Review Article

Visual skills essential for rugby

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ABSTRACT

Background: Keen vision is one of the most important qualities required of athletes. It enables players to perform sports-related drills and apply decision-making skills. To accurately measure the visual ability of athletes, it is important to first identify the variety of visual skills involved in the particular sport. The objectives of this novel review are to identify the most important visual skills required for rugby, and to create a reference point for further studies to include visual skills essential to rugby players.

Methods: We conducted an electronic search with various combinations of relevant keywords using the following databases: Sport Discuss, Ovid's Evidence-Based Medicine Reviews, PubMed/MEDLINE, Current Contents, Science Direct, the National Research Council's Canada Institute for Scientific and Technical Information, Cochrane Database of Systematic Reviews, Google Scholar, and international electronic catalogues to assess the scientific literature related to the visual skills required for rugby. Only the records published in English were included. We extracted data on the relationship between vision and match performance, the defined problem or purpose of the study, and the inclusion of theoretical definitions of tactical behaviors.

Results: Our search yielded 80 records, 51 of which fulfilled the inclusion criteria. The most important visual skills in rugby are classified based on whether they meet the requirements for visual hardware or visual software skills. Visual hardware skills include visual acuity, depth perception, fusion flexibility, and contrast sensitivity; visual software skills include eye tracking, hand-eye coordination, eye focusing, peripheral vision, speed and span of recognition, visual response time, and visual memory.

Conclusions: Rugby players must use both visual hardware and software skills to reliably observe their teammates' positions, understand their opponents' actions and tactics, handle the ball, analyze the immediate circumstances, and anticipate what will occur. Further studies are needed to verify the significance of each visual skill in actual competition to determine a relationship between vision and the results of a championship.

KEYWORDS

vision test, sport, athletic performances, sport medicine, visual feedback, motor skill, sensory feedback, league play rugby, sensory processing, optometrist, ophthalmologist

INTRODUCTION

The field of ophthalmology over the years has emphasized what should be considered 20 / 20 or "normal" vision [1, 2]. *Eyesight* entails how an object's image is focused on the retina, whereas *vision* has a broader meaning. Vision is a mental process because the information is derived from what is seen [1, 2]. Abernethy [1] described vision as the result of visual pathway integrity, efficiency, and information processing. It is an intriguing component of the human presence that assists with visual recollection, color identification, and processing of visual information [2]. The specific objective of vision in sports is to improve visual physiology and athletic performance. Vision is vital to sports performance by increasing psychological, perceptual, and physical capacities [2].

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Keen vision is one of the most essential requirements in athletics. It enables players to perform sports-related drills, apply decision-making skills, and respond to perceived stimuli. Visual skills, such as peripheral vision and awareness, are essential for success in sports [2, 3]. There are two types of vision-training programs: generalized vision training (GVT) and sports-specific vision training (SVT). GVT programs aim to improve fundamental visual functions, such as depth perception, motion perception, and peripheral vision [3]. Vision professionals such as optometrists and ophthalmologists generally use various techniques [3]. Although these professionals typically work with people having a visual impairment, the same methods have recently been employed with athletes to improve sports performance. SVT research has led to task-specific gains in sports performance [4, 5]. The rationale for GVT is that improving the fundamental components of vision will enhance the perceptual-motor abilities that exploit the functions being taught [3].

Visual skills in netball and rugby enhance the athlete's performance in target acquisition, scanning the opponents' playing style, locating player positions, reacting to audio-visual signals such as those indicating where a ball ought to be played, and most critically, maintaining hand-eye and foot-eye coordination [6-8]. A player executing a pass must have a peripheral awareness of other players to the rear. The passer must also swiftly recognize how quickly the recipient aims to get the ball and how much force should be applied to the ball to complete the pass [6-8]. An action such as the line-out requires good hand-eye coordination with the ball and timing of the throw and catch, in which the opponents' eye gazes must be perceived, as well as central and peripheral vision to complete the catch. All players require a good accommodation facility to prevent knocking the ball, and backline players require good reflexes for ball handling, decision-making, speedy judgment for saving line breaks, and hand-eye / foot-eye coordination [6-8]. Movement in response to stimuli during a game is one of the most significant characteristics of a successful athlete. Rugby players who cannot manipulate a ball, pass and catch, navigate the rugby field, or respond to a spin ball will fail in the sport [6-8].

Until now, most studies involving netball and rugby have focused on single visual skills that play a significant role in sports performance, such as accommodation facility, speed of recognition, hand-eye / foot-eye coordination, and visual performance [7, 9-12].

To our knowledge, no review articles have combined all the visual skills essential for playing rugby. Therefore, this review aimed to establish a reference point for further studies to create a comprehensive list of important visual skills for rugby players. This will assist in player talent recognition and develop sports-specific visual testing batteries and training programs for rugby players.

METHODS

Our search strategy aimed to assess the scientific literature related to the visual skills required for to netball and rugby, using various combinations of relevant keywords. Studies complying the inclusion criteria were eligible for this review. Only full-text records published in English were considered. Exclusion criteria were applied to ensure the inclusion of only relevant records. The studies irrelevant to the field, or if they provided no evidence that the mentioned visual skills were essential for success in to netball and rugby, were excluded.

For the electronic literature search, we used the following search terms or corresponding Medical Subject Heading terms, which were combined and explored in a keyword search: "visual skills," "sport vision," "rugby vision," "vision in sport," "depth perception," "eye-coordination," "concentration in sport," "fixation skill," "focusing on sport," "speed in rugby," "reaction time," "colour discrimination," "fusion flexibility," "visual memory," and "contrast sensitivity." These headings were used to search for records published from the years 1966 to 2022. We searched as far back as 1966 to find a comprehensive list of visual skills that are essential to netball and rugby players, as research in this field is limited.

We undertook an electronic search using the following databases: Sport Discuss (1975 to April 2022), Ovid's Evidence-Based Medicine Reviews (1975 to April 2022), PubMed/MEDLINE (1966 to April 2022), Current Contents (1975 to April 2022), Science Direct (1993 to April 2022), the National Research Council's Canada Institute for Scientific and Technical Information (NRC-CISTI) (1993 to April 2022), Cochrane Database of Systematic Reviews (1975 to April 2022), Google Scholar (1975 to April 2022), and international electronic catalogues (1975 to April 2022). Figure 1 displays a study flowchart summarizing our search strategy, screening, and selection of eligible records.

Studies that did not fulfill the inclusion criteria were excluded after the first author collected and analyzed all significant data, which also included analyses of the critical visual abilities in netball. The first author also conducted full-text analyses for inclusion eligibility. The final selection was approved by one of the co-authors, and all uncertainties were addressed until clarity was achieved. If there was any discrepancy, another coauthor made the final decision regarding study inclusion.

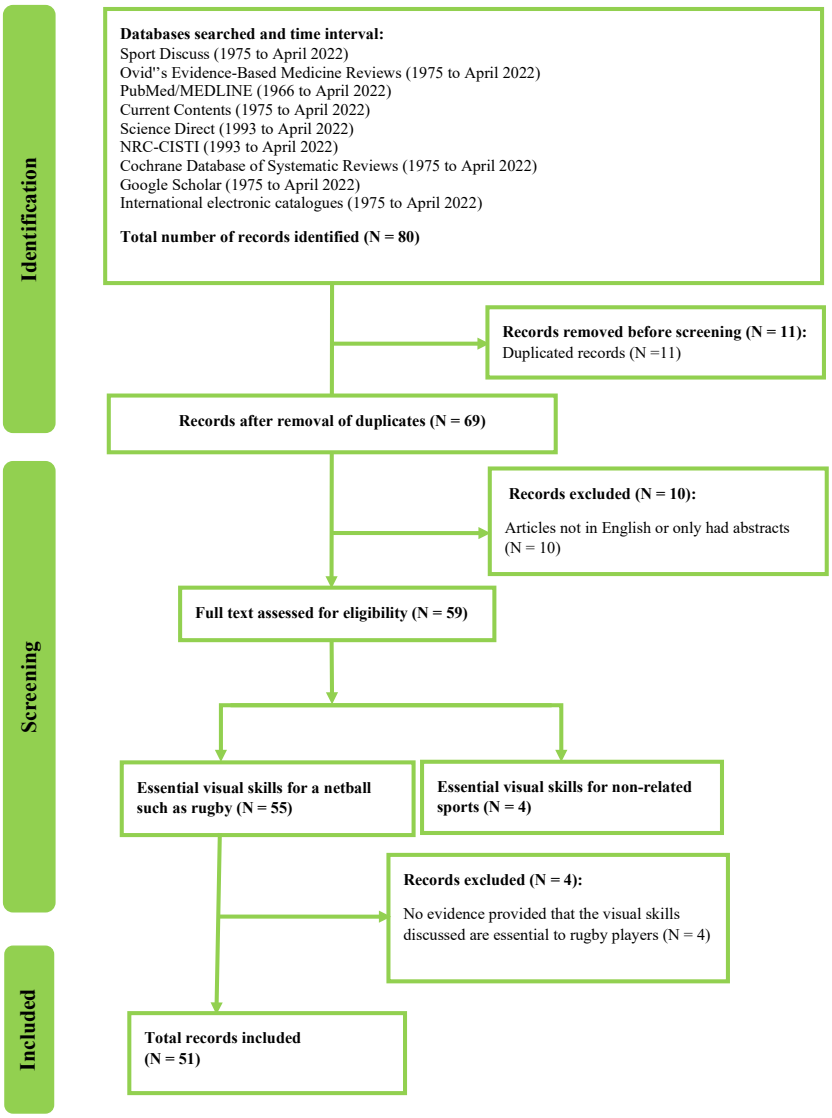

Figure 1. Flowchart illustrating the search strategy, screening, and selection of eligible records for this review. Abbreviations: NRC-CISTI, the National Research Council's Canada Institute for Scientific and Technical Information.

All included records were categorized under the headings of "vision in rugby" or "essential visual skills in rugby" depending on the corresponding keywords. Information regarding data collection was then extracted. To examine the contributions of all research on essential visual skills, we extracted data on analysis methodologies, window selection, and spatial aggregation features. To assess the interpretability of all included studies, information on the relationship between visual skills and match performance, the problem definition, study purpose, and the inclusion of a theoretical explanation of strategic behavior was also extracted. All findings were then organized into categories and placed under a single framework as a basis for our discussion of the findings.

RESULTS

The initial electronic database search yielded 80 records. After removal of duplicate ones, 69 records remained, of which only 18 met the exclusion criteria. Therefore, 51 records were ultimately included (Figure 1). All visual skills discussed in this review are classified based on whether they meet the requirements of visual hardware or software skills. Visual hardware skills include [1] (Table 1) visual acuity [13-16], depth perception [17-20], fusion flexibility [21-25], and contrast sensitivity [23, 25, 26]; visual software skills [1] (Table 2) include eye tracking [27-31], hand-eye coordination [19, 21, 32-36], eye focusing [15, 21, 37-43], peripheral vision [17, 19, 34, 44-47], speed and span of recognition [22, 23, 38, 48-50], visual response time [24, 25, 51-53], and visual memory [24, 50, 54, 55].

Table 1. Visual hardware skills essential to rugby players

Visual Hardware Skills	Description
Visual acuity [13-16]	Athletes with dynamic visual acuity can clearly perceive moving objects.
Depth perception [17-20]	This refers to a player's ability to accurately judge the distances to the ball, the teammates, and the opposing players on the rugby field.
Fusion flexibility [21-25]	This is essential for rapidly and precisely combining two pictures into one image.
Contrast sensitivity [23, 25, 26]	Contrast sensitivity measures the smallest amount of contrast needed to detect a visual stimulus.

Table 2. Visual software skills essential to rugby players

Software Skills	Description
Eye tracking [27-31]	This allows players to shift the eyes to track moving objects without moving the head.
Hand-eye coordination [19, 21, 32-36]	Hand-eye coordination determines how quickly one physically reacts after seeing an object, such as a ball.
Eye focusing [15, 21, 37-43]	Rugby players must be mindful of their teammates' positions, understand their opponents' actions and tactics, handle the ball, analyze the immediate circumstances, and predict what will happen when they act. Maintaining a high level of focus throughout the game allows the player to perform well in both the early and late phases, and if the game goes into overtime, this becomes the most crucial visual talent.
Peripheral vision [17, 19, 34, 44-47]	This refers to an athlete's ability to identify objects in the area of vision away from fixation.
Speed and span of recognition [22, 23, 38, 48-50]	Players must remember a large quantity of information while quickly scanning the rugby field to decide when, where, and to whom the ball must be passed.
Visual response time [24, 25, 51-53]	The faster a player reacts to any set of circumstances, regardless of position on the team, the better the odds of success.
Visual memory [24, 50, 54, 55]	Athletes in various sports must absorb and retain fast-moving and complex images of people and objects.

DISCUSSION

The most variable of the senses that determine sports performance is thought to be vision [31]. Visual information prevails over other sensory systems and is considered vital for proper performance in all sports practically [28]. Rugby requires keen eyesight and visual skills. However, these talents are rarely recognized as sports vision skills [34]. Rugby can be described as visually non-static, requiring continual processing of visual information in motion and the changes in visual information, requiring more than an hour of dynamic visual attention for the athlete to perform effectively [21]. Because of the difficulty in maintaining balance while moving, the range of vision is constantly disrupted and requires distance vision, directional positioning, and visuospatial recognition [16].

Visual demands vary by sport [56]; however, our findings suggest that these visual skills are important for success in rugby [57]. Although previous research examined the impact of vision on performance, studies examining outcomes, movement, and cognition are scarce. Visual skills can be classified as visual hardware or software skills [1] (Tables 1 and 2). Visual hardware is defined as the physical differences in the visual system's mechanical and optometric assets [1]. Abernethy [1] defined visual software as the cognitive differences existing in the analysis, selection, and presentation of information, as well as coding and general handling of a person's visual information during a competition or everyday life training [1]. Rugby players require both visual hardware [1, 13-26] (Table 1) and software skills [1, 15, 17, 19, 21-25, 27-55] (Table 2) to achieve perfect visual performance. Those visual skills essential to rugby players are reviewed below.

Visual Hardware Skills

Visual acuity: Visual acuity is one of the most well-studied qualities of sports vision [13]. Certain academics and therapists have theorized a link between dynamic visual acuity and sports performance [14]. Athletes with dynamic visual acuity can clearly perceive moving objects. Rugby is a sport in which the players are always in motion. As a result, in a game, dynamic visual acuity is especially important because this visual attribute allows players to see the ball kicked on the field, the passes between players, and a return to its original conditions during the opponent's movement [15]. Rugby has the following visual characteristics: *non-static*, in that the task of the sport requires visual information and changes in visual information must be continually processed; *continuous*,

necessitating more than an hour's worth of visual effort; and *dynamic*, in that athletes must constantly maintain balance in the game. Despite the constant challenge to maintain balance in sports, the contender must continue to drive the action in the game, which involves long-distance vision, directional positioning, and visuospatial recognition [16].

Depth perception: This refers to a player's ability to accurately judge the distances to the ball, the teammates, and the opposing players on the rugby field [17]. This skill helps individuals perceive images as three-dimensional; the brain combines the image from each eye to form one three-dimensional picture indicating whether the object is near or far [18]. There is no substitute for a player's ability to judge the rotation of the ball and the approach speed of the opposing players. This skill is crucial in sports such as rugby, which involves moving objects, including the ball, teammates, and opponents [19]. In rugby, players must be aware of their positions relative to their teammates and the ball because of the crowded conditions [20]. The ability to accurately interpret the distance and speed of the ball is essential for effective kicking. Good depth perception allows athletes to monitor the approaching ball, as they can easily place it in the correct space [20]. Depth perception helps athletes to avoid objects such as the in-bounds and out-of-bounds lines and other players. No player stays in the same place for an extended period. The ball and the player constantly move relative to each other; thus, good depth perception is needed [58].

Fusion flexibility: This is essential for rapidly and precisely combining two pictures into one image while maintaining the uniqueness of the image when gazing in different directions [23]. This visual capacity is necessary to avoid double vision and to judge direction and distance when following other players and the ball [24]. Strengthening a mental image without generating double vision enables a player to notice holes and opponents more quickly without becoming disoriented by the visual perception and what is actually in front of the player [24]. Players with fusion flexibility can rapidly recognize the ball as it passes through space [21]. Visual adaptability refers to the rugby player's ability to swiftly change and direct the body's motor reflexes [25]. The player's reactive movement is more consistent if the player's visual system can adjust to changing demands throughout the game [22].

Contrast sensitivity: The visual system's capacity to process temporal and spatial information and to distinguish between an object's backdrop and nearby objects [39] is valuable for discriminating objects of various sizes and contrasts [59]. Contrast sensitivity aids in distinguishing the ball under various lighting conditions [23]. The contrast between an item and its backdrop tends to decrease when there is fog, glare, or insufficient lighting [25]. Color perception is used in sports to differentiate athletes wearing different colored uniforms [60]. Athletic performance may benefit from speedy glare recovery, especially during night sports conducted under artificial lighting [61]. This also assists in distinguishing between opposing players and referees [54]. This characteristic is related to contrast sensitivity; however, it is particular to contrast sensitivity, such as when a rugby player must swiftly identify a ball in the air against a background of the sky (i.e., blue sky, overcast, or sunlight) [16]. A unique component of rugby is the choice of the best filter for the present lighting levels and surroundings [16].

Visual Software Skills

Eye tracking: This allows players to shift the eyes to track moving objects without moving the head, which aids in equilibrium and allows for a more effective manner of seeing [27]. For a rapid motor response, eye tracking is required to follow the path of the ball, to ensure that the player is in the correct position to receive a pass, and to locate teammates and opponents [28]. To track other players and the ball, rugby players must visually monitor the ball, which necessitates quick and accurate saccades [29]. Rapid detection of important visual information is critical for timely motor responses to preceding actions or decisions [30]. Perceptual strategies to extract significant information can be recommended based on the position and duration of fixation. This search strategy allows the processing of data from numerous sources and is manifested in gaze behavior [31]. Because of this visual talent, rugby players can maintain sight on the ball at all times while it moves between players and changes location in a matter of seconds [31].

Hand-eye coordination: This refers to the ability of the hands and eyes to function as a unit. The athlete's eyes must guide the body to execute the appropriate motor skill at a given time [19]. This skill affects the athlete's timing, reaction speed, body control, and balance. An individual's visual system guides the motor system because the eyes look straight and the body follows [21]. Hand-eye coordination determines how quickly one physically reacts after seeing an object, such as a ball, and the ability to guide the hands or feet to the proper place using peripheral vision. In rugby, attacking players require good hand-eye coordination to effectively evade a defender while making a successful pass to a teammate [32]. This enables the player to accomplish an appropriate task at the moment of thought via limbic innervation pathways, which can be crucial in the last actions of a match,

such as a save or tackle. Fixation / gaze describes what an individual's eyes are doing to ensure that they collect more detailed information than during the eyes' normal actions [33]. While playing, participants may be able to react quickly and effectively because they fixate their vision or judgment on the moving ball or opponent with greater accuracy [34]. Rugby players are required to rapidly process information in a changing, unpredictable environment, which helps them improve their hand-eye coordination, visual attention, decision making, and executive action [35, 36].

Eye focusing: This is necessary because the ball and other players move so quickly [37]. Even as general body stamina is depleted with intense exercise, players must be able to quickly shift attention from near to far or intermediate targets during the game [38]. Eye focusing also helps players shift concentration away from the coach's instructions and onto offensive colleagues and goaltenders at the far end of the field [39]. Rugby players must be mindful of their teammates' positions, understand their opponents' actions and tactics, handle the ball, analyze the immediate circumstances, and predict what will happen when they act [40]. Visual concentration and focusing allow athletes to continue concentrating on an object or game when distracting visual stimuli are present [41]. This visual ability allows players to concentrate on the game, particularly when spectators react or cheer at them. Training that forces the brain and body to work continuously can aid concentration, focus, and attention span [15]. Maintaining a high level of focus throughout the game allows the player to perform well in both the early and late phases, and if the game goes into overtime, this becomes the most crucial visual talent [21]. Another crucial aspect of concentration is knowing when and how to shift attention during game play [15]. It does not have to be difficult to incorporate focus abilities into fast-paced sports. Activities geared toward selective attention, attention focus patterns, and attentional transitions become easier to master through repetition [42]. In a continually changing environment, selective attention is required to interpret signals [43]. If all players stay focused throughout a game while exploiting an opponent's mistakes on the field, they may find that this skill determines whether a championship is won or lost [38].

Peripheral vision: This refers to an athlete's ability to identify objects in the area of vision away from fixation. This visual skill can be trained to increase the individual speed and accuracy with which the ball, opponent, or teammate can be identified [17]. Peripheral vision is also associated with athletes' reaction time as they quickly register objects, opponents, or teammates to their sides. Sports disciplines involving multiple stimuli, such as rugby, should improve the players' peripheral visual awareness [44]. This skill not only helps players improve their performance during matches but also helps them avoid injuries [45]. Improving a player's peripheral vision enhances reactions to recognizing an open space and watching the movements of their opponents, as they will have a better general vision of the field. Athletes with poor peripheral vision must first look around before they can respond, which increases response time and may allow the opposing team to score [46]. Rugby players who want to perform grubber kicks require strong peripheral vision [19]. Peripheral vision can help rugby players avoid or prepare themselves for collisions, tackles, or opponents approaching from the side. This visual skill can be trained and improved, as it involves learning how to broaden attentional focus, which itself is a skill [34]. A wing with good peripheral vision will not only focus on a passed ball but will also be aware of the surrounding opponents and the supporting players to the side or rear [47]. Rapid processing of information from the environment enables the individual to decide, prepare for movement, and execute a skill [17].

Speed and span of recognition: In rugby, activities consist predominantly of running. A change in direction during attack moves beyond the opponent's defense line [48]. Thus, rugby players must recognize patterns or movements and react quickly to prevent scoring by the opposing team. This visual ability is crucial for quickly scanning the environment and absorbing all the information necessary to quickly react to a given situation [49, 50]. Players must remember a large quantity of information while quickly scanning the rugby field to decide when, where, and to whom the ball must be passed [22]. Dynamic sports require rapid shifts in balance using the hands, legs, and feet [23]. Skills such as running, tackling, and kicking are essential to playing the game [22, 38, 49]. A faster player has broader cognition and faster reaction and is more likely to be successful on the field [38]. Within a few seconds, a player could make the correct pass, steal the ball from the ruck without fouling, or kick the ball into a precise space.

Visual response time: This refers to the speed with which a player's brain analyzes and reacts to the opponent's actions [62]. A player must respond in a "split second" while recognizing options and dangers on the field [25]. The ability to react faster than the opponent may also increase a player's chance of defeating the opposing team [24]. To keep up with the competition, players must interpret visual information more quickly to achieve faster plays [51]. The faster a player reacts to any set of circumstances, regardless of position on the team, the better the odds of success [51]. Players with dark-colored eyes have demonstrated a shorter reaction time than those with light-colored eyes [52]. Thus, in rugby, when a ball is thrown, players with dark eyes respond faster and perform

better under high balls, because their eyes are less sensitive to light. This may be due to a higher concentration of melanin in the iris of dark-colored eyes [52]. Top rugby league players had shorter reaction times when compared with non-sporting controls [53]. Barrett et al. assessed virtual response time by counting how many saccades and blinks occurred in relation to stimulus onset, and they hypothesized that shorter visual response time in athletes could be associated with improved gaze stability [53].

Visual memory: Athletes in various sports must absorb and retain fast-moving and complex images of people and objects. This is referred to as visual memory. An athlete with a strong visual memory appears to be at the right place at the right moment [50, 54]. Through pre-match footage, athletes can study the opposing team's modes of play, strengths, and weaknesses, enabling anticipation of the opponent's tactics and maneuvers [55], suggesting that enhanced memory occurs only when confronted with task-specific experiences. This may imply numerous possibilities—that visual memory is unimportant to rugby skills, that visual memory cannot differentiate the level of performance in rugby players, or that visual memory has an upper limit in rugby [50]. Skilled players are better than less-skilled opponents at remembering and recognizing patterns of play, and they have greater knowledge of what may happen in different scenarios [24].

We performed an extensive literature search to create a comprehensive list of visual skills essential to rugby players. This was aimed to create a basis for future studies to identify more visual skills to test and train these skills to aid in high performance. Furthermore, we implemented multiple techniques and had specific inclusion and exclusion criteria to rule out biases regarding selection of the included records. Although the search was exceedingly broad, it is possible that some visual skills essential to rugby players were missed. This provides opportunities for additional research to add to the visual skills list. Ultimately, further studies should focus on the position-specific visual skills that rugby players may require for optimal performance.

CONCLUSIONS

This study highlights the essential visual skills required for optimal rugby performance and their contributions to enhancing sporting performance and conferring a competitive advantage. The visual skills highlighted in this review create a platform for human performance professionals to include in their training programs to maximize performance, recognize talent, and formulate visuospatial test batteries. Although this list is comprehensive, it is only a starting point for further research to identify additional visual skills essential to rugby and develop these ancillary skills in yet unexplored ways. Our findings suggest that interdisciplinary professional relationships addressing sports vision should be established to maximize team and individual performances.

ETHICAL DECLARATIONS

Ethical approval: This is a review study and no ethical approval is needed.
Conflict of interest: None.

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