δpre-post intervention = 2.7 touches) but a subsequent increase in the retention test (Δpost-ret intervention = 1.9 touches). No main effect of time was observed for dribble time ($F_{(2,68)} = 1.901$, $p = 0.157$, ES = 0.05) or touches ($F_{(2,68)} = 2.606$, $p = 0.081$, ES = 0.07). No main effect was observed for intervention group on dribble time ($F_{(1,34)} = 0.712$, $p = 0.405$, ES = 0.02) and touches ($F_{(1,34)} = 0.030$, $p = 0.863$, ES = 0.00). Table 2 shows the descriptive statistics (mean ± (SD), F-values and effect sizes) for the control and intervention groups for each dribble test (pre, post & retention).

Table 2. Dribbling time and number of touches for pre, post and retention tests for control and intervention groups following stroboscopic training

	Control			**Intervention**			**C/I**		**Time**		**Time * C/I**	
	Pre	**Post**	**Retention**	**Pre**	**Post**	**Retention**	**F**	**ES**	**F**	**ES**	**F**	**ES**
Time (s)	21.36 ± 2.6	20.85 ± 2.6	21.25 ± 2.9	20.71 ± 2.3	20.08 ± 2.5	20.75 ± 2.2	0.712	0.021	1.901	0.053	0.087	0.003
Touches (n)	37 ± 34	37 ± 4	36 ± 4	37 ± 5	35 ± 4	37 ± 4	0.030	0.001	2.606	0.071	4.308*	0.112

Note: Data is means ± SD, * = p < .05: ** = p < 0.01, ES = partial eta squared, C/I = Control/Intervention, Time = pre, post, retention.

DISCUSSION

The aim of this study was to examine the effect of a four-week stroboscopic vision training program embedded in the regular training of youth soccer players on skill performance (dribbling time and ball control) measured using the UGent soccer dribbling task. While the results of this study showed that intermittently restricting vision using stroboscopic glasses resulted in poorer dribbling performance, both in terms of the time taken and the amount of touches required to complete a dribbling course, no training-related performance changes in dribbling performance were observed. These findings correspond with our hypothesis and with a recent study by Hülsdünker et al. [24] who did not reveal on-field performance differences in 32 badminton players' smash defence skill after 10 weeks of stroboscopic vision training.

When the amount of visual feedback during performance is reduced, a decrease in performance is usually observed [27]. Indeed, both Fransen et al. [15] and Beavan et al. [16] who studied how stroboscopic vision affects soccer performance concluded that under intermittently restricted vision conditions, players perform worse in dribbling and passing, shooting and controlling tasks. The same performance decrement as a result of stroboscopic vision was observed in the current study, where dribbling performance was worse with increasing levels of visual restriction through an increased duration of the periods with opaque vision vs full vision. In these previous studies on the effect of stroboscopic vision on dribbling and passing, shooting and controlling performance, relative experts were also found to be more substantially affected by stroboscopic vision conditions [15,16]. These authors offered two potential explanations for what they observed. The first explanation may lie in the ‘Specificity of Practice Hypothesis’ which proposes that learning is specific to the conditions of practice during skill acquisition [17]. This theory indicates that if highly skilled soccer players were highly dependent on visual feedback during training, due to a potentially greater exposure to training under full vision conditions, the limited availability of visual feedback while dribbling under stroboscopic conditions will result in decreased performance. A second explanation is related to the dribbling velocity of more expert performers. As the speed of dribbling increases, greater changes in ball position are observed following each intermittent period of visual restriction, making it difficult for fast dribblers participants to predict ball motion and make appropriate adjustments when vision is available. This may result in more expert dribblers dribbling deliberately slower in order to maintain control of the ball. While in this study a gradual decrease in performance was observed between the full vision, Strobe3 and Strobe7 conditions, with the worst dribbling performances observed in conditions with the least amount of available visual feedback, no differences in the effect of stroboscopic vision on performance were observed in relatively slow or fast dribblers. This misalignment between the findings from previous research on soccer dribbling skill [15] and the current study may have been the participants' level of expertise. The previous study [15] utilised a relatively homogeneous cohort of players from Belgian high-level football teams aged between 10-18 years whereas participants in the present study were recruited from an Australian representative football club, were aged between 9-13 years, and could likely be considered more heterogeneous in terms of their dribbling skill (i.e. standard deviations of slow and fast dribblers in the control condition of Fransen et al. [15] = 1.34 and 1.08s respectively; in the current study = 2.17 and 0.97s respectively). This highlights that differences in training age, training years and existing skill level may affect the extent to which stroboscopic vision affects performance.

As hypothesised, the four-week stroboscopic vision training intervention used in this study was not related to dribbling performance improvements in youth soccer players. While undoubtedly a lack of training effects in the current study may be a result of the study's lack of statistical power (despite using similar or larger sample sizes than have previously been reported in similar studies) or the relative short duration of the training program, the findings of the current study are in line with a recently conducted study [23] which showed no beneficial effects of stroboscopic vision training on badminton smash-return performance. Therefore, the results of this study provide further, preliminary evidence that while stroboscopic vision training can elicit acute changes in perceptual performance [19], it may not lead to improvements in sport-relevant skill. However, further studies need to be conducted, including those with longer practice programs with more exposure to stroboscopic training and those studying different soccer skills, to support this conclusion.

One interesting finding was revealed in the current study which may warrant further attention in subsequent studies. While stroboscopic vision training was not related to changes in dribbling performance, univariate analysis showed that stroboscopic vision training had a moderate and temporary effect on the number of touches required to exert control over the ball during dribbling, without therefore affecting dribbling speed. The findings in this study suggests that players who trained under restricted visual conditions may have subsequently changed their dribbling performance, by touching the ball less often than before. The same was not observed for the control condition. These findings may indicate that training under stroboscopic vision conditions may improve the ability to predict where the ball is at any point in time, ultimately requiring less touches on the ball to guide the ball through the cones on the dribbling course. While not explored explicitly, these results may allude to the potential for stroboscopic vision training to elicit short term decreases in visual attention allocation to the ball. This would be in line with research that found that skilled dribblers are able to extract more pertinent information from the performance environment by allocating visual attention towards other sources of information other than the ball such as opposition players, positioning of teammates and environmental cues. This may ultimately provide players with critical information that enables them to make effective decisions during on-field performance [28].

CONCLUSION

In conclusion, the results of this exploratory study showed no beneficial effects of stroboscopic training on on-field dribbling performance, despite revealing moderate differences between the intervention and control group in pre-post differences in the amount of touches on the ball. While this study is undoubtedly an addition to the existing literature thanks to the use of an intervention and the assessment of a soccer-relevant skill, the findings of this study need to be viewed in light of its limitations. First, despite previous recommendations that stroboscopic training studies should utilise a single blind approach by implementing non-occluded glasses for control participants to act as a placebo [18], these recommendations were not followed in this study. This is particularly relevant as athletes feel stroboscopic glasses make training feel more novel and enjoyable [29]. While skill retention was investigated, the lack of a transfer test limits the ability of the study to measure whether changes in dribbling performance as a result of stroboscopic training would demonstrate adaptability to *in situ* dribbling performance. Additionally, while this study examined the behaviour of youth footballers 'in the field', and used a stroboscopic vision intervention in the context of real practice, the task used (i.e. the Ugent Dribble Test) is not representative of actual game play. Therefore, the lack of association we observed between the intervention and dribbling outcomes may not be representative of the association between stroboscopic vision interventions and actual competitive game play. Next, while this study randomly allocated players into an intervention or control group, it did so by allocating an equal amount of participants to each group. While this does not constitute true randomisation, it increased the feasibility of the study where each practice session consisted of the same number of players. Last, the sample used in this study was a convenience sample and not a random sample drawn from the population. As a result, the findings of this study may not be representative of the population of footballers of that age.

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