Asian J Sports Med. 2023 March; 14(1):e126591. https://doi.org/10.5812/asjsm-126591.

Published online 2023 March 2. **Review Article**

A Review of the Essential Visual Skills Required for Field Hockey: Beyond 20-20 Optometry

Thabile Sneyimani [1], Musa Lewis Mathenjwa [1], Lourens Millard [1,*] and Gerrit Jan Breukelman [1]

[1] Department of Human Movement Science, University of Zululand, KwaZulu-Natal, Republic of South Africa

[*] *Corresponding author*: Department of Human Movement Science, University of Zululand, KwaZulu-Natal, Republic of South Africa. Email: millardl@unizulu.ac.za

Received 2022 April 23; **Revised** 2022 December 12; **Accepted** 2023 January 06.

Abstract

Context: Field hockey is a very technical and tactical sport, requiring immense levels of visual concentration on moving and stationary targets, which can improve visual and team performance. However, in literature, this area of specialty remains underutilized, with most studies seeking to improve physical and physiological performance. Essential visual skills cannot only be attributed to field hockey but to other ball-playing sports and activities of daily living, which allow humans to coexist. The essential visual skills reduce the propensity of making poor decisions, ill preparations, and the exclusion of potent and capable players.

Objectives: This review novelly aims to not only compile a comprehensive list of essential visual skills for field hockey players but also to create a starting point for future studies to add to this list, to aid in player talent identification, and eventually create sport-specific visual exercise programs and testing batteries.

Discussion: The skills identified in this review preface a platform for human performance professionals to include in their training regimens, with an intent to maximize performance and talent identification and to aid in the formulation of visuospatial test batteries. Even though this list is comprehensive, this is only a starting point for future research to find more visual skills that are essential to field hockey, as well as provide the opportunity to develop the performance of the visual skills of these athletes in ways that have not been done before.

Keywords: Visual Skills, Sport Vision, Field Hockey Vision, Vision in Sport

1. Context

Vision is a fascinating aspect of human existence that aids with visual memories, color identification, and the interpretation of visual stimuli resulting in images formed at the retina, which provides a "20-20 optometry," or perfect vision (1-3). Citizen scientists utilize vision in activities of daily living, such as driving automobiles, signage interpretation, photographic memory recalls, and performing house or work-related responsibilities (2). The main objective of vision in sports is to improve visual physiology and sports performance. To date, it is recorded that vision plays an integral part in sports performance, which enhances psychological, perceptive, and physical abilities (1). Vision is an important aspect of field hockey as it provides players with perception, the ability to perform sports-related drills, synchronization between eyes and playing limbs, and also providing action upon the perceived stimuli (3-5). Visual skills in field hockey simplify an athlete's life by performing tasks such as target identification, scanning of the opponents' playing style, player positioning, reaction to audio-visual signals such as pointing where a ball should be played, and most importantly mastering the hand-eye coordination (6-10). During the execution of a shot, the player executing the shot has to have a peripheral awareness of who's behind him or her. As such, the stroke player will also need to have a good speed of recognition of how fast the player is intended to receive the ball and how much force the ball should be hit with in order to be received by the intended recipient (10-13).

Field hockey is a technical and tactical sport comprised of eleven players on each side, which requires a great deal of visual expertise in reaction time, hand-eye coordination, ball speed judgment, opponent eye gazes, and central and central and peripheral vision (4). The game is played on a rectangular surface which is 91,4 meters long and 55 meters wide, which is divided into areas such as a 25-yard line, pitch boundary, penalty spot, striking circle, goal post, and penalty corner landmarks, that require perfect visual skills in intercepting the opponents' offense (4, 14). Areas such as the penalty corner and striking circle require players to have good hand-eye coordination with the ball and bat; in the process, must utilize opponent eye

gazes alongside central and peripheral vision to complete the stroke (15). All infield players require good accommodation facilities to prevent ball-foot offense. Furthermore, goalkeepers require good reflexes to perfect split-second saves through object speed judgment, hand-eye coordination, and accommodation facility (15, 16).

To date, most studies have focused on single visual skills in field hockey that is important for sports performance, such as accommodation facility, visual performance, speed of recognition, and hand-eye coordination (11-13, 15, 17-20). The abovementioned studies all focused on individual skills, and nowhere in the literature has there been a study to bring all of these visual skills that are essential to performing field hockey together. In this vain, this review novelly aims to not only compile a comprehensive list of essential visual skills for field hockey players, but also to create a starting point for future studies to add to this list, to aid in player talent identification, and eventually create sport-specific visual exercise programs and testing batteries.

2. Methods

2.1. Inclusion Criteria

The studies that qualified for this review met the following criteria: A keyword search yielded MeSH headings; "visual skills, "hand-eye coordination", "peripheral vision", "eye movements","field hockey vision","field hockey rules", "reaction time", "speed of recognition", "accommodation facility," "visual memory", "discriminating efficiency", "visual endurance", "motor learning" and "cognitive function" which were combined and exploded. All the above headings were used to search for article ranging from 1980 - 2021, as mentioned below in the data sources section. The reason for the wide search is to find as many visual skills that are essential to field hockey players as possible, to create a starting point for future studies to identify more of these visual skills to test and train these skills to aid in high-performance.

2.2. Exclusion Criteria

To ensure that only relevant research was included in this review, certain exclusion criteria were implemented. For the purposes of this study, only full-text articles in the English language were considered. Furthermore, articles were excluded if the studies did not show to be relevant to field hockey. Lastly, articles were excluded if no evidence was provided in the studies to show that the mentioned visual skills are essential to field hockey.

2.3. Search Strategy

The literature was retrieved utilizing the guidelines of systematic reviews from the Centre for Reviews and Dissemination (CRD), the Database of Abstracts of Reviews of Effects (DARE), and Cochrane database of systematic reviews (CDSR). The electronic search was accessed through PubMed (1980 - 2021), Google Scholar (1980 - 2021), Biomedical Central (1980 - 2021), Sports Discuss, Science Direct, and International E-catalogues. A keyword search of "visual skills, "hand-eye coordination", "peripheral vision", "eye movements", "field hockey vision", "field hockey rules", "reaction time", "speed of recognition", "accommodation facility," "visual memory", "discriminating efficiency", "visual endurance", "motor learning" and "cognitive function". The searched data was narrowed down to peer-reviewed articles written in English (21).

2.4. Data Extraction

Data corresponding to the topic was collected and structured together by the first author, this included the collection and analysis of essential visual skills in field hockey. The inclusion criteria included published papers that were in full text, studies that had the corresponding title and abstract only, and without a full text were excluded. All the co-authors validated the final choice for the studies selected for the inclusion criteria through an agreement. Depending upon the journals or conference papers they were published in, the keywords associated with the publications were classified as vision in field hockey or essential visual skills in field hockey. As such, the data was collected and extracted. Techniques such as window selection and spatial aggregation were utilized to extract the data collected. Data coinciding with performance, problem description, inclusion criteria, and the aim of the study were extracted to evaluate the relationship of the included studies. Lastly, the overall findings were classified and placed in a tabular format that would allow further discussions based upon the findings. Please see Figure 1 below on how studies were selected and data was extracted.

3. Results

The current study utilized 80 full-text English published papers utilizing an electronic search. After critical dissection of duplicate papers, 64 published papers in accredited journals remained, of which only 26 matched the criteria to form part of this study. Table 1 below mentions and discusses the essential visual skills for field hockey players, and Table 2 provides insight into the previous literature dissecting essential visual skills in field hockey.

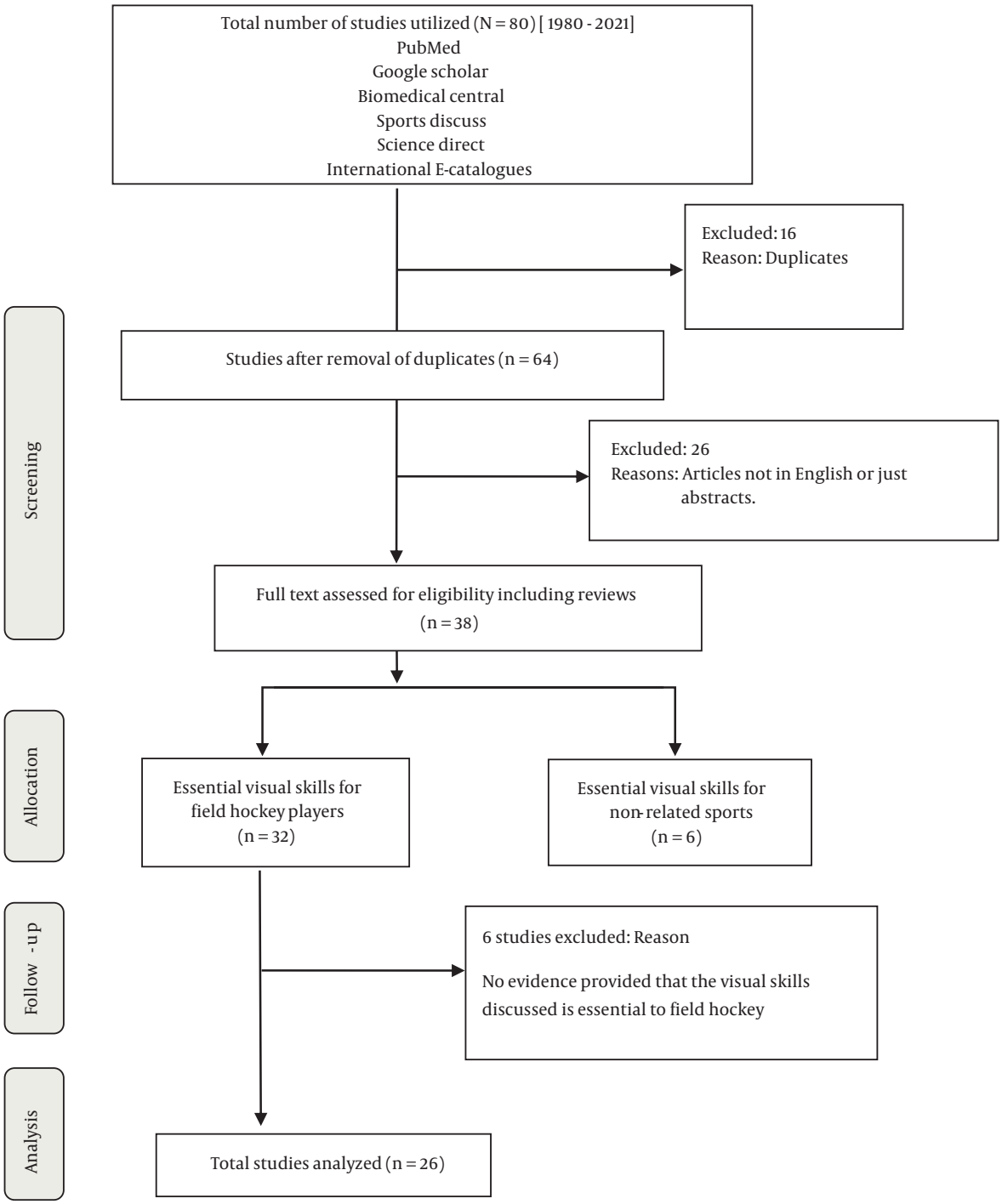

Figure 1. PRISMA flow chart of the study selection process

Table 1. Essential Visual Skills for Field Hockey

Visual Skill	Description	References
Accommodation facility	Identifies object size (goal line, ball, and opponent), its significance, and pattern (mode of play) in relation to the performed tasks (strokes). This later increases the brain processing capacity resulting in greater cognitive abilities and reaction times of the perceived stimuli. As such, field hockey players can calculate the distance to be covered, ball interception, and game judgment.	(15, 18-20)
Saccadic eye movements	Allows an athlete to scan the environment for any potential threats or areas that an athlete would like to exploit, such as defenders not being well organized during a penalty corner, which can result in them conceding a goal. Furthermore, eyes create visual attention which keeps them locked to the target.	(6, 14)
Speed of recognition	Provide athletes with an added advantage in identifying targets and stimulus judgment. Players of all departments (defense to attack) are tasked with one duty, identify the ball and eliminate the threat as quickly as possible, this means converting defense into attack at the blink of an eye.	(17, 22, 23)
Hand-eye coordination	Provides athletic population with the ability to perform the desired task during the moment of thought through limbic innervation pathways, which can prove to be pivotal in the dying minutes of the game, such as a save or a tackle. Furthermore, hand-eye coordination is an essential element of playing any desired stroke, such as a flick or a push; the success of the shot depends on this skill.	(15, 24)
Peripheral vision	Provides an athlete with the probability capacity of estimating ball trajectory or possible opponents' movements based upon playing experience. Players can use their field of view which acts as side mirrors to identifying players on their blind spots.	(17, 25, 26)
Visual memory	Athletes can study other teams' mode of play, strengths and weaknesses, through pre-match videos. This later creates an expected outcome of the opponents' tactics, and their movements can be intercepted easily. This skill in hockey is used to remember the pattern of play that teams have created in the training grounds so to succeed or dissecting a particular player because of the identified weakness. For example, finding the weakest link in the team, such that player will be used as an outlet.	(10, 27)
Depth perception	Provides an athlete with possible reactive means and possible judgements when under pressure, comprised of choices. Among these choices, there would be one, that would be ideal for the current situation faced. For example, fouling a player, or covering the adequate distance to intercept the goal bound puck.	(15, 28)
Dynamic-visual acuity	Enables players with the capacity to focus on the intended object of focus, by neglecting factors such as contrast sensitivity, that can disrupt the athlete, in focusing on the desired target. While the ball is moving at great speeds, players have to be able to reach it and play the ball with minimal offense	(29, 30)
Anticipatory action	Providing an athlete with the capacity of identifying opponents' visual cues prior to the event, by means of utilizing body language, game atmosphere and verbal cues. This skill is heavily dependent upon the athlete's ability to assess movement at short intervals. For example, if a defender imitates a fake shot, naturally attackers/ strikers would try to block the pseudo shot, in that way the faking player gets away with the ball.	(31, 32)
Visual Reaction time	This skill does not only improve individual and team performance but is found to be the key item that minimizes errors and judgments during the game. Such judgements enable the brain to relay impulses quickly so that a reaction is produced, a visual reaction enables athletes to reduce unforced such errors, when a player passes the ball to you quickly and you attempt to play it instantly, but you are a little late and miss the ball completely.	(33, 34)
Atentional expertise	Enable teams and coaches, with cross communication of knowing opponent positioning, response to referee's signals, and man marking of the assigned player. For example, players know that when they attack from the near post the goalie will try to cover it.	(35-37)

4. Discussion

4.1. Previous Findings

Previous studies that were closely related to this review had a common factor of one specialist equipment, which was in the form of computerized software. However, it is worth noting that not all visual skills can be isolated and studied using one method, which is why this review is necessary. Field hockey requires all players, regardless of a specialist position, to understand the field of view (the ability of a player to make decisions based on landmarks on the field), choice of reaction (action based on perceived stimuli), and peripheral vision as indicated by (15, 18-20). This study used methods such as eye charts, eye ports, Dyna vision D2 trainer, a vision performance enhancement program, and P-Rotators, on 34 male athletes. To investigate factors such as field of view, reaction time, and peripheral perception, a six-week intervention consisting of a special training program to improve visual ability (intervention group) participated in the three different measuring points (control group).

Land and Tatler, as well as Alvarez & Franconeri (6, 14), used a speed limit session and an accuracy check session (8 black circles on a grey background) to assess a population of 14 observers with normal or corrected vision. The observers were assessed by exploring visual reaction, target accuracy, and saccadic eye movements using computerized blinking targets that appeared on screen for 2 seconds. The study's main finding was that target tracking was more effective at slow speeds than at fast speeds. In the context of field hockey, all infield players are supposed to track both the ball and the opponent simultaneously

Table 2. Previous Literature Dissecting Essential Visual Skills in Field Hockey

Population	Intervention Protocol	Key Findings	Methods	Explored Factors	References
34 male field hockey players (age 12 - 16)	Special training program to improve visual ability over six weeks (intervention group) took part in the three different measuring points (control group)	Field of view, choice of reaction & peripheral perception can be improved by visual training	Eye charts; eye ports; dyna vision D2 trainer; vision performance enhancement program; P-rotators	Field of view; Reaction time; Peripheral perception	(6-14)
14 observers with normal or corrected vision	Speed limit session; Accuracy check session (8 black circles on a grey background)	Target tracking was more effective at slow speeds compared to fast speeds.	Blinking computerized targets (for 2 seconds)	Visual reaction; target accuracy; saccadic eye movements	(15, 17-20)
Unspecified	None	Visual reaction; Target accuracy; Saccadic eye movements are all under the influence of one commanding center	Scan path fixations during tea making process	Gaze system; motor system; visual system	(20-23)
38 university student athletes from men & women's hockey (18 - 23 years)	There was no control group, all players were part of the intervention during the hockey season	Faster reaction time to a visual stimulus, results in improved visual stimulus discrimination, better visual memory and a faster ability to shift focus between far and near objects significantly.	Nike SPARQ Sensory Performance System (Nike SST)	Visual clarity; depth perception; dynamic visual acuity; contrast sensitivity; hand reaction time	(25-27)
11 skilled male basketball players & 11 less skilled, aged 25	No intervention was utilized.	Experienced players had an expert advantage in identifying the full visual field of an opponent and had better central and peripheral views.	Eye link software; Data viewer software; Experiment builder software	Line of gaze; dynamic visual stimuli; peripheral visual fields; target accuracy; saccades	(29-31)
12 female hockey players (Age 20, height: 162 cm, weight: 62 kg & training experience: Eight years)	Visual exercises training; eight weeks of training included exercises.	Visual exercise training significantly increased the shooting ball velocity and accuracy.	Vienna test system	Double labyrinth, reaction time, time/movement anticipation, and visual pursuit	(32, 33)

to achieve the teams' objectives. For this to be successful, skills such as visual reaction, target accuracy and saccadic eye movements are required.

According to (14), visual reaction, target accuracy, and saccadic eye movements are all influenced by a single commanding center that functions in three ways, gaze system (fixating eyes on a target or object), motor system (the ability of muscles responding to stimuli), and visual system (formation of image in the retina, by determining how far or close the player should be towards the ball or opponent). During the game, the improved visual reaction can result in better responses to stimuli; for example, a goalkeeper with better visual reaction can have better reflexes much better reflexes than one who does not, as evidenced by (10, 27). Furthermore, the data obtained in this study came from 38 collegiate men and women who played field hockey. The data obtained in this study was obtained using Nike SPARQ Sensory Performance System (Nike SST), by exploring factors such as visual clarity, depth perception, dynamic visual acuity, contrast sensitivity, and hand reaction time.

In a study (17, 25, 26) between expert ball players and non-expert players, factors such as line of gaze, dynamic visual stimuli, peripheral visual fields target accuracy saccades were investigated using computerized methods such as eye link, data viewer, and experiment builder. According to the findings of this study, experienced players had a greater advantage when it came to identifying the field of view, central and peripheral views. In a study conducted by (22, 23), the population consisted of 12 female hockey players who participated and had a visual training program for a duration of 8 weeks virtual training program. The results showed that visual exercise training increased shooting ball velocity and accuracy significantly.

4.2. Key Visual Skills for Field Hockey & Direct Play Applications of This Review

Accommodation facility is a skill facilitated by the amount of time required by the visual system to identify the image, and its significance to the field of play, which creates an anticipatory action. Additionally, the field hockey ball can travel at great speeds of up to 147 kilometers per hour, which would require an athlete to have

a good accommodative facility, so as to know the direction of the ball to be intercepted (15, 38). Many strokes, such as pushes, drags, and flicks, can be played during a field hockey match, necessitating greater accommodative capacities from players to spectators (8). Accommodative facility can also be seen as a "screening tool" in field hockey or other team sports. In field hockey, there are midfield players, defenders, and goalkeepers who provide an athlete with spatial awareness as to what and when to execute a certain shot, depending on the athlete's position (31).

Saccades are used in field hockey to read the game's atmosphere, such as body language, providing an athlete with an anticipatory reactive mechanism. Goalkeepers use saccades and body language to anticipate the type of shot that an opponent will play, which improves their perception and action; additionally, successful athletes perform saccadic eye movements 5 - 8 times before any stroke is played (16). Saccadic eye movements selectively identify ball trajectory, and ball position, without requiring an athlete to turn their head completely (39). As a result, saccades in field hockey helps athletes regardless of playing position, with "where" and "when" to process the visual information. For example, when a penalty corner is conceded, striking players and defenders are selectively tasked to locate the fast-moving ball intended for the goal among the crowded territory using saccades (15).

During practice and games, an athlete must use their eyes and upper limbs in synergy to execute shots perfectly. This is accomplished by emphasizing technique and frames of reference (40). During a penalty a goalkeeper is expected to save the ball as it travels at high speeds. Hand-eye coordination is the most important skill for the success of the save; the eye detects the speed of the ball, and visuomotor reflexes are activated, resulting in a successful save (24, 41). The success of hand-eye coordination is dependent on the player's ability to concentrate on the ball intended for a shot and stick holding position (42). The importance of hand-eye coordination can be seen in defenders flicking a ball about 20 - 30 meters away from the goal mouth to a striker and delivering it to the intended recipient who can score; this skill requires a lot of practice on the training field but can be improved (42). Furthermore, when playing field hockey, an athlete must always hold the playing stick, requiring substantial amounts of arm, chest, and shoulder strength, as well as being a key factor in hand-eye coordination

Peripheral vision aids in the processing of visual stimuli that require eye gazes to locate the target, resulting in a dart or an interception from the player (17). Field hockey is a fast-paced sport that requires split-seconds decisions. Because of this, players must have a high level of visuospatial awareness in relation to the athlete's playing position (43). The mastery of peripheral vision can be seen in playing formations such as 5-3-2, which consists of four forwards, three half-backs, and three full-backs, and 4-3-3, which is influenced by the opponents' playing style, coaches' objective, and the team's position in the level of competition (4). In field hockey, the surface markings are used to remind athletes what to do in relation to the territory they find themselves in. As such, the defending team uses peripheral vision to create an anticipatory action, which triggers tactical and technical defending to be practiced in the form of zonal marking (27, 44). In some cases, coaching departments encourage athletes to be vocal, especially if an opponent is approaching the player with the ball's blind spots; as a result, teams develop their own jargon to alert players to the potential threat on their periphery (45).

An athlete's visual memory retains a precise sequence of previously seen events, resulting in a replication of action (27). Teams use pre-match video analysis to study an opponent's strengths and weaknesses to maximize performance (27). Trans saccadic memory (memory lasting tens of milliseconds), active online scene memory (memory lasting seconds), and long-term scene memory (memory lasting minutes, hours, days, and years) are the three types of visual memory (27). Field hockey requires the use of all three types of memories in tandem during a game, with trans-saccadic memory being ideal for territory screening of opponents using saccadic eye movements and ball speed identification. Active online scene memory is used during accommodative facility, where a player and ball position must be identified to be intercepted, and long-term scene memory can be attributed to learning a skill such as performing a push and a flick, as well as having good hand-eye coordination.

The choice of reaction is determined by the team's playing style, organization, score line, and opposition team resistance; as such results, this creates a visual memory, for retaliation to the opponent's game plan, without violating the rules (4, 15). Goalkeepers must have a wide range of reactions to make a successful save. For example, when diving with an outstretched leg or arm, the goalkeeper must decide what is the best reaction for the encountered stimuli (15). Coaches who want to strengthen their team by signing new players must make an informed decision based on the athlete's consistency, adaptive responses to varying game conditions, and whether the athlete fits the coach's playing style (46). The choice of reaction can be seen during stroke plays; for example, in a crowded territory, short passes can be effective (31). When the opponents decide to be compact, the players in possession of the ball can choose the intensity of play, causing the compact team to begin to open. Furthermore, diagonal balls have been shown to be an effective way to hit opponents on a coun-

terattack (46).

Another critical skill is reaction time, which is aided by the hemispheres of the cerebrum assisting in the coordination of field hockey duties (47). Because of the high intensity and tempo of the game, players must be agile and fast to adapt to the sport (48). The ability of the infield players to have quick times determines the team's success. A field hockey ball can travel at high speeds when hit with good technique, requiring a player to react as quickly as possible (15, 38, 47). Reaction times can be used to classify athletes' game intelligence, implying that mastery of basic drills and exposure to different playing styles would indicate a high level of game intelligence (33). When a team is trailing, especially in the fourth quarter, the trailing team becomes very technical and tactical to level the scores, by having good hand-eye coordination skills and reaction times to the strokes played by opponents (8).

The teams play for 15 minutes per quarter, with the referee having the authority to enforce fair play and allow the game to flow. Players pay close attention to not violating the fair play rules (4, 35). Man marking is a technique used in many ball-playing sports to limit an opponent's potential moves (49). Man marking can only be successful if an athlete focuses his or her attention on the assigned player while using drills learned during training (49). Field hockey requires divided attention to focus on opponent positioning, teammates' position, distance to cover, and coaches' signals (35). Divided attention is defined as an athlete's ability to multi-task to fulfil their positional duties. For example, a goalkeeper would call for reinforcements when the opposing team is overriding his/her team at the same time the goalkeeper is anticipating a potential shot (35, 37). Players must be zoned into the game by paying close attention for an extended period, allowing goalkeepers and strikers to communicate with one another. Sustained attention allows players to be vigilant of potential opponents' exploits, have in-depth spatial awareness, and reduce the possibility of making faulty decisions during the game (3).

The dorsal section of the brain recognizes ball velocity recognition and complex strokes, providing an athlete with a perception of ball trajectory. The cortical pathways innervate the eyes and, more importantly, aid in visual motion identification, such as territory, player, and shot patterns (23, 50). During practice sessions, a lot of emphasis is put on drills such as dribble, dodge, and shoot, which should be performed as quickly as possible, putting a lot of strain on the athlete's fight or flight mechanism (23). Players with greater ball velocity recognition can intercept a ball from an opponent before the intended recipient receives it; additionally, a faster rate of recognition can excite muscles corresponding to received stimuli and improve cognitive function (51, 52).

4.3. Conclusions

This review focused on what had been studied previously as research in field hockey as experimental research involving collegiate athletes, amateurs, semi-professional athletes, and elite athletes. Because visual skills are essential in hockey, this review combined all data, regardless of the level of play, to produce a comprehensive list. The visual skills highlighted in this study provide a platform for human performance professionals to include them in their training programs to maximize performance, identify talent, and aid in the development of visuospatial test batteries. According to the findings, interdisciplinary professional relationships related to sports vision should be established to maximize team and individual performance. It is clear from the current literature that no review has been compiled comparing visual skills for field hockey. While the essential visual skills have been compiled and identified in this review, previous studies in this field should not be overlooked as a result of this review. However, they should also be used as a frame of reference for future research.

Footnotes

Authors' Contribution: TS assisted with the design of the study, article dissection, and formulation and direction of the article. MLM contributed to the design of the study as well as the content of the study. LM contributed to the article dissection, the content of the study, writing as well as the formulation and direction of the article. GJB contributed to the content of the study, writing, as well as the formulation and direction of the article.

Conflict of Interests: Funding or research support: The authors received no funding or research support. This is a review article so none was needed. Employment: All authors are employed at the University of Zululand. Personal financial interests: The authors have no personal financial interests. This is a review article, so personal financial interests did not play a role. Stocks or shares in companies: None of the authors have any stocks or shares in a company. Our institution does not allow us to have stocks or shares in other companies. Consultation fees: This was a review article, so no outside consultation was required. Patents: For the purposes of this study, no patents were filed as it is not needed. Personal or professional relations with organizations and individuals (parents and children, wife and husband, family relationships, etc.): All authors only have a professional relationship with the University of Zululand and no other organizations or individuals. Unpaid membership in a government or non-governmental

organization: None of the authors have any unpaid membership in any government or non-governmental organizations. Are you one of the editorial board members or a reviewer of this journal? None of the authors is on the editorial board or is a reviewer for the Asian Journal of Sports Medicine.

Funding/Support: The authors received no funding or research support.

References

1. Nascimento H, Martinez-Perez C, Alvarez-Peregrina C, Sanchez-Tena MA. Citations Network Analysis of Vision and Sport. *Int J Environ Res Public Health*. 2020;**17**(20). [PubMed ID: 33081012]. [PubMed Central ID: PMC7589043]. https://doi.org/10.3390/ijerph17207574.
2. Irvine F, Weissman BA. *Physiology of the Eye: An Introduction to Vegetative Functions*. Massachusetts, USA: Heinemann; 1992.
3. Millard L, Shaw I, Breukelman GJ, Shaw BS. Visio-spatial skills in athletes: comparison of rugby players and non-athletes. *Sport Sci Health*. 2020;**17**(1):137–43. https://doi.org/10.1007/s11332-020-00663-1.
4. Connolly H. *Field hockey: rules, tips, strategy, and safety (sports from coast to coast.)*. The Rosen Publishing Group; 2004.
5. Bressan ES. Effects of visual skills training, vision coaching and sports vision dynamics on the performance of a sport skill. *Afr J Phys Act Health Sci*. 2003;**9**(1):20–31.
6. Alvarez GA, Franconeri SL. How many objects can you track? Evidence for a resource-limited attentive tracking mechanism. *J Vis*. 2007;**7**(13):1–10. [PubMed ID: 17997642]. https://doi.org/10.1167/7.13.14.
7. Farrow D, Abernethy B. Can anticipatory skills be learned through implicit video-based perceptual training? *J Sports Sci*. 2002;**20**(6):471–85. [PubMed ID: 12137177]. https://doi.org/10.1080/02640410252925143.
8. Wimshurst ZL, Sowden PT, Cardinale M. Visual skills and playing positions of Olympic field hockey players. *Percept Mot Skills*. 2012;**114**(1):204–16. [PubMed ID: 22582689]. https://doi.org/10.2466/05.22.24.PMS.114.1.204-216.
9. Hoffman JE, Subramaniam B. The role of visual attention in saccadic eye movements. *Percept Psychophys*. 1995;**57**(6):787–95. [PubMed ID: 7651803]. https://doi.org/10.3758/bf03206794.
10. Poltavski D, Biberdorf D. The role of visual perception measures used in sports vision programmes in predicting actual game performance in Division I collegiate hockey players. *J Sports Sci*. 2015;**33**(6):597–608. [PubMed ID: 25142869]. https://doi.org/10.1080/02640414.2014.951952.
11. Kumar MS. Impact of sport vision training for enhancing selected visual skills and performance factors of novice hockey players. *Indian J Mov Educ Exerc Sci*. 2011;**1**(1):1–5.
12. Pandey G, Acharya J, Pandey V. Comparison of coordinative and proprioceptive abilities among selected team games. *Int J Phys Educ Sports Health*. 2020;**7**(3):261–4.
13. Nayak AK. Effect of hand-eye coordination on motor coordinative ability of tribal adolescents. *Int J Phys Educ Sports Health*. 2015;**2**:328–30.
14. Land M, Tatler B. *Looking and Acting: Vision and eye movements in natural behavior*. Oxford University Press; 2009. https://doi.org/10.1093/acprof:oso/9780198570943.001.0001.
15. Schwab S, Memmert D. The impact of a sports vision training program in youth field hockey players. *J Sports Sci Med*. 2012;**11**(4):624–31. [PubMed ID: 24150071]. [PubMed Central ID: PMC3763307].
16. Morris-Binelli K, van Rens FE, Müller S, Rosalie SM. Psycho-perceptual-motor skills are deemed critical to save the penalty corner in international field hockey. *Psychol Sport Exerc*. 2020;**51**:1–9. https://doi.org/10.1016/j.psychsport.2020.101753.
17. Erickson GB, Horn FC, Barney T, Pexton B, Baird RY. Visual performance with sport-tinted contact lenses in natural sunlight. *Optom Vis Sci*. 2009;**86**(5):509–16. [PubMed ID: 19319013]. https://doi.org/10.1097/OPX.0b013e31819f9aa2.
18. Erickson GB. Optimizing Visual Performance for Sport. *Adv Ophthalmol Optom*. 2018;**3**(1):1–19. https://doi.org/10.1016/j.yaoo.2018.05.001.
19. Schmidt JD, Guskiewicz KM, Mihalik JP, Blackburn JT, Siegmund GP, Marshall SW. Does Visual Performance Influence Head Impact Severity Among High School Football Athletes? *Clin J Sport Med*. 2015;**25**(6):494–501. [PubMed ID: 25380282]. https://doi.org/10.1097/JSM.0000000000000143.
20. Bethel AC, Rogers M, Abbott R. Use of a search summary table to improve systematic review search methods, results, and efficiency. *J Med Libr Assoc*. 2021;**109**(1):97–106. [PubMed ID: 33424470]. [PubMed Central ID: PMC7772975]. https://doi.org/10.5195/jmla.2021.809.
21. Christenson GN, Winkelstein AM. Visual skills of athletes versus nonathletes: development of a sports vision testing battery. *J Am Optom Assoc*. 1988;**59**(9):666–75. [PubMed ID: 3183281].
22. Badr MA. Effects of visual exercises training on developing ball velocity and accuracy shooting of penalty corner in field hockey. *Int J Sports Sci Arts*. 2019;**9**(9):121–30. https://doi.org/10.21608/eijssa.2019.72914.
23. Laird P, Sutherland P. Penalty Corners in Field Hockey: A guide to success. *Int J Perform Anal Sport*. 2017;**3**(1):19–26. https://doi.org/10.1080/24748668.2003.11868270.
24. Rowe D, Lawrence G, Miller T, McKay J. Global Sport? Core Concern and Peripheral Vision. *Media Cult Soc*. 1994;**16**(4):661–75. https://doi.org/10.1177/016344379401600408.
25. Ryu D, Abernethy B, Mann DL, Poolton JM. The contributions of central and peripheral vision to expertise in basketball: How blur helps to provide a clearer picture. *J Exp Psychol Hum Percept Perform*. 2015;**41**(1):167–85. [PubMed ID: 25485663]. https://doi.org/10.1037/a0038306.
26. Konarski J, Matuszynski M, Strzelczyk RYSZARD. Different team defense tactics and heart rate during a field hockey match. *Stud Phys Cult Tour*. 2006;**13**:145–7.
27. Memmert D. Pay attention! A review of visual attentional expertise in sport. *Int Rev Sport Exerc Psychol*. 2009;**2**(2):119–38. https://doi.org/10.1080/17509840802641372.
28. Hansen T, Pracejus L, Gegenfurtner KR. Color perception in the intermediate periphery of the visual field. *J Vis*. 2009;**9**(4):26 1–12. [PubMed ID: 19757935]. https://doi.org/10.1167/9.4.26.
29. Wexler M, van Boxtel JJ. Depth perception by the active observer. *Trends Cogn Sci*. 2005;**9**(9):431–8. [PubMed ID: 16099197]. https://doi.org/10.1016/j.tics.2005.06.018.
30. Raglin JS, Morris MJ. Precompetition anxiety in women volleyball players: a test of ZOF theory in a team sport. *Br J Sports Med*. 1994;**28**(1):47–51. [PubMed ID: 8044494]. [PubMed Central ID: PMC1332158]. https://doi.org/10.1136/bjsm.28.1.47.
31. Barthelemy S, Boulinguez P. Orienting visuospatial attention generates manual reaction time asymmetries in target detection and pointing. *Behav Brain Res*. 2002;**133**(1):109–16. [PubMed ID: 12048178]. https://doi.org/10.1016/s0166-4328(01)00446-6.
32. Nakamoto H, Mori S. Sport-specific decision-making in a Go/NoGo reaction task: difference among nonathletes and baseball and basketball players. *Percept Mot Skills*. 2008;**106**(1):163–70. [PubMed ID: 18459365]. https://doi.org/10.2466/pms.106.1.163-170.
33. Shaw BS, Jan Breukelman G, Millard L, Shaw I. Effect of a Prolonged Maximal Bout of Exercise on Visual Performance. *Asian J Sports Med*. 2022;**13**(1). https://doi.org/10.5812/asjsm.119406.
34. Ngo JK, Tsui MC, Smith AW, Carling C, Chan GS, Wong del P. The effects of man-marking on work intensity in small-sided soccer games. *J Sports Sci Med*. 2012;**11**(1):109–14. [PubMed ID: 24149127]. [PubMed Central ID: PMC3737838].
35. Wilson MR, Vine SJ, Bright E, Masters RS, Defriend D, McGrath JS. Gaze training enhances laparoscopic technical skill acquisition and

multi-tasking performance: a randomized, controlled study. *Surg Endosc*. 2011;**25**(12):3731–9. [PubMed ID: 21671125]. [PubMed Central ID: PMC3213335]. https://doi.org/10.1007/s00464-011-1802-2.
36. Sanchez-Lopez J, Silva-Pereyra J, Fernandez T. Sustained attention in skilled and novice martial arts athletes: a study of event-related potentials and current sources. *PeerJ*. 2016;**4**. e1614. [PubMed ID: 26855865]. [PubMed Central ID: PMC4741076]. https://doi.org/10.7717/peerj.1614.
37. Appelbaum L, Erickson G. Sports vision training: A review of the state-of-the-art in digital training techniques. *Int Rev Sport Exerc Psychol*. 2016;**11**(1):160–89. https://doi.org/10.1080/1750984x.2016.1266376.
38. Liversedge SP, Gilchrist I, Everling S. *The Oxford handbook of eye movements*. New York, USA: Oxford University Press; 2012. https://doi.org/10.1093/oxfordhb/9780199539789.001.0001.
39. Travassos B, Araújo D, Davids K, Esteves PT, Fernandes O. Improving Passing Actions in Team Sports by Developing Interpersonal Interactions between Players. *Int J Sports Sci Coach*. 2012;**7**(4):677–88. https://doi.org/10.1260/1747-9541.7.4.677.
40. Biswas SK, Paul M, Sandhu JS. Role of sports vision and eye hand coordination training in performance of table tennis players. *Braz J Biomotricity*. 2011;**5**(2):106–16.
41. Millard L, Shaw B, Breukelman G, Shaw I. Visual Abilities Distinguish Level of Play in Rugby. *Ann Appl Sport Sci*. 2020;**8**(3):0. https://doi.org/10.29252/aassjournal.906.
42. Vater C, Kredel R, Hossner E. Examining the functionality of peripheral vision: From fundamental understandings to applied sport science. *Curr Issues Sport Sci*. 2017:1–11. https://doi.org/10.15203/ciss_2017.010.
43. Abrosimova LS, Bogdanova MA. Jargon in Sport Discourse: Formation and Functioning. *Res Res Theor Appl Linguist Ser*. 2015;**1**(4):12–7. https://doi.org/10.18413/2313-8912-2015-1-4-12-17.
44. Pill S. Smart Play: Sport is not just about skills and drills. *Teach Nat Educ Mag*. 2011;**4**(2):30–2. https://doi.org/10.21913/JSW.v4i2.723.
45. Maryan P, Yuriy B, Olha Z. Features of theoretical training in combative sports. *J Phys Educ Sport*. 2013:195–8. https://doi.org/10.7752/jpes.2013.02032.
46. Sunawa MK, Rustiadi T, Soekardi S. The Contribution of Hand-Eye Coordination, Muscle Arm Strength, and Concentration to Standing Throw Shoot Results. *J Phys Educ Sport*. 2018;**7**(2):141–51. https://doi.org/10.15294/jpes.v7i2.25120.
47. Deary I. Reaction times and intelligence differences A population-based cohort study. *Intelligence*. 2001;**29**(5):389–99. https://doi.org/10.1016/s0160-2896(01)00062-9.
48. Ando S, Kida N, Oda S. Central and peripheral visual reaction time of soccer players and nonathletes. *Percept Mot Skills*. 2001;**92**(3 Pt 1):786–94. [PubMed ID: 11453206]. https://doi.org/10.2466/pms.2001.92.3.786.
49. Baker J, Cote J, Abernethy B. Sport-Specific Practice and the Development of Expert Decision-Making in Team Ball Sports. *J Appl Sport Psychol*. 2003;**15**(1):12–25. https://doi.org/10.1080/10413200305400.
50. Yao WX, Ranganathan VK, Allexandre D, Siemionow V, Yue GH. Kinesthetic imagery training of forceful muscle contractions increases brain signal and muscle strength. *Front Hum Neurosci*. 2013;**7**:561. [PubMed ID: 24133427]. [PubMed Central ID: PMC3783980]. https://doi.org/10.3389/fnhum.2013.00561.
51. Ahmad Rudin AM, Sharipan MN. Improvement of the Saccadic Eye Movements with the Sport Training Activity.In: Ismail S, Sulaiman N, Adnan R, editors. *Proceedings of the 2nd International Colloquium on Sports Science, Exercise, Engineering and Technology*. Singapore. Springer; 2016. p. 261–8.
52. Kaluga E, Straburzynska-Lupa A, Rostkowska E. Hand-eye coordination, movement reaction time and hand tactile sensitivity depending on the practiced sports discipline. *J Sports Med Phys Fitness*. 2020;**60**(1):17–25. [PubMed ID: 31640309]. https://doi.org/10.23736/S0022-4707.19.09726-3.