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The influence of sport goggles on visual target detection in female intercollegiate athletes

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Abstract
The aim of this study was to examine the effects of sport goggles on visual target detection in female intercollegiate athletes. Participants were randomly divided into three groups that varied in goggle use (G) or no goggle use (NG) over a total of three 1-min trials during a visual target detection task. The NG-NG-NG group did not wear goggles for any of the trials, whereas the NG-G-NG group wore goggles for the second trial only, and the G-NG-G group wore goggles for the first and third trials. The task consisted of illuminated targets arranged in five concentric rings from central to peripheral visual angles. The effects of sport goggles on response time to detect targets were most evident in the peripheral rings. Those who did not wear sport goggles showed improved performance from the first to second trials. This improvement was impaired, however, in those who wore sport goggles. Moreover, there was a reversal of the performance improvements achieved without goggles in those who wore goggles on the third trial. Together, these findings suggest the sport goggles not only impaired the expected initial performance but also impaired visual target detection after performance improvements were seen. These findings suggest sport goggles may impair detection of peripheral visual stimuli in athletes.

Keywords: *visual attention, peripheral vision, sport performance, sport goggles, reaction time*

1. Introduction

There are potentially substantial lifelong risks associated with head injuries and concussions resulting from sport activities, for example, chronic depression, Alzheimer's disease and Parkinson's disease (Khurana & Kaye, 2012). This has prompted efforts by sport organisations to institute regulations aimed at the prevention of head injury. Primary preventative methods, for example, modifying the rules of the sport, aim to prevent injuries from occurring; while secondary methods, for example, requiring specific types of helmets, safety equipment and attempt to lessen or reduce the severity of an injury upon impact. While the central goal of these efforts is to protect the athlete, it is important that these changes do not compromise safety or impair performance, which may unintentionally lead to additional injuries. Most recently, a rule change in US high school field hockey has mandated protective sport goggle use, either with or without protective lenses (National Federation of State High School Associations, 2011). The intention of this rule change is to reduce the severity of a stick or ball impact directly to the orbit of the eye. However, it is unknown if sport goggles interfere with visual field perception in athletes, particularly peripheral vision, thereby possibly increasing the risk of injury. Since the implementation of goggles into the game of field hockey is relatively recent, there are no studies showing the effects of the 2011 rule change that mandated all players to wear goggles.

An informal non-scientific survey conducted on 324 female field hockey players at a major tournament found that almost 80% of the field hockey players reported that the goggles made a negative difference in their performance on the field (Locke, 2011). The informal survey also found that 60% of the players who responded reported that the goggles caused injuries to themselves or other players, 26% reported that the goggles did not cause injuries, and 14% remained "undecided" (Locke, 2011). This suggests that there is a perceived association between sport performance, physical injuries, and goggle use. However, it has not been clearly established that sport goggles impair the ability to identify and react to visual stimuli. The purpose of this study was to examine the effects of sport goggles on visual target detection in female

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intercollegiate athletes. We systematically varied the location of the visual targets from peripheral to central locations within the visual field in order to test the hypothesis that sport goggles would selectively impair the detection of peripherally located targets.

In a previous study, male soccer players were tested while running during straight sprints versus shuttle runs, which consist of sprinting a short distance, turning and sprinting back multiple times, both with and without goggles that were altered to restrict peripheral vision. With goggles, the straight sprint was not affected but the shuttle runs were slower, suggesting the goggles increase the time it takes to accurately change directions, perhaps by obstructing the view of the shuttle run markers (Lemmink, Dijkstra, & Visscher, 2005). Another study found that while wearing goggles that reduced peripheral vision, participants experienced impaired balance on both a foam and firm surface (Wade, Weimar, & Davis, 2004).

Few studies have previously examined the effects of protective eyewear on reaction time to visual stimuli. Gallaway, Aimino, and Scheiman (1986) studied the effects of protective sport goggles for racquetball on the peripheral visual field. Although the different types of glasses limited the peripheral visual field to different degrees, a performance task was unaffected. Dawson and Zabik (1988) studied the effects of five different types of racquetball protective eyewear on a peripheral vision performance task and found that the central lights were unaffected by the presence of protective eyewear, but the peripheral lights were affected to various degrees depending on the type of eyewear.

Despite these earlier investigations, it is unknown whether the current widely used sport goggles affect detection of and reaction to multidirectional stimuli. Previous studies have limited the presentation of visual targets to the horizontal plane (i.e., at the height of the eyes, left to right) and have not included targets that appeared above or below a central fixation (Dawson & Zabik, 1988; Gallaway et al., 1986). Our study used a more complex response task as the 64 lights were arranged along the *x*- and *y*- planes, which is closer to a game-like situation where stimuli may come from any direction. Moreover, the effect of goggles on visual target detection has not been tested in intercollegiate athletes. In the current study, we determined the effects of goggle use in female intercollegiate athletes on reaction time to visually presented cues that systematically varied within foveal and peripheral visual spaces. It was hypothesised that overall response time (RT) would improve as the athletes performed this novel task over repeated trials. However, it was predicted that RT would be greater when protective sport goggles were worn and, additionally, that this performance deficit from goggle use would be specific to peripherally located targets.

2. Methods

2.1. Participants

Fifty-four female Division I athletes (ages 18–22 years) volunteered to complete this study. All the experimental procedures were approved by Institutional Review Board of the University of Maryland, and written informed consent was obtained. Compensation was not provided. Inclusion criteria included being a member of the University of Maryland-sponsored women's athletic team and having normal or corrected-to-normal vision with contact lenses. Exclusion criteria (based on self-report) included regular use of sport goggles, or any previous injury to the upper limbs, head or eyes, and past experience with the Dynavision D2 (Dynavision, West Chester, OH, USA) system. Past experience was defined as using Dynavision D2 more than once in the past 6 months, which resulted in the exclusion of two potential participants. Due to the consideration of required goggle use in the sport of field hockey, Division 1 field hockey players who would compete in 2013 season were excluded in order to reduce potential bias. In the no goggles-no goggles-no goggles (NG-NG-NG) group, there were eight soccer players, one golfer, one field hockey player, four volleyball players and five gymnasts. In the no goggles-goggles-no goggles (NG-G-NG) group, there were six soccer players, three field hockey players, four volleyball players and five gymnasts. In the goggles-no goggles-goggles (G-NG-G) group, there were eight soccer players, one field hockey player, three volleyball players and five gymnasts.

2.2. Materials

The Dynavision D2, a Food and Drug Administration (FDA)-cleared medical device, was used to test RT to visual targets (Clark & Trofatter, 2012). The Dynavision D2 system consists of a wall-mounted board (165 cm × 120 cm × 20 cm) that has 64 small square buttons (1 cm × 1 cm) arranged in five concentric rings (diameter of ring 1 = 20.6 cm; ring 2 = 43.8 cm; ring 3 = 54.6 cm; ring 4 = 88.3 cm; ring 5 = 110.5 cm). Each button contains a light-emitting diode (LED). The button located at the centre of the board is referred to as the central fixation point. The task for the participant is to perform each trial while maintaining focus on the central fixation point LED. Then, one of the 64 target LEDs turns on, and the participant's task is to hit that target as quickly as possible. The RT to press each button, defined as the time between target LED onset and its corresponding button press, was recorded as the dependent variable. Each button press signalled the onset of the next target LED. Dynavision D2 has been found to be a reliable instrument for assessing reaction time (Wells et al., 2014). Initial performance on Dynavision system is significantly correlated with some of the constitutional psychomotor and visuomotor tasks such as Simple Response Time, Choice Response Time, Minnesota Manual Dexterity Test and Ring Replacement Tasks (Vesia, Esposito, Prime, & Klavora, 2008). The 5 mm Cascade Iris™ goggle (Cascade, Liverpool, NY, USA), consisting of a plastic rim with a wire cage (but no lenses) covering both the eyes, was used since it is widely used by lacrosse and field hockey players (Locke, 2011).

2.3. *Design*

This study had a crossover design. Three groups performed three 1-min trials on the Dynavision D2 system; however, the use of goggles varied from trial to trial depending on the group. The three groups are named according to their experimental conditions for trial 1, trial 2 and trial 3. The NG-NG-NG group performed all three trials without goggles. The NG-G-NG group wore goggles only on their second trial. The G-NG-G group wore goggles for their first and third trials. With these groups we were able to compare the effects of goggle use (within two of the groups) on performance across trials, as performance on the task was expected to improve from the first to the second trial without goggles. We were also able to compare the groups on the change in performance from trial 1 to trial 2 and from trial 2 to trial 3.

2.4. *Experimental task*

The participants used the A* program on the Dynavision D2 machine. This program is a reactive program in which a single light illuminates until the participant deactivates it by striking it with a hand. Once that button is pressed, another button LED is activated. This cycle continued for 60 s. The A* test is self-paced, meaning that each light stayed on until the participant pressed its button to turn it off. The objective of the self-paced test is to see how fast the participant can react to the lights. The number of lights hit in each concentric ring (ring 1, ring 2, ring 3, ring 4 and ring 5) and the mean RT within each ring were recorded. Mean RT served as the dependent variable.

2.5. *Procedures*

Each participant was tested during, or within 1 hour prior to, their normal team practice time. Upon arrival, the participant was given a hard copy of the consent form. After informed consent was obtained, the participant filled out an eligibility questionnaire to determine if the participant met the inclusion criteria. Those who fit the inclusion criteria were then randomly assigned to one of the three groups. All the participants were individually tested and the testing environment was kept as consistent as possible. First, the system was adjusted so that the central fixation screen was at eye level. The participant was instructed to stand at a comfortable distance away from the machine so that all of the lights were visible yet reachable by hand. A standard demonstration and instructions were provided and any questions were answered. The participants then completed three 1-min trials with varying goggle usage depending on their assigned group. The participants were instructed to hit as many lights as quickly as possible during each minute-long trial while maintaining their gaze on the central fixation screen. Between each trial, participants rested for approximately 2 min. The experiment lasted about 10 min.

2.6. *Data analysis*

A 3 (group) × 3 (trial) × 5 (ring) repeated measures analysis of variance (ANOVA) was conducted using SPSS 21 (IBM, Chicago, IL, USA). Paired t-tests were used for within-group contrasts and independent samples t-tests were used for between-group contrasts when significant main effects or interactions were found. Statistical significance was set at $P < 0.05$, and the false discovery rate (FDR) was used to control the family-wise error rate. The degrees of freedom were adjusted using the Huynh–Feldt epsilon when violation of the sphericity assumption was detected using Mauchly's test.

3. Results

As a manipulation check for the internal validity of the experimental task, there was a significant main effect for ring, $F(4, 204) = 230.7$, $P < 0.0001$, $\eta_p^2 = 0.819$, indicating a strong linear effect of ring position with greater RTs as the distance from central fixation increased from ring 1 to ring 5 (mean RT of each ring is significantly different from all other rings, all $P < 0.0001$).

The omnibus analysis revealed a significant three-way interaction, $F(16, 408) = 2.05$, $P = 0.040$, $\eta_p^2 = .075$. The mean RTs for each group at each ring across trial 1, trial 2 and trial 3 are shown in Table I. Decomposition of this three-way interaction revealed that performance over trials varied based on the ring location of the targets and also depended on the experimental group and whether the NG or G condition was being performed on a particular trial. For

Table I. Mean (±*s*) response time (ms) during visual target detection for three experimental groups as a function of the concentric distance from the central fixation point.

		Group		
		NG-NG-NG	NG-G-NG	G-NG-G
Trial	Ring	*n* = 19	*n* = 18	*n* = 17
		NG	NG	G
Trial 1	Ring 1	612 (120)	652 (115)	645 (102)
	Ring 2	677 (121)	676 (124)	678 (121)
	Ring 3	789 (152)	786 (182)	773 (114)
	Ring 4	998 (317)	938 (201)	919 (196)
	Ring 5	1138 (305)	1086 (289)	1164 (403)
		NG	G	NG
Trial 2	Ring 1	619 (98)	630 (80)	613 (76)
	Ring 2	639 (99)	681 (111)	623 (77)*
	Ring 3	715 (105)*	771 (104)	705 (109)*
	Ring 4	877 (154)*	945 (165)	805 (118)*
	Ring 5	976 (269)*	1142 (285)	963 (139)*
		NG	NG	G
Trial 3	Ring 1	640 (87)	607 (91)*	605 (87)
	Ring 2	646 (89)	626 (85)*,**	661 (87)**
	Ring 3	736 (136)*	735 (101)	724 (98)
	Ring 4	856 (154)*	857 (144)*,**	862 (162)**
	Ring 5	1012 (211)*	1020 (186)**	1039 (238)**

Notes: Within-group contrasts.
*$P < 0.05$ vs. trial 1; **$P < 0.05$ vs. trial 2.

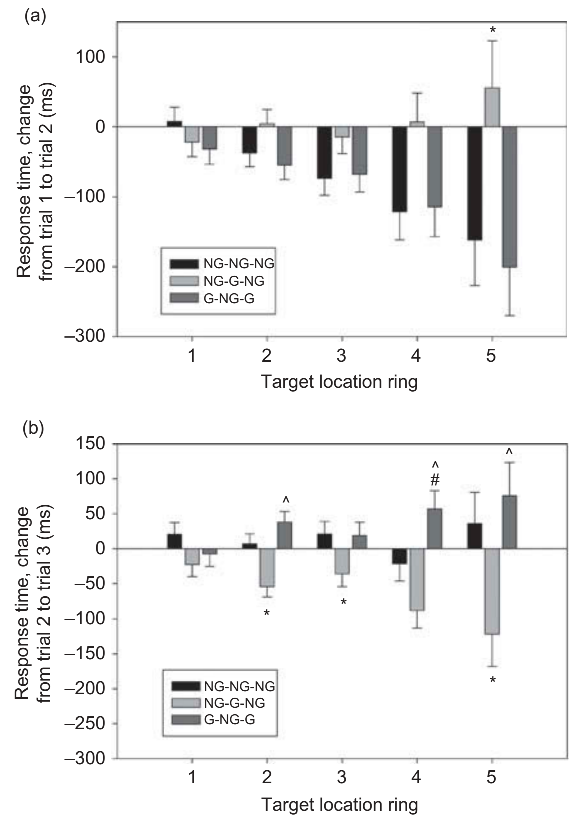

Figure 1. Change in response time (milliseconds) from (a) trial 1 to trial 2 and (b) trial 2 to trial 3 for all groups at all target ring locations. Notes: * indicates that the NG-G-NG group differed significantly from the other two groups at that ring location; # indicates that the G-NG-G group differed significantly from the other two groups at that ring location; ^ indicates change in response time was significantly greater than zero. Error bars represent the standard error of the mean ($s_{\bar{x}}$).

the NG-NG-NG group, performance significantly improved (decreased RT) from trial 1 to trial 2; however, this effect was significant only for the three outer-most rings (all $P < 0.05$) and no further improvement occurred on trial 3.

For the NG-G-NG group, the goggles worn on trial 2 interfered with the expected performance improvement resulting in no difference in performance between trial 1 and trial 2 at any of the ring locations. Furthermore, on trial 2 the NG-G-NG group (goggles) showed a significantly slower RT to ring 4 targets ($t(33) = 2.86$, $P = 0.007$) and ring 5 targets ($t(33) = 2.34$, $P = 0.026$) compared to the G-NG-G group, and was slower, though not significantly, than the NG group in response to ring 5 targets ($t(35) = 1.82$, $P = 0.078$). On trial 3, in the absence of the goggles, the NG-G-NG group showed significantly improved performance compared to trial 2 (ring 2, ring 4 and ring 5; all $P < 0.05$) and trial 1 (ring 1, ring 2 and ring 4; all $P < 0.05$).

For the G-NG-G group, performance at trial 2, in the absence of goggles, significantly improved from trial 1 on all but ring 1 targets (all $P < 0.05$). However, on trial 3, when the goggles were worn again, the G-NG-G group showed a significant *worsening* of performance (*increased* RT) compared to their performance on trial 2 (at ring 2, ring 4 and ring 5; all $P < 0.05$; see Figure 1(b)). Moreover, and in contrast to the other two groups, the performance of the G-NG-G group did not differ significantly between trial 1 and trial 3 at any of the ring locations.

To further illustrate these effects of goggle use and to make additional comparisons between the groups, we computed the change in RT from trial 1 to trial 2, and from trial 2 to trial 3, at each ring location. Then, we conducted a 3 (group) × 5 (ring) repeated measures ANOVA on each of the RT change scores (trial 2 minus trial 1; trial 3 minus trial 2), with *a priori* predictions for significant linear effects of ring location and interactions with group status. These analyses confirmed significant interactions between group and ring for the change from trial 1 to trial 2, $F(1,51) = 5.45$, $P = 0.007$, $\eta_p^2 = .176$, and from trial 2 to trial 3, $F(1,51) = 6.62$, $P = 0.034$, $\eta_p^2 = 0.124$. As shown in Figure 1(a), the two groups not wearing goggles showed RT improvements from trial 1 to trial 2 (denoted by negative change in scores and faster RTs) that became greater as the ring location increased from the central fixation. However, for the group that wore goggles on trial 2 (NG-G-NG), performance did not improve. The change from trial 1 to trial 2 for NG-G-NG group differed from the other two groups at ring 4 ($t(35) = 2.03$, $P = 0.050$ vs. NG-NG-NG; $t(33) = 2.48$, $P = 0.019$ vs. G-NG-G) and ring 5 ($t(35) = 2.33$, $P = 0.026$ vs. NG-NG-NG; $t(33) = 2.71$, $P = 0.011$ vs. G-NG-G), although the contrasts at ring 4 did not meet the FDR threshold. Then, without goggles on trial 3, shown in Figure 1(b), performance improves in the NG-G-NG group from trial 2 to trial 3 and the change significantly differs from the other two groups at rings 2, 3 and 5 (see Figure 1 (b)). Notably, for the G-NG-G group now wearing goggles on trial 3, RT increases from trial 2 to trial 3 at the outer rings and significantly differs from the other two NG groups at ring 4 ($t(34) = 2.73$, $P = 0.010$ vs. NG-NG-NG; $t(33) = 3.44$, $P = 0.002$ vs. NG-G-NG) and from the NG-G-NG group at ring 5 ($t(33) = 3.40$, $P = 0.002$).

4. Discussion

4.1. *Key findings*

The novel result of this study was that detection of a visual stimulus appearing in the peripheral visual field was impaired in female athletes when sport goggles were worn. When participants went from without goggles on trial 1 to wearing goggles on trial 2 (the NG-G-NG group), the expected improvement in performance did not occur as compared to those participants who never wore goggles (the NG-NG-NG group). Once the goggles were removed at trial 3, the NG-G-NG group showed significantly improved performance over trial 1 and trial 2 (with the exception of ring 3). Thus, the use of goggles interfered with task-based improvement to detect a visual cue in peripheral visual space. In contrast, and as expected, those who performed trial 1 with goggles and then trial 2 without goggles (the G-NG-G group) improved significantly. These improvements were more pronounced in the outer rings, which were identified more quickly when peripheral vision was not blocked by the goggles.

Another important finding was the apparent reversal of the performance effects in the G-NG-G group on trial 3. This group showed clear improvement in performance on trial 2 (NG) for rings 2–5. Then, when wearing the goggles once again on trial 3, the G-NG-G groups showed impaired performance with an increase in RT, particularly to the outer-most targets in ring 4 and ring 5. Taken together, these findings suggest that the sport goggles not only impaired the expected performance improvements from trial 1 to trial 2 on the more peripherally located targets but also significantly impaired visual target detection performance after performance of the task already had improved. Thus, even after initial performance improvements, sport goggles resulted in slower RT to targets in the peripheral visual field. This, we feel, is a concern because of the risk of decreased field awareness for athletes during competition.

In contrast to the effects observed in the outer rings, the groups performed nearly equivalently on all three trials for ring 1 targets. Only the NG-G-NG group showed improvement over time at ring 1 under the NG condition. This suggests that the goggles had minimal, if any, influence on foveal vision. These key findings extend the literature regarding the effects of sport goggles on performance by utilising a standardised visual target detection task among female athletes within a motor learning paradigm in which the performance varied by whether the sport goggles were being worn (impaired performance) or not worn (improved performance). Moreover, we demonstrated that these effects were specific to the more peripherally located targets, indicating that sport goggles may interfere only with peripheral visual processes.

Interestingly, all the three groups performed at about the same level for trial 1 regardless of whether goggles were worn or not. Although we did not measure or control for head movements, we theorise that this was because all the participants, unskilled at the task, moved their heads to see the lights using foveal vision instead of relying on peripheral vision. Although participants were instructed to keep their heads and eyes straight ahead, they were not forbidden from moving their heads if needed. As all participants became more skilled and efficient at the task, they may have relied on peripheral vision more and may not have moved their heads as much. Thus, the effects of sport goggles on peripheral vision may have been more pronounced in the latter trials.

4.2. *Implications*

This study clearly demonstrates that as the distance between the central fixation point and the visual cue increases, the slower the reaction time. After the task was performed on the first trial, improvement in reaction time occurred for those not using goggles on the second trial. However, reaction time worsened at the more peripheral target locations with the use of sport goggles. In addition, peripheral vision is more affected by sport goggle use than central vision which may lead to poor performance and potentially increased, not decreased, risk of injury. Increased injury risk is suspected here because of impaired reaction times to peripheral visual field tasks, which could render an athlete at risk from a "blind side" type of injury mechanism.

From the performance perspective, the ability to be aware of a movement or situation even a split second faster than an opponent is critical to success. In a field hockey game, a hockey ball can reach speeds of up to 147 km · h^{-1} or 91 mph, or approximately 40 m·s^{-1} (Schwab & Memmert, 2012). The use of goggles in our study resulted in an approximate 50–75 ms delay to respond to ring 4 and ring 5 targets (based on data in Figure 1(b)). A hockey ball traveling at 40 m · s^{-1} will cover an additional 2–3 m before detection with a delay of 50–75 ms to visually identify it. From the safety perspective, being able to detect movement is crucial to avoiding collisions with the ball, stick or an opponent. When both the player and an opponent are wearing goggles, both the parties have delayed reaction time and the chances they collide with each other are also greater.

As we demonstrated, the use of goggles is associated with peripheral visual impairment, and this may also result in performance impairment. When peripheral vision is limited, it is possible that visual cues associated with the need to change directions (Lemmink et al., 2005), or other aspects of the game such as other players or the ball, may not be identified quickly enough for optimal performance in a competitive environment that is constantly changing. Peripheral visual input to the brain comes from the lateral aspects of the retina. These cells respond to movement and coarse visual changes (players moving into the peripheral fields, lights flashing, etc.). Their input to the visual cortex helps the brain build a picture or mental image of the field of play and can do this for approximately 180° in front of the player, without the need for moving the head. Impairing the visual input from the peripheral visual fields will require the player to take time to scan the field of play and thereby alter performance and even reaction times. Although the exact impact of sport goggles in an actual game is unknown, it can be theorised that because of impaired reaction time to events in the periphery as well as psychological interference, the game will be influenced. When deciding whether to implement goggles or not, all aspects need to be taken into consideration including the nature of the game, as the threat of an eye injury differs depending on the sport.

4.3. *Limitations and future directions*

Our participants had varying levels of Dynavision D2 experiences. Ideally, naïve participants should be included to best observe the expected performance curve; however, as Dynavision D2 and visuomotor training popularity is increasing across varsity sports, it became difficult to recruit athletes who did not have Dynavision D2 experience. Nevertheless, the fact that the goggles manipulation had an impact among even experienced performers suggests that the observed effects may be even stronger among less experienced athletes. Additionally, this sample was a convenience sample and contained only women. We did our best to test the participants as close to the beginning of their normally scheduled practice as possible under the assumption that this would be the time when the participant would be most ready to perform; however, the nature of our cohort made this extremely difficult since, as student-athletes, their schedules were very busy. The participants were encouraged to come before practice; however, if they weren't able because of various reasons (e.g., class and treatment), they came during the normally scheduled practice time on their off-day which may potentially result in a source of variance. In our study we examined RT, which comprises perceptual and motor components. Future studies should separate RT into these components to better understand the effect of goggles. The goal of this study was to assess the performance impact of sport goggles; the control or measurement of head movement was beyond the scope of this article and were not assessed. Since we only studied the short-term effects of not wearing sport goggles, and the transition from sport goggles to no goggles, we did not include a group who wore goggles for all three trials and we did not test all possible combinations of the G and NG conditions or include people who have worn goggles extensively in the past. Thus, we were unable to determine how continuous use of sport goggles may affect performance, or possible neural adaptations in response to changes in the visual field. An unavoidable limitation of this study was that a double-blind experiment in which the participant and the experimenter were unaware as to whether or not goggles were being worn was not possible.

As all sport goggles have slightly different designs, the visual impairment created by the Cascade Iris Sport Goggle may vary from one type to another. Future studies should examine different sport goggles currently available to determine which impairs performance the least amount while still performing its safety duties. Also, it is imperative to determine how the sport goggles influence the game outcomes and game safety. It is not clear as to whether or not the goggles interfere with performance during play and if they actually influence the rate of injury. Despite these limitations, our findings add important information to the literature by demonstrating the impact of goggle use on peripheral target detection.

In summary, the current study demonstrates that sport goggles interfere with an individual's response to identify events that occur in the peripheral visual fields. It was found that as stimuli move further out into the peripheral visual field, the greater the interference of the sport goggles. In competition, this decreased ability to recognise and react to stimuli in the periphery may increase the rate of collisions. Future studies should determine if this results in an elevated risk of injury rather than a decreased risk of injury, as intended by the implementation of sport goggle use.

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References

Clark, J. F., & Trofatter, L. P. (2012, Fall). Goggles and vision impairment. *National Field Hockey Coaches Association (NFHCA) Newsletter*.

Dawson, M. L., & Zabik, R. M. (1988). Effect of protective eyewear on reaction time in horizontal field of vision. *Perceptual and Motor Skills*, *67*(1), 115–120. doi:10.2466/pms.1988.67.1.115

Gallaway, M., Aimino, J., & Scheiman, M. (1986). The effect of protective sports eyewear on peripheral visual field and a peripheral visual performance task. *Journal of the American Optometric Association*, *57*(4), 304–310.

Khurana, V. G., & Kaye, A. H. (2012). An overview of concussion in sport. *Journal of Clinical Neuroscience*, *19*(1), 1–11.

Lemmink, K. A., Dijkstra, B., & Visscher, C. (2005). Effects of limited peripheral vision on shuttle sprint performance of soccer players. *Perceptual and Motor Skills*, *100*(1), 167–175. doi:10.2466/pms.100.1.167-175

Locke, S. (2011, December 11). Survey results on goggle use tallied from USA field Hockey's fall festival. *USA Field Hockey Weekly Report*.

National Federation of State High School Associations. (2011). *2011–2012 Field Hockey rules book*. Indianapolis, IN: Author.

Schwab, S., & Memmert, D. (2012). The impact of a sports vision training program in youth field hockey players. *Journal of Sports Science and Medicine*, *11*(4), 624–631.

Vesia, M., Esposito, J., Prime, S. L., & Klavora, P. (2008). Correlations of selected psychomotor and visuomotor tests with initial Dynavision performance. *Perceptual and Motor Skills*, *107*(1), 14–20.

Wade, L. R., Weimar, W. H., & Davis, J. (2004). Effect of personal protective eyewear on postural stability. *Ergonomics*, *47*(15), 1614–1623. doi:10.1080/00140130410001724246

Wells, A. J., Hoffman, J. R., Beyer, K. S., Jajtner, A. R., Gonzalez, A. M., Townsend, J. R., … Stout, J. R. (2014). Reliability of the Dynavision D2 for assessing reaction time performance. *Journal of Sports Science and Medicine*, *13*, 145–150.