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Essential visual skills required for boxing: A review

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Background: Boxing requires athletes to possess specific visual skills to effectively evaluate situations and react in a timely manner. Understanding these skills is crucial for the training and development of athletes.

Aim: This review aimed to summarise and analyse the essential visual skills required for boxing, highlighting their importance beyond basic visual acuity.

Method: Studies were obtained from various databases, including Science Direct, Google Scholar, CISTI Source, SPORTDiscus and PubMed. A comprehensive keyword search was conducted, searching Medical Subject Headings (MeSH) 'visual skills', 'hand-eye coordination', 'peripheral vision', 'eye movements', 'boxing', 'boxing rules', 'reaction time', 'speed of recognition', 'accommodation facility', 'visual memory', 'combat sport', 'depth perception', 'motor learning', and 'cognitive function'.

Results: A total of 35 full-text English-language articles were included in the review after the removal of duplicates and the full-text review process. The review found that the essential visual skills required for boxing are depth perception, accommodation facility, saccadic eye movements, hand-eye coordination, peripheral awareness, speed and span of recognition, reaction time, visual memory and anticipation.

Conclusion: The findings suggest that training programmes for boxers should incorporate exercises to enhance these visual skills. Further research is needed to develop specific training protocols and evaluate their effectiveness.

Contribution: This review provides a comprehensive overview of visual skills in boxing, offering insights into their role in athletic performance. The study contributes to the development of more effective training strategies and highlights the need for further research in sports vision.

Keywords: vision; reaction time; boxing; depth perception; visual skills.

Introduction

While 'sight' refers to the clarity of the image formed on the retina, 'vision' involves a broader concept, including the cognitive process of interpreting and understanding what is observed.[1] Vision results from the integrity of visual pathways, visual efficiency, and the processing of visual information.[2] It is one of several senses that gather information from the external environment, and its importance in sports is well-recognised, as specific visual skills are crucial for many athletic activities.[3] The vital role of vision in sports is highlighted by common phrases such as 'the eyes lead the body', 'keep your eye on the ball', and 'you can't hit what you can't see'.[4] Visual information is essential for executive functions because the eyes gather data that the brain processes to create a clear picture of the surroundings.[5] From an evolutionary perspective, vision is considered one of the most critical sources of sensory information.[5] Research suggests that the brain often prioritises vision over other senses, and inefficient use of visual processes can significantly affect an individual's abilities.[1] Although the role of vision in sports performance continues to be discussed, research indicates that vision is one of the key senses influencing athletic ability.[1,3,4]

Athletes' visual skills can be divided into two categories: hardware and software skills.[6,7] Hardware skills refer to non-task-specific abilities of the visual system, such as visual acuity, depth perception, accommodation, fusion flexibility, colour vision, and contrast sensitivity.[6,7] On the other hand, software skills encompass cognitive abilities and include visualisation, visual reaction time, central-peripheral awareness, eye-hand coordination, and eye-body coordination.[6,7]

Boxing is a sport where athletes are in close quarters, requiring the ability to quickly evaluate the situation and predict the opponent's next move.[8] This necessitates the capability to initiate a prompt and effective motor response.[8] As a multifaceted combat sport, boxing involves fighters engaging in stand-up fist fighting, using various punches such as jabs, crosses, hooks, and uppercuts, either individually or in combinations.[7] Essential defensive manoeuvres include slipping, bobbing, dodging, and weaving, along with techniques such as parrying, blocking, and clinching.[7] Fighters assume different stances, either orthodox (right-handed) or southpaw (left-handed) and maintain balance while executing their unique fighting styles.[7] Proper distance management at long, medium, and short ranges is also critical.[7] Because of the sport's complexity, athletes must possess high perceptual abilities to gather and retain crucial information before and during their opponent's attacks, allowing them to make timely and appropriate decisions and responses.[7]

Previous research has primarily concentrated on the physical and physiological profiles, biomechanical characteristics, and injuries of amateur boxers.[9,10,11] Additionally, while several studies have explored the visual skills required for boxing, there has not been a thorough compilation of these skills necessary for optimal visual performance.[12,13,14,15] This highlights the need for a review to understand this aspect of boxing better. Therefore, this review aims to compile a comprehensive list of essential visual skills for boxers, which will inform the development of specialised test batteries for Visio-Spatial Skills (VSS) and in identifying potential future talents in boxing.

Ethical considerations

Ethical clearance to conduct this study was obtained from the University of Zululand Research Ethics Committee (No. UZREC 171110-030 PGD 2022/31).

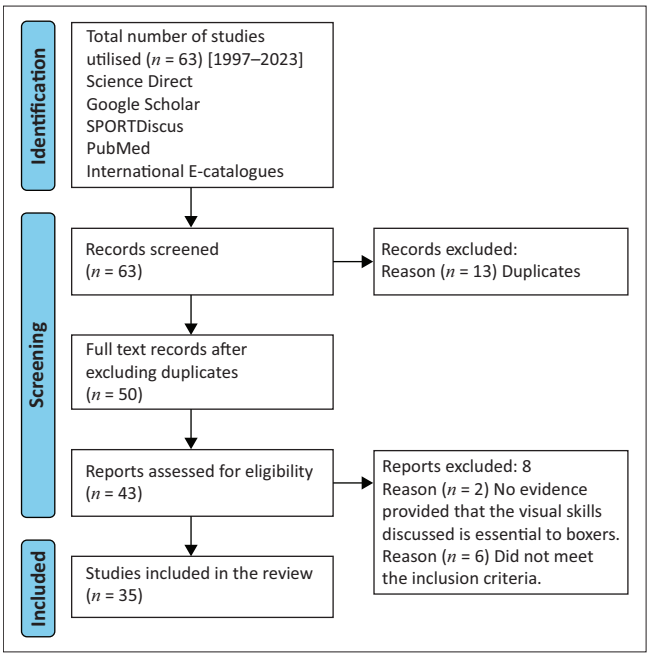
Methods

Search strategy

The literature review on the visual skills required for boxing involved electronic searches across various databases, including Science Direct, Google Scholar, CISTI Source (1997–February 2023), SPORTDiscus (1997–February 2023), PubMed (1997–February 2023), and international e-catalogues. A keyword search included MeSH headings such as 'sport vision', 'boxing vision', 'vision in sport', 'depth perception', 'eye-coordination', 'accommodation facility', 'fixation skill', 'saccadic eye movements', 'visual skills', 'reaction time', 'peripheral awareness', 'visual memory', 'concentration', and 'visual perception'. Only peer-reviewed articles in English were considered, and the search results were categorised for discussion, as illustrated in Figure 1.

Inclusion and exclusion criteria

The inclusion criteria were the following: (1) studies that utilised MeSH headings such as 'visual skills', 'hand-eye coordination',



Source: Adapted from Mathe N, Millard L, Breukelman G, Mathunjwa M. A review of the essential visual skills required for netball: Beyond 20-20 optometry. Ann Appl Sport Sci. 2023;11(3):e1179. https://doi.org/10.52547/aassjournal.1179

FIGURE 1: The Preferred Reporting Items for Systematic Reviews and Meta-Analysis flow diagram showing the summary of study selection and the inclusion process.

'peripheral vision', 'eye movements', 'boxing', 'boxing rules', 'reaction time', 'speed of recognition', 'accommodation facility', 'visual memory', 'combat sport', 'depth perception', 'motor learning', and 'cognitive function' during keyword searches, (2) studies published between 1997 and 2023, as detailed in the data sources section, and (3) studies exploring a diverse range of visual skills essential for boxers. The exclusion criteria were the following: (1) studies not published in the English language, (2) articles not directly relevant to boxing, and (3) studies lacking evidence demonstrating the essential nature of the mentioned visual skills for boxing.

Data extraction

Studies that did not meet the inclusion criteria were excluded from the analysis. After collecting and analysing substantial data on crucial visual skills in boxing, the primary author evaluated each study for eligibility during the full-text review. A systematic approach was used for data analysis, which included the extraction of relevant findings related to visual skills, followed by a qualitative synthesis to identify and summarise the key visual skills essential for boxing performance. Final selections were approved by one of the co-authors to ensure clarity and consistency.

All included articles were categorised as either 'vision in boxing' or 'essential visual skills in boxing' based on their respective journal or conference publications and associated keywords. Data extraction involved gathering information on analysis methodologies, sample selection criteria, and spatial aggregation features to evaluate each study's contributions to essential visual skills. In addition, information regarding the connection between match performance, research objectives or study aims,

and the inclusion of theoretical explanations for strategic behaviours was extracted to assess research interpretability. The findings were systematically categorised and organised within a comprehensive framework, as illustrated in Figure 1, which will guide the discussion of outcomes. The Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) statement was selected for its effectiveness in transparently depicting the study selection process, ensuring clarity in reporting systematic reviews and meta-analyses.[16]

Review findings

This research utilised 63 full-text English-language articles obtained from 63 citations identified through electronic searches. After eliminating duplicates and reviewing full-text versions, 35 articles were retained for analysis. The study identified various visual skills essential for boxing, recognising that some are more critical for performance than others. However, all these skills are deemed relevant and contribute to enhanced performance in boxing. Refer to Table 1 for a comprehensive list of essential visual hardware skills and Table 2 for a comprehensive list of essential visual software skills.

It is widely believed that the visual system offers the most comprehensive and abundant source of information about our surrounding environment.[34,46] Vision is a crucial sense that plays a vital role in processing external information from our surroundings.[4] It is the primary sense involved in planning and executing responses to specific stimuli.[4] Vision contributes significantly to coordinating movement by interacting with both visual perception and proprioception.[37] While other sensory systems may offer more relevant information for appropriate behaviour, vision allows athletes to concentrate on the specific task or motor skill at hand.[37] This helps them to avoid being distracted by irrelevant elements or information in their environment, such as other players, spectators, or unrelated colours.[37] The communication between the eyes and the brain is essential for conveying details about an object's dimensions, form, colour, and surface characteristics.[38] Moreover, the eyes play a crucial role in alerting a boxer to the proximity of an incoming punch, whether it is static or in motion towards them, and its velocity.[38]

Optimal vision, which requires exceptional visual skills, contributes to roughly 80% of how athletes gather information about their sports environment. The visual skills identified in this review are as follows. Visual Hardware includes depth perception, accommodation facility, peripheral awareness, and saccadic eye movements. Visual Software includes eye-hand coordination, speed and span of recognition, visual reaction time, visual memory and anticipation.

Visual hardware

Dodging punches in boxing is like a high-stakes game of timing and precision. Boxers must swiftly calculate the distance and direction of each incoming blow, almost like anticipating the next move in a fast-paced dance.[17] That is where depth perception comes in. Depth perception is the ability to judge the distance between objects in the environment.[18] The best depth perception is necessary for an athlete to have the best stereo vision.[19] Depth perception allows an athlete to judge the relative distance between two objects that are at different distances from one another as well as to perceive movement in three-dimensional space.[19] In the context of boxing, fighters must ascertain the distance between an incoming punch and their position. An essential component of depth perception in humans involves discerning motion in depth, such as when a punch is advancing towards a boxer.[20]

For athletes to be able to focus quickly on stable and clear vision, especially when trying to fixate from far to near or vice versa, accommodation facility is essential.[21] Accommodation is the ability of the eye to adjust its refractive power to focus objects at various distances.[22] Furthermore, accommodation facility is the ability of the eye to quickly switch from one distance to another.[23] Weaknesses in accommodating facility are likely to affect one's ability to

TABLE 1: Visual hardware skills.

Visual skills	Description	References
Depth perception	Helps boxers to accurately judge distances in the ring	17,18,19,20
Accommodation facility	Refers to the ability of the eyes to rapidly adjust focus, crucial for accurately judging distances, perceiving punch speed, and maintaining visual clarity during a fight	14,17,21,22,23
Peripheral awareness	Helps boxers stay alert to their surroundings beyond their direct line of sight	12,24,25,26
Saccadic eye movements	Allow rapid shifts of gaze between different points of interest, enabling quick assessment of the opponent's movements and strategic planning during a fight	27,28,29,30,31,32

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Note: Please see full reference list of this article https://doi.org/10.4102/aveh.v83i1.981 for more information.

TABLE 2: Visual software skills.

Visual skills	Description	References
Hand-eye coordination	Ensures accurate control and synchronisation between boxer's vision and physical movements, facilitating precise actions in the ring	4,12,33
Speed and span of recognition	Influences how rapidly and accurately boxers can identify and process visual cues, such as their opponent's stance, movements, and openings	20,34,35,36
Reaction time	Determines how quickly boxers can respond to their opponent's movements	37,38,39,40,41
Visual memory	Helps boxers recall and analyse their opponent's movements during a fight, aiding in quick decision-making and strategy adjustments	42,43
Anticipation	Enables boxers to predict their opponent's moves, enabling them to effectively strategise, evade punches, and seize opportunities during a match	35,44,45
Gaze control	Allows athletes to maintain a soft focus on their opponent's body, enhancing peripheral vision	26

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perceive depth and may slow down one's ability to process visual information quickly.[23] In the ring, boxers need sharp focus to react quickly to their opponent's moves.[14] During a round, they constantly shift their attention to assess threats and openings.[17] Accommodation facility is crucial as it allows them to rapidly adjust focus between their opponent, their position, and the surroundings, ensuring they can make split-second decisions with precision throughout the fight.

In sports, it is crucial for an athlete to gaze in the right place to take advantage of his or her sharp foveal vision, but it's also crucial to use one's peripheral vision to pay attention to nearby objects without looking directly at them.[25] Peripheral vision is the capacity to perceive objects and motion away from one's line of vision.[24] Peripheral vision provides athletes with the benefit of encompassing approximately 180° of the visual surroundings, allowing them to perceive pertinent information well beyond the central focus of the eye.[26] It has been demonstrated that peripheral vision plays a role in controlling the amplitude of a movement, and visual performance is generally regarded as an important factor for sporting excellence.[26] This aspect is particularly advantageous in combat sports, where attacks often originate from the extremities, such as the opponent's arms or legs.[26] Given the close proximity to the opponent and the considerable distance between the limbs, it is impractical to focus sharply on all regions using the fovea, as the foveal field of clear vision is limited to (less than) 2° of visual angle.[26] Boxing often imposes both physical and perceptual demands, and they frequently necessitate the development of certain skills in order to evade attacks that come at fast speeds from the peripheral.[12]

Combat sports and ball activities prioritise precise object tracking and quick reactions more than many other sports.[27,28] Saccadic eye movements are brief, abrupt, and rapid eye movements that happen when the eye is fixating on one point to another.[29] A saccade is a rapid and conjugate eye movement in which the eyes voluntarily shift from one target to another, bringing an object of interest into focus on the fovea, the region of the eye with the highest visual acuity.[30,31] It is important for combat athletes to quickly pick out important details from a lot of changing information about the competition as this helps them predict what their opponent might do and react fast and accurately.[32]

Visual software

As in any full-contact combat sport, the main objective is to be efficient in attacks and counterattacks, hitting the opponent correctly and accurately, and avoiding getting hit, which all require a strong hand-eye coordination.[12] Hand-eye co-ordination is the brain's ability to receive and analyse visual information and respond to it with coordinated hand movements.[4] When boxers have excellent hand-eye coordination, they find it simpler to perform combinations of punches and kicks with precision, particularly when considering the right timing and distance for their attacks.[33] Fighters with superior hand-eye coordination can effectively control the distance between themselves and their opponent, allowing them to strike with accuracy while minimising the risk of being countered. Additionally, in competitions, it is vital for athletes to target effectively to score points, highlighting the importance of solid hand-eye coordination for delivering successful combinations.[33]

In the intense realm of boxing, the speed of recognition stands as a critical determinant of a fighter's success in the ring. Speed of recognition is the amount of time required to correctly judge a visual stimulus.[35] These responses can be applied to a variety of visual tasks, such as identifying a target, differentiating between objects, recognising an object as familiar, determining what an object is, indicating its spatial location, and making other kinds of decisions about visually complex events.[35] As is the case in many sports, a behavioural response to a visual stimulus frequently needs to be quicker than conscious perception of that stimulus.[36] A boxer's speed in throwing punches is really important.[20] Being able to punch fast and catch your opponent off guard often decides who wins the fight, thus making speed of recognition an essential skill in boxing.[20] The ability to quickly recognise gaps in the opponent's defence and react with precision could make the difference between victory and defeat in the fast-paced and dynamic environment of a boxing battle.[34]

Boxing is a competitive combat discipline where two contenders fight for success.[37] To achieve this objective, each participant must swiftly adjust to evolving circumstances, mentally predict their opponent's moves, and respond to external cues while also thwarting the opponent's strategies.[37] These objectives must be executed rapidly because boxing is a dynamic sport characterised by swift movements.[37] Because boxing is characterized by swift movements, reaction time is an especially important factor in this sport.[38] Reaction time is the time that elapses between receiving an immediate and unexpected stimulus and responding to it.[39] For daily tasks, alertness, and general wellness, quick reaction time is crucial, because of this, reaction time plays a significant role in both an athlete's day-to-day activities and athletic performance.[40] Athletes possessing quicker reaction times are of greater significance compared to athletes who share similar neuromuscular mechanisms, cognitive abilities, and tactical capacities.[40] Boxing requires two important qualities: reaction speed and punch force.[41] The faster a boxer reacts to his or her opponent's movements during a fight, the more likely he or she will be successful in aspects of his or her own performance such as parings, counter blows, and blow initiatives.[41] The speed with which a punch can be delivered thus determines the success of a performance.[41]

As discussed, in boxing, quick reactions are essential. A key factor in achieving this is effective gaze control, which helps optimise peripheral vision while minimising the drawbacks of rapid eye movements or saccades.[26] Because attacks typically come from the opponent's upper body, boxers can benefit from anchoring their gaze around the head or chest to monitor key cues like arm movements without constantly shifting focus.[26] This technique enables faster detection of

attacks through peripheral vision, improving reaction time and defence.[26] Moreover, steady gaze control prevents visual suppression during saccades, ensuring important details are processed without interruption.[26] This effective gaze control enables boxers to focus less on distracting elements, such as facial expressions, and more on the movement of their opponent's body, ultimately enhancing their ability to anticipate attacks.

Visual memory involves the mental skill of remembering and bringing back to mind visual images or information that was seen or noticed before.[42] During competition, athletes are constantly presented with varying stimuli within their field of view.[43] This view is typically confined to specific areas such as a playground, track, or ring, depending on the sport.[43] Athletes must process and respond to these stimuli, with the number and complexity changing dynamically.[42] For instance, in combat sports such as boxing, athletes need to memorise their opponent's position and individual characteristics.[42] This highlights the significance of short-term visual memory in athletes' preparedness, as it enables them to quickly recall and respond to the relevant information presented during the competition.[42]

In sports and other fast-paced situations, it's important to be able to guess what others are going to do.[44] In combat sports, athletes often cannot afford to wait until an attack is executed.[45] Ideally, they should anticipate the opponent's next move based on cues gathered from their preparatory movements or the current situation.[45] That is why experts in combat sports tend to react more accurately – they use cues or clues to predict what the opponent will do next.[45] In boxing, being able to predict what your opponent will do before they do it can really boost performance.[44]

Although this review focuses on visual skills specific to boxing, many of the identified skills, such as hand-eye coordination, depth perception, and reaction time, are integral to performance in a wide range of sports. For instance, hand-eye coordination is critical in tennis for hitting the ball accurately and reaction time is crucial for performance in martial.[25,47,48] These commonalities highlight that visual skills are foundational across different sports, even when the demands and applications vary. The inclusion of references from non-boxing sports literature reflects this shared importance, providing a broader context for understanding how visual skills contribute to athletic success in both boxing and other sports.

The study's limitations lie in the scarcity of prior research focusing on the visual skills necessary for boxing, as well as their specific significance in the context of boxing. Additionally, despite conducting a thorough examination of the critical visual skills required for boxing, there remains the possibility of overlooking certain visual skills. Therefore, this study serves merely as a foundational exploration, leaving room for future research to identify and incorporate essential visual skills relevant to boxing. Furthermore, the exclusion of visual acuity (static and dynamic) is a notable limitation. While visual acuity is an important foundational skill, the lack of available studies on its specific role in boxing led to its omission in this review. Future research could address this gap by exploring the impact of visual acuity on boxing performance and its interplay with other visual skills.

Recommendations

Future studies should prioritise the creation and validation of training protocols designed to enhance visual skills in boxers, utilising advanced technologies such as eye-tracking and motion capture for precise measurement. Longitudinal research is essential to track the development of visual skills over time, while comparative studies should explore these abilities across various levels of expertise and different combat sports. Moreover, incorporating visual skills assessments into regular health evaluations and promoting interdisciplinary collaboration among sports scientists, optometrists, neuroscientists, and coaches will be vital for developing comprehensive training programmes that address the diverse aspects of visual skills in boxing.

Conclusion

This review identifies several essential visual skills critical to boxing performance, including depth perception, accommodation facility, saccadic eye movements, hand-eye coordination, peripheral awareness, speed and span of recognition, reaction time, visual memory, and anticipation. The findings emphasise the need for targeted training regimens to develop these visual skills in boxers. While this review provides valuable insights, there are gaps in the literature regarding the role of specific visual skills in combat sports. Future research should focus on determining the trainability of these skills and assessing their direct impact on performance in both amateur and elite boxers. Additionally, investigations into the contributions of optometrists, ophthalmologists, and sports psychologists in developing training protocols could provide a more comprehensive understanding of how to optimise visual performance in athletes. Moving forward, further studies could explore the efficacy of visual skill training in other combat sports, the long-term benefits of such training, and the potential for visual testing to identify talent in young athletes. These topics represent key areas for future research that could significantly advance our understanding of the role of visual skills in athletic performance.

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Competing interests

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S.M., L.M., G.J.B., and M.L.M. contributed equally to the study's design, article analysis, content, and writing.

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Data availability

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