Importance of vision and sun protection in outdoor sports: a narrative review

YOSHIMITSU KOHMURA

Faculty of Health and Sports Science, Juntendo University, JAPAN

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Abstract:

All sports have positive effects on health; however, in some cases, they may also have negative effects on the human body. In this narrative review, I explored the topics of vision and sun protection against sunlight in outdoor sports. The results on both eyes and skin protection against ultraviolet light were included. Accumulated knowledge in this area can help maintain health and improve competitiveness in the specialized field of outdoor sports. Visual functions and visual search strategies are important factors in outdoor and indoor sports events. Sports participants play and compete by relying on visual information. In outdoor sports, sunlight has a large effect on the eyes; thus, participants need to protect their eyes when playing sports. Participants in outdoor sports feel glare from the sunlight, which affects their performance and health. It is important to protect eyes with sunglasses because participants will be exercising outside for long periods of time. In addition, outdoor sports participants should protect their skin from ultraviolet light. Sunlight exposure is considered a serious risk factor for skin. The effectiveness of educational approaches for sun protection has also been examined in recent years. There have been reports on efforts to promote sun protection using the apps and wearable sensors. The current situation and issues related to sun protection for each outdoor sports event should be clarified. It is desirable for people to enjoy outdoor sports in an efficient and healthy manner. Thus, it is important to provide information about ultraviolet rays and ways to protect eyes and skin from childhood.

Keywords: Visual Functions; Visual Search Strategy; Ultraviolet light; Eye Protection; Skin Protection; Physical Education

Introduction

Although outdoor sports are restricted by seasons of the year and certain geographical regions, there are many major sports events in the outdoor sports category. Representative outdoor sporting events include soccer, track and field, baseball, cricket, hockey, rugby, skiing, and snowboarding. Many outdoor sporting events are conducted in natural light, which allows participants to enjoy a clear sky and comfortable nature but also forces them to perform in harsh natural conditions. Exercise in nature has positive effects on physical and mental health. In contrast, considering the physical impact, players need sun protection for the eyes and skin.

Practicing outdoor sports requires physical fitness, and the topic of sports medicine and injuries is discussed in numerous studies (Oosterhoff et al., 2019; Salamh et al., 2020; Waldén et al., 2018). In addition, sports-related physical activities require accurate information based on visual perception. Numerous studies have explored this visual perspective, and ball games heavily rely on this aspect (Laby et al., 2011; Zwierko et al., 2010). Moreover, research on visual search strategies has revealed the points necessary for collecting information in various sports. Vision is considered to cover a large area. Thus, there is a need for studies focusing on the visual aspects of many sports events, including outdoor sports.

In many outdoor sports, sunlight has a significant influence on the eyes and visual information. When assessing the relationship between vision and light in sports, different perspectives come into play such as artificial light sources and reflections when studying indoor sports and bright sunlight in outdoor sports. Vision is highly influenced by sunlight in outdoor sports. Its impact can be divided into the influence of sunlight on eye health and performance. The former usually presents as concerns about cataracts and pterygium caused by ultraviolet light (McCarty & Taylor, 2002; Threlfall & English, 1999). The latter focuses on the positive effects of protecting the eyes from glare and other light-related impacts on visual function and subjective perception.

In addition to sunlight, those who engage in outdoor sports are liable to other outdoor environmental effects. These include temperature, air pressure, wind, and humidity, which have a major impact on players' performance. Sunlight has a large effect on the skin as it does on vision. It is mainly ultraviolet light that significantly affects the skin, and the concerns, in this case, are related to the risk of skin cancer (Parkin et al., 2011). The amount of exposure to ultraviolet light should be limited to prevent health problems. These topics have been studied in the past. However, in recent years, there has been an increase in the number of studies focused on appropriate education, sun protection approaches, and their promotion.

This study summarizes previous research on the importance of vision and sun protection in outdoor sports and describes the issues that have been elucidated. My objective was to identify future topics for academic

studies. I categorized previous studies based on the following three perspectives: 1. vision in sports, including outdoor sports; 2. the effects of sunlight on the eyes, and 3. the effects of sunlight on the skin. Although there is a limited number of studies on vision in outdoor sports events, numerous results were obtained by selecting data from indoor sporting event reviews. I believe that these efforts will provide an appropriate foundation and ideas regarding academic research advancements required in this field.

Sports and Visual Functions

Visual information is essential, particularly in ball games and open-skill sports. Many studies have focused on these types of sporting events (Beckerman & Hitzeman, 2003; Laby et al., 1996; Laby et al., 2011). The number of sporting events that have been the focus of studies is extremely large. Even though there may be slight differences between different sporting events, vision is essential to most of them. The competitive levels of players involved in the target sports vary; however, many studies on visual function focus on athletes who have achieved high skill levels. Laby et al. (2003) described the results of measuring multiple visual functions of 387 professional baseball players. The comparison between the results of major and minor league players showed that major league players had significantly superior stereopsis and some contrast sensitivity elements. Although they focuses on indoor sports, Poltavski & Biberdorf (2015) recently studied the link between the visual function and competitive performance of ice hockey players. This study found a valuable relationship between visual skills and game statistics such as goal percentage and number of points.

There have been studies on many other sporting events (Beckerman & Hitzeman, 2003; Laby et al., 1996; Zweirko, 2007). Beckerman et al. (2003) studied the visual function of junior Olympic-level athletes (aged 5–19 years). The study focused on a wide variety of sporting events such as basketball, gymnastics, track, soccer, tennis, baseball, softball, wrestling, karate, powerlifting, surfing, and hockey. The abovementioned study mentioned the need for athletes to care about their vision and the importance of measurement evaluation criteria, including outdoor sports. There have also been studies conducted on many Olympic-level sporting events, which assessed the visual functions of outdoor sports athletes (Laby et al., 2011). In some sporting events, the athlete as well as the targets move at high speeds. In addition, athletes must make extremely fast decisions about the ground surface conditions and the positional relationship between players and targets (e.g., goal, ball, and players). In a natural environment, visual functions are essential in making decisions about situations that are distant from the athlete. With the growing number of studies focused on athletes' visual functions, we can use certain approaches and methods to improve competitive sports performance, including evaluating visual functions and correcting visual acuity. Thus, there is a need to promote further research in this area.

A study focused on vision in shooting-type sporting events has also been conducted. Di-Russo et al. (2003) examined the fixation stability and saccadic latency of clay pigeon-shooting athletes. Their analyses indicated that the clay pigeon shooters were superior in both skills compared to the control subjects. Their results may apply to other outdoor sports such as archery, shooting, biathlon, and ballgames. Vickers & Williams (2004) focused on the gaze control of biathlon athletes under a particular condition (under pressure). Moreover, shooting-type sports athletes often wear sunglasses or goggles.

There are various visual functions, and each has been a subject of study. Representative visual functions include dynamic visual acuity, depth perception, contrast sensitivity, and hand–eye coordination. Dynamic visual acuity is the ability to accurately distinguish a moving target. It is thought to have a particularly close relation to eye movement, and its latency is considered to be interrelated (Kohmura et al., 2008). Depth perception, or the ability to judge the distance between objects, is another visual function that is closely related to sporting activities. The importance of this ability has been mentioned regarding sporting events that involve a judgment of the distance and positional relationship of players and between players and a target (e.g., ball and goal). Contrast sensitivity is the ability to distinguish between dark and light, which is essential when playing sports (Hoffman et al., 1984; Laby et al., 1996). These visual functions are also considered to be important in outdoor sporting event performances.

Similar studies use physiological and psychological approaches in fields related to vision and in studies with various terms such as “perceptual”, “cognitive”, and “decision-making”. (Alves et al., 2013; Stewart & Hall, 2017; Zweirko et al., 2010). The differences between the researchers' perspective may arise from differences between physicians, optometrists, and researchers in the field of sports science, coaches, and trainers. The future development of these relevant fields requires cooperation beyond the conventional boundaries of each field and the researchers' perspectives.

Gaze and Visual Searching in Sports

In recent years, in addition to the field of visual functions, there has also been an increase in the number of sports science studies focused on either visual searching or gaze behaviors. Researchers conducting these studies analyzed where and how players looked using specialized equipment. The direction of the players' gaze differs based on the particular characteristics of each sporting event. In addition, their visual search strategies change as they gain experience. In the past, it was difficult to objectively quantify where people were looking. In recent years, while the need for highly advanced equipment remains, measurement technologies have advanced.

Many previous studies have focused on ball games, similar to visual function research. Gaze (visual search strategy) has become the focus of attention because it is closely related to situational assessment and decision-making. These studies have focused on sporting events such as soccer, volleyball, and judo (Krzepota et al., 2016; Piras et al., 2014a; Piras et al., 2014b; Vaeyens et al., 2007). Krzepota et al. (2016) analyzed gaze in defense situations in soccer. They found that experienced players used search strategies more efficiently than novices. A study on predictions of whether a volleyball setter would toss a ball forward or backward found that volleyball players could make accurate predictions using searching strategies (Piras et al., 2014a). Studies related to gaze behaviors, including decision-making and judgment, have been conducted. There has also been a study on gaze behavior that focused on hitting balls that bounced at high speeds while playing cricket (Croft et al., 2010; Land & McLeod, 2000). In other outdoor sporting events, there is a need to study gaze behavior related to characteristics such as decision-making, judgment, fast-moving targets, and fast-moving players.

Recently, studies on gaze in outdoor winter sporting events have been conducted. Decroix et al. (2017) conducted a survey of gaze behavior during alpine slalom skiing that compared experienced skiers to novices. The researchers measured eye movements using an eye-tracker as skiers navigated an indoor ski slope with a temperature of approximately -6°C . Their results showed that experienced skiers focused on the next turn pole (gate). An analysis of experienced alpine skiers' gaze behavior during extremely fast movement and in a cold environment has been conducted, and its results are quite valuable. A study of gaze that focused on ice hockey players engaged in one-on-one play was also conducted (Vickers et al., 2017).

Studies from the different perspective of the visual search of football referees have also been conducted (Spitz et al., 2016). Recently, efforts to replay images of referees' judgments and apply the latest equipment to such research have been advancing, which has further underscored the need for accurate referee judgments to be made during all types of sporting events. Another research topic that is of great interest is the recent focus on what coaches pay attention to in players' training and coaching (Avila & Moreno, 2003; Moreno et al., 2006). Studies of gaze behaviors that focus on the transmission of techniques and skills have been conducted in other fields. These fields are highly varied and include psychology, sociology, and marketing. We look forward to future studies of this kind in the fields of sports in general and outdoor sports in particular.

In this section, I provided an overview of previous studies that highlighted the importance of vision. These studies reported that a variety of visual skills are involved in many sporting events. In outdoor sports, the number of studies focused on a wide variety of sports have increased, and it is expected that further research on the particular characteristics of vision in each sport will continue. In the next section, I will discuss sunlight and sunlight protection, which considerably effect vision in the environment of outdoor sports, from the perspective of health.

Effects of Sunlight on the Eyes

In the previous section, I discussed the importance of vision. However, the effect of sunlight on the eyes, particularly in outdoor sports, is also a matter that requires attention. Sunlight includes ultraviolet light. Human eyes cannot perceive ultraviolet light, but it has a major effect on them. Previous studies indicate the influence of ultraviolet light on the development of conditions such as cataracts and pterygium (McCarty & Taylor, 2002; Threlfall & English, 1999). Eyes are exposed to large amounts of ultraviolet light during outdoor sports activities, including outdoor leisure activities. Therefore, preventive measures should be taken to avoid the risk of physical harm caused by ultraviolet light while practicing and enjoying outdoor sports, which are considered to be valuable health activities. When people are engaged in sporting activities for extended periods of time, from childhood to adulthood, the effects of ultraviolet light can be particularly considerable, which demonstrates the accumulative effect.

In general, athletes frequently use sunglasses for a variety of reasons, including eye protection. However, the state of eye protection in all types of outdoor sporting activities, including the use of sunglasses, has yet to be elucidated. There have been reports on the effectiveness of sunglasses and guidelines for their use in the past; however, these studies were conducted at least 35 years ago (Fishman, 1986; Miller, 1974). Thus, there is a need to research the topic of characteristics and use of sunglasses in the environment of individual sports and in environments in which they are played. Lawler et al. (2007) conducted a study on competitive athletes and investigated sun protection. The abovementioned study elucidated the use of sunglasses and differences in their usage by each sporting event. This study was a survey of outdoor sporting events, and the use of sunglasses and other ultraviolet eye protection measures differed between sports. While engaging in winter outdoor sports, goggles and sunglasses are commonly used to protect against the cold and wind. Previous studies report the importance of protecting the eyes in cold weather and specify the need to protect the eyes using goggles and sunglasses (Cope & Kropelnicki, 2015; Luria et al., 1983). However, eyes may be affected differently by different colors and the degree of light transmittance. Therefore, this topic needs to be investigated further.

Moreover, skiers and snowboarders have been surveyed from an injury prevention perspective (Hansom & Sutherland, 2010). The results of a study on 181 individuals regarding preparations made to avoid medical problems showed that over 90% considered warm clothing, and approximately 50% demonstrated improved fitness and "sun protection." There were some differences between snowboarders and skiers. Thus, there is a

high probability that the circumstances may differ by specific sport even among outdoor sports; thus, a detailed analysis is necessary. It has been considered that many snow riders wear goggles or sunglasses; therefore, it is reasonable that the usage rate of these equipment is not low. However, the abovementioned study did not focus mainly on sun protection. Some outdoor sports studies have focused on the amount of ultraviolet light exposure and the use of sun protection by young adults and university athletes (Down et al., 2009; Hamant & Adams, 2005; Schofield et al., 2001). These findings indicate the importance of an approach focusing on preventive measures in young adults in outdoor sports.

Glare also has a major effect on outdoor sports activities. It causes discomfort and makes vision indistinct (hard to see). As indicated in the previous section, because visual functions and sports are closely related, glare is believed to affect visual functions. Among the various types of visible light, there is a concern about the effects of short-wavelength blue light on the eyes. In recent years, the effects of blue light and glare on the eyes have undergone increasing scrutiny. Therefore, there is a need to explore the relationship between eye health and the various components of sunlight, in particular, ultraviolet light.

Eye Protection

Eye protection primarily consists of the use of sunglasses and goggles. The fundamental objective is to protect the eyes from ultraviolet light. However, in recent years, various products that feature different colors and degrees of light transmittance have appeared on the market. There have been studies on eye protection that have been recommended for pilots and for people with similar jobs. Pilots are engaged in highly advanced activities. Although the circumstances are not the same as those found in outdoor sports, some elements can be used as a reference when studying outdoor sports. Chorley et al. (2011) conducted a literature review on the exposure of pilots to ultraviolet light. They summarized that exposure to ultraviolet light increases the risk of cataracts and recommended the use of sunglasses.

In contrast, there have not been many studies on the selection of sunglasses in outdoor sports. In addition to being an ultraviolet light countermeasure, sunglasses are also used for fashion and to reduce glare; thus, sunglasses are common. Sunglasses come in a variety of colors and degrees of light transmittance. People often select sunglasses based on their personal preferences; however, it would be better if they chose lenses based on an understanding of the effect of sunglasses on their vision. Lee et al. (2002) studied the impact of various lens colors on visual functions. This study reported that gray, brown, yellow, green, purple, and blue lenses improved contrast thresholds.

Many studies on the variety of lens colors have focused on the yellow color. Yellow lenses are believed to be effective against the effect of blue light. Blue light is a short-wavelength light and has a powerful impact on the eyes and glare. Yellow is the complementary color of blue and is highly visible; therefore, it is frequently used as a lens color. Several studies have reported that yellow lenses affect contrast sensitivity and brightness (Chung & Pease, 1999; De Fez et al., 2002; Kelly et al., 1984; Kelly, 1990; Rieger, 1992). The review of ultraviolet light exposure and sunglass usage by pilots also mentioned blue light (Chorley et al., 2011).

Kohmura et al. reported the effects of yellow and gray lenses, which have different degrees of light transmittance, on the visual functions that are important in sports (Kohmura et al., 2013; Kohmura et al., 2015). Although it is thought based on these studies that lenses with a low degree of light transmittance, i.e., dark-colored lenses fully block glare, they may affect the visual functions (performance). In contrast, while light-colored lenses may not have sufficient ability to block glare, they have little impact on visual functions. Thus, it is conceivable that there is a need to adjust the color and relative darkness of the lenses depending on the sports environment and light conditions. There is a need for further investigations and surveys on the effect of the lens color of sunglasses and goggles on outdoor sports and exercise.

Furthermore, it is expected that lens color would have some effect on the perception of color (Dain et al., 2009; De Fez et al., 2002). In some cases, changes in color perception may affect sports and exercise. I recommend increasing the number of studies and surveys on color perception in sports and exercise. I also believe that it is necessary to conduct studies on guidelines for the use of sunglasses and goggles in outdoor sports. Studies have been performed on sports-tinted contact lenses, and their findings may apply to some sports events (Cervino et al., 2008).

Impact of Sunlight on the Skin

In the previous section, I discussed the effects of sunlight from the perspective of vision. Reviews of dermatologic disorders in athletes have highlighted the need to consider their health from a variety of perspectives (Adams, 2002). In sports and healthcare fields, numerous studies have investigated the effects of sunlight on vision and skin. Sunlight exposure is considered a serious risk factor for skin cancer (Moehrle, 2008; Parkin et al., 2011). Sunburn, suntan, and ultraviolet light are keywords related to skin cancer. In recent years, there have been an increasing number of studies on skin protection from sunlight and on educational approaches related to this issue. For people to enjoy sports while simultaneously ensuring that their health is protected, there is a need for further research in this field.

Naturally, a certain degree of exposure to sunlight is essential for production of vitamin D in the body (Alfredsson et al., 2020). To lead a healthy life, there is a need to engage in appropriate exercise, including

participation in outdoor sports. However, exposure over a short period of time is considered beneficial, whereas exposure over a long period of time harms the skin. In outdoor sports, there have been studies on ultraviolet light exposure that focused on professional cyclists, water sports athletes, and ironman triathletes (De Castro-Maqueda et al., 2021; Moehrle et al., 2000; Moehrle, 2001). Rigel et al. (2003) surveyed skiers and reported the amount of exposure to ultraviolet light that was experienced while skiing. Their results indicated that there were hourly patterns to ultraviolet light exposure.

Lawler et al. (2012) conducted a study on the practice of sun protection during sports and physical exercise, particularly outdoor activities. This study focused on the use of sunscreens. A survey on the attitudes and behaviors of university students in the United Kingdom reported that there was no strong relationship between the knowledge that ultraviolet light is associated with skin cancer and sun protection behaviors (Kirk & Greenfield, 2017). Finally, a study was conducted on mountain guides and farmers who experience greater exposure to sunlight in their daily lives (Zink et al., 2018a; Zink et al., 2018b). This study focused on protection against skin cancer. The conditions studied were similar to the severe conditions present in the natural environment associated with outdoor sports. The proposed countermeasures and survey results can be used as reference material for outdoor sports.

Initiatives and Education Designed to Promote the Use of Sun Protection

In summary, there are studies elucidating the association between ultraviolet light and its harmful effects on skin. In addition, the number of studies focusing on the approaches that can be used by people engaged in outdoor sports to protect their health have also been growing. There has been a study reporting efforts to promote sun protection among athletes (Ally et al., 2018). It determined the need for student athletes, trainers, and coaches to get involved in promotion initiatives. Athletes need to make enormous efforts to improve their competitiveness and physical fitness. Therefore, they need to engage in preventive initiatives and receive support to ensure that they protect their current and future health status. These efforts can be equally applied to anyone from the general population practicing outdoor sports.

There have also been several similar studies on sun protection in the environment of outdoor sports (Hall et al., 2009; Stölzel et al., 2020; Varedi et al., 2018). Walkosz et al. (2008) surveyed 6,516 individuals from 26 ski areas. Several studies on winter outdoor sports, including the study by Walkosz et al., have focused on the significance of sun safety education and programs (Varedi et al., 2018; Walkosz et al., 2007; Walkosz et al., 2008; Walkosz et al., 2015). The results of these studies are likely to be useful in elucidating ways of transmitting information and changing behaviors aimed at protecting the skin from sun exposure. Though outdoor sports have a generally positive effect on both body and mind, they can also present challenges to our health. There is a need to create awareness about this fact in everyone engaged in such sports and motivate them to take preventative measures.

Furthermore, there have been literature reviews on the risks of sun exposure that was initiated in childhood (Whiteman et al., 2001). Many epidemiologic studies reporting the risk factors for melanoma have been included in this review. There is a need to promote awareness of and adopt sun protection initiatives from an early age (childhood and adolescence). Mahe et al. (2011) reported ultraviolet light exposure experienced during childhood in the environment of outdoor sports. This study described the risks of ultraviolet light exposure during childhood for subjects who played in soccer tournaments. Similar studies need to be conducted in the environment of other outdoor sports. Recently there have been reports on efforts to promote sun protection by utilizing latest technologies. These include information on apps and wearable sensors (Hacker et al., 2018; Horsham et al., 2020a; Horsham et al., 2020b). We look forward to the further use of sun protection efforts that take advantage of these technologies in outdoor sports.

Based on the fact that ultraviolet light exposure is a major risk factor for skin cancer, many studies aim to identify dangerous levels of exposure to ultraviolet light and define possible approaches to prevention. While the number of studies on the current status and risks of engaging in outdoor sports since childhood remain insufficient, research on skin cancer has accumulated many results in sports and the role of environmental factors. Because outdoor sports are praised as sports to be practiced during a lifetime, involving a wide range of age groups, there is a need to elucidate their association with overall health. Further studies are needed to determine the precautions that should be taken when engaging in outdoor sports by promoting a variety of preventive measures.

Conclusions

In this study, I presented a literature review of studies related to vision in sports, including outdoor sporting events, focusing on sunlight as a representative environmental factor. The number of studies conducted on the topics of outdoor sports is small compared to that on other topics. A number of these studies have discussed the effects of sunlight on the skin. In recent years, the focus of academic research has shifted toward warning people about the adverse effects of sunlight on health through the use of high-tech equipment and applications. I hope that studies in the field of vision and outdoor sports will continue to advance and their findings will be put into practice. In terms of the effects of sunlight on the eyes and skin, detailed research is needed, considering the differences in specific sporting events and the regions in which they occur. Many

outdoor sporting events take place in the natural environment. Thus, there is a need to define the harmful consequences of environmental factors on the body and the positive effects on the mind and body. Currently, there is a tendency for more research related to the skin for winter sports. Outdoor sports are events in which participants should be aware of these issues. Further research on the role of environmental factors on health may help promote the safe and efficient use of outdoor sports for people to maintain their mental and physical health.

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