ORIGINAL ARTICLE

The effect of protective eyewear on free throw performance in basketball players without refractive defects

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Abstract

Background and Study Aim Sports-related eye injuries are a significant concern, particularly in high-risk activities such as basketball, where protective measures are often necessary. Protective eyewear is designed to prevent injuries, but its potential impact on athletic performance remains unclear. This study aimed to evaluate the effect of wearing protective eyewear on shooting performance in basketball athletes without refractive errors.

Material and Methods Sixteen basketball athletes aged 16 to 24 years (mean = 21.56 ± 1.71) voluntarily participated in the study. The athletes underwent a 1-week familiarization period to adjust to the goggles. Shooting tests were conducted under three conditions: with goggles, without goggles, and with goggles after fatigue. The mean and standard deviation values were calculated for each condition. The Wilcoxon Signed Ranks Test, a non-parametric statistical method, was used to identify differences between the protocols. Data analysis was performed using Microsoft Excel and SPSS 26.0 software (IBM, Chicago, IL, USA), with a significance level set at $p < 0.05$.

Results The analysis revealed significant differences between the test conditions. Shots performed without goggles consistently showed better accuracy compared to those performed with goggles across all protocols. In the first protocol, the mean shooting accuracy was higher without goggles (0.620 ± 0.169) compared to with goggles (0.450 ± 0.100). Similarly, in the second protocol, the mean pre-test score without goggles (0.704 ± 0.058) was significantly better than the post-test score with goggles (0.673 ± 0.043, $p < 0.05$). The third protocol demonstrated the most pronounced difference, where pre-test accuracy without goggles (0.70 ± 0.05) decreased to a post-test accuracy with goggles (0.44 ± 0.04, $p < 0.05$) under fatigue conditions. These results suggest that the use of protective eyewear negatively impacts shooting accuracy, with the effects being more pronounced in fatigue-inducing scenarios.

Conclusions The findings of this study underscore the importance of considering the potential trade-offs between safety and performance when designing protective eyewear for athletes. While protective goggles are essential for preventing sports-related eye injuries, their influence on critical performance metrics, such as shooting accuracy, highlights the need for a balanced approach.

Keywords: basketball, shooting, refractive error, protective eyewear.

Introduction

The ability to perceive visual information and generate appropriate motor responses is fundamental to achieving optimal sports performance. Identifying and tracking a target, whether it is an opponent, a moving object, or a stationary goal, is crucial for success in sports. The mechanisms through which the visual system contributes to performance and the extent of its influence remain complex questions for further investigation [1]. Refractive error, a condition characterized by the eye's inability to properly focus light on the retina, is a common cause of correctable visual impairment [2]. The most prevalent types of refractive error include myopia, hyperopia, astigmatism, and presbyopia [3]. Eyeglasses, often the first-line treatment for refractive errors, provide a simple and effective solution [4].

Interestingly, athletes may wear protective eyewear even without refractive errors, seeking various performance-related benefits. Sports goggles offer advantages such as eye protection, enhanced contrast, glare reduction, improved comfort, and clearer vision. These goggles shield the eyes from sunlight, wind, dust, and other potentially harmful elements, contributing to a safer and more controlled sports environment [5].

Eyeglasses and sunglasses designed to correct refractive errors provide no protective benefits during sports activities. Furthermore, athletes who wear such glasses are reportedly at a higher risk of

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sustaining severe eye injuries compared to those who do not wear glasses [6, 7]. To address this issue and reduce the risk of eye injuries in sports, protective goggles made from 3-mm polycarbonate have been developed [7, 8]. These goggles are 20 times stronger than glass and offer high impact resistance while also absorbing ultraviolet light [6].

The importance of such goggles becomes evident when considering the potential hazards in various sports: a squash ball can carry more energy than a 0.22 caliber bullet, a hockey puck can travel at speeds of up to 160 km/h, and a badminton shuttlecock can reach speeds of 290 km/h. Protective goggles help mitigate these risks by distributing the high energy across a larger area of the skull, thereby reducing the likelihood of severe injuries, including intracranial trauma [8].

Basketball is a globally popular sport that attracts millions of spectators on both national and international stages and hosts major events [9]. It is characterized by high intensity, long duration, frequent jumping, rapid sprints, and sudden changes in direction [10]. Among the various physical skills required in basketball, shooting is one of the most complex to master, yet it plays a pivotal role in determining scoring efficiency and securing victory [11].

The free throw is arguably one of the simplest shots in basketball, as it involves a stationary player without defensive pressure or external obstacles. Traditionally, it has been executed as an overhead shot throughout the history of the sport [12].

This study aims to investigate the impact of protective eyewear on shooting accuracy among basketball players without refractive errors. The primary objective is to scientifically evaluate how protective eyewear influences basketball performance. Research of this kind is expected to contribute to a better understanding of potential advancements in technique and equipment selection, ultimately aiding in the optimisation of athletic performance.

Materials and Methods

Participants

Sixteen male athletes aged 18 to 24 years, with an interest in basketball, voluntarily participated in this study. Medical examination results performed within the past six months were obtained for all participants. Ethical approval for the study was granted by the Ethics Committee of the Gazi University Faculty of Sports Sciences. All athletes were informed about the research and provided written informed consent. The study adhered to the principles outlined in the Declaration of Helsinki.

The demographic characteristics of the participants are summarized in Table 1. The table provides the mean (X) and standard deviation (SD) values for age, height, weight, and BMI of the athletes who participated in the study. The data suggest that the participants represent a relatively homogenous group in terms of age, height, weight, and BMI. The low standard deviation values across all parameters indicate a consistent physical profile among the athletes.

Table 1. Demographic Characteristics of the Participants

Characteristic	X	SD
Age	21.56	1.71
Height (cm)	182.56	5.01
Weight (kg)	77.31	4.58
BMI	23.18	0.56

Note: X: mean, SD: standard deviation, BMI: Body Mass Index.

Research Design

Data Collection

To familiarize participants with the equipment, a trial session with the protective eyewear was conducted one week before the study. Three protocols were implemented during the study, with one-day intervals between each protocol. Participants were instructed to remain in a rested state before the tests. All protocols were conducted on the same basketball court, at the same time of day, and participants followed a consistent testing order. During the tests, accurate shots were recorded as 1, while inaccurate shots were recorded as 0.

The study plan, including the sequence of protocols applied during the research, is presented in Table 2. The table outlines the three protocols: Free Throw Protocol (F.T.P.), Intermittent Free Throw Protocol (I.F.F.P.), and Fatigue Protocol (F.P.).

Free Throw Protocol

The free throw shooting test and warm-up protocol, as described in the literature for basketball players, were applied. The warm-up protocol included a 10-minute general warm-up consisting of running and a 7-minute dynamic warm-up incorporating sprinting and jumping. Additionally, a 20-minute warm-up specific to the free throw test was conducted, during which players performed shooting drills to familiarize themselves with the court, ball, and hoop.

Following the warm-up, the test procedures were explained to the players. Each player attempted 10 shots in three series, with a three-minute rest interval between each series. Two players were positioned to the left and right of the basket to retrieve and pass the ball back to the player performing the free throw test. After completing the 10 shots, the player performing the test switched places with one of the players under the basket.

The average of the three series was calculated and expressed as a percentage [13].

Intermittent Free Throw Protocol

The intermittent free throw protocol was conducted on the second day. The same warm-up protocol used on the first day was repeated. Unlike the initial free throw protocol, athletes performed 30 free throws without goggles, followed by a five-minute rest. They then performed 30 free throws with goggles, took another five-minute rest, and completed a final set of 30 free throws with goggles.

Fatigue Protocol

The tests involving the fatigue protocol were conducted on the third day. Before the tests, the free throw shooting test and the warm-up protocol were applied. The warm-up included a 10-minute general warm-up consisting of running and a 7-minute dynamic warm-up involving sprinting and jumping.

Following the warm-up, a fatigue protocol was implemented, which consisted of 60 total shots performed over 45 minutes using various shooting drills, including 3-point shots, standing shots, jump shots, and free throws. All drills were conducted while wearing goggles. Immediately after the 45-minute training session, the athletes were given a 3-minute rest. At the end of the rest period, participants performed a free throw test comprising three series of 10 shots each, for a total of 30 free throws. Successful shots and accuracy rates were recorded [13].

Characteristics of the Protective Goggles Used

The protective goggles used in the tests featured impact-resistant lenses and frames with a transparent, dioptric polycarbonate structure. The goggles were designed to fit the athlete's face and nose securely. A rubber strap attached to the ends of the handles ensured the frame remained fixed in place, preventing the goggles from slipping or falling during activity.

Statistical Analysis

The mean and standard deviation values of the participants' descriptive statistics were calculated. The Shapiro-Wilk test was used to assess the normality of the data, and skewness and kurtosis values were examined to further evaluate the data distribution. It was determined that the data did not follow a normal distribution. Therefore, the Wilcoxon Signed Ranks Test, a non-parametric test, was applied to identify differences between the protocols. Data analysis was performed using Microsoft Excel and SPSS 26.0 software (IBM, Chicago, IL, USA). A significance level of $p < 0.05$ was considered statistically significant.

Results

The mean scores of the first protocol (F.T.P.) test, comparing performance with and without goggles, are summarized in Table 3. The table presents the accuracy results for three consecutive series of 10 shots and the overall mean scores for all 30 shots. Analysis of Table 3 reveals a consistent trend where the mean scores of shots without goggles are higher across all series compared to those with goggles. This pattern is also evident in the overall average for 30 shots, suggesting that shooting performance improves when goggles are not worn.

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The descriptive statistical results of the pre-test and post-test accuracy measurements for the study group are presented in Table 4. The table summarizes the mean values, standard deviations, and the range (minimum and maximum) of scores for the second protocol (I.F.F.P.). The data indicate a slight decrease in accuracy scores from the pre-

Table 2. Study Plan.

1st Protocol (F.T.P.)		2nd Protocol (I.F.F.P.)		3rd Protocol (F.P.)
1st Day		Day 2		3rd Day
Warming up		Warming up		Warming up
30 Shots with Glasses		30 Shots Without Glasses		30 Shots with Glasses
30 Shots Without Glasses		2 min. Rest		3 min. Rest
	Rest (One Day)	30 Shots with Glasses	Rest (One Day)	3-point shots (15)
		2 min. Rest		Standing Shot (15pcs)
		30 Shots Without Glasses		Free Throw (15Spcs)
				Leaping Shot (15pcs)
				3 min. Rest
				30 Shots with Glasses

Note: F.T.P.: Free Throw Protocol, I.F.F.P.: Intermittent Free Throw Protocol, F.P.: Fatigue Protocol

Table 3. Mean Scores of the First Protocol (F.T.P.) Test for the Research Group

Shot Series	With Glasses (Mean ± SD)	Without Glasses (Mean ± SD)
1–10 shots	0.531 ± 0.904	0.662 ± 0.474
11–20 shots	0.462 ± 0.500	0.638 ± 0.482
21–30 shots	0.356 ± 0.480	0.563 ± 0.498
1–30 shots	0.450 ± 0.100	0.620 ± 0.169

Note: Mean (X), SD: Standard deviation, F.T.P.: Free Throw Protocol.

Table 4. Statistical Results of Pre-Test and Post-Test Scores in the Second Protocol (I.F.F.P.)

Test Stage	N	Mean (X) ± SD	Min.	Max.
Pre-Test	16	0.704 ± 0.058	0.600	0.800
Post-Test	16	0.673 ± 0.043	0.633	0.767

Note: X: Mean, SD: Standard deviation, Min.: Minimum, Max: Maximum, I.F.F.P.: Intermittent Free Throw Protocol.

Table 5. Wilcoxon Signed Ranks Test Results for the Second Protocol (I.F.F.P.)

Test Stage	Comparison	N	Rank Mean	Row Total	Z	P
Pre-Test Final Test	Negative Sequence	10[a]	8.45	84.50	-2.055[b]	0.040
	Positive Sequence	4[b]	5.13	20.50		
	Equal	2[c]				
	Total	16				

Note: a: Post-test scores lower than pre-test scores; b: Based on negative ranks; c: Post-test scores equal to pre-test scores; Z: Wilcoxon Signed Ranks Test statistic; P: Significance level; I.F.F.P.: Intermittent Free Throw Protocol.

Table 6. Statistical Results of Pre-Test and Post-Test Scores in the Third Protocol (F.P.)

Test Stage	N	Mean (X) ± SD	Min.	Max.
Pre-Test	16	0.70 ± 0.05	0.60	0.80
Post-Test	16	0.44 ± 0.04	0.37	0.53

Note: X: Mean, SD: Standard deviation, Min.: Minimum, Max.: Maximum, F.P.: Fatigue Protocol.

test to the post-test stage. This trend suggests a potential influence of the intermittent protocol on shooting performance, which may reflect the impact of fatigue or adaptation to the conditions.

The results of the Wilcoxon Signed Ranks test, comparing the pre-test and post-test mean scores of the second protocol (I.F.F.P.) test, are summarized in Table 5. The analysis highlights significant differences in the accuracy scores of the study group. The statistical analysis revealed a significant difference between the pre-test and post-test scores of the second protocol, with pre-test values showing better performance compared to post-test results. This trend suggests that participants' accuracy decreased after the intermittent protocol, possibly due to fatigue or the impact of test conditions.

The descriptive statistical results of the pre-test and post-test measurements for the third protocol (F.P.) are summarized in Table 6. The table highlights the mean values, standard deviations, and score ranges for the fatigue protocol. The data show a clear decline in performance from the pre-test to the post-test in the third protocol. This trend suggests that the fatigue protocol significantly reduced the participants' accuracy, reflecting the impact of sustained physical and mental exertion during the test.

The results of the Wilcoxon Signed Ranks test, comparing the pre-test and post-test mean scores for the third protocol (F.P.), are presented in Table 7. The analysis identifies significant differences between the two test stages. The analysis reveals a statistically significant decrease in accuracy from the pre-test to the post-test stage of the third protocol ($p < 0.05$). This finding indicates that the participants' performance declined following the fatigue protocol, emphasizing the impact of fatigue on their shooting accuracy.

Discussion

The primary aim of this study was to evaluate the effect of protective eyewear on shooting accuracy among basketball players without refractive errors under different protocol conditions. The findings revealed significant differences in performance between the tested conditions. Specifically,

Table 7. Wilcoxon Signed Ranks Test Results for the Third Protocol (F.P.)

Test Stage	Comparison	N	Rank Mean	Row Total	Z	P
Pre-Test Final Test	Negative Sequence	16[a]	8.50	136.00	-3.536[b]	0.000
	Positive Sequence	0[b]	0.00	0.00		
	Equal	0[c]				
	Total	16				

Note: a: Post-test scores lower than pre-test scores; b: Based on negative ranks; c: Post-test scores equal to pre-test scores; Z: Wilcoxon Signed Ranks Test statistic; P: Significance level; F.P.: Fatigue Protocol.

shooting accuracy tended to decrease when athletes wore protective goggles, with the most pronounced decline observed during the fatigue protocol. These results highlight the potential impact of protective eyewear on basketball performance.

Although sports-related eye injuries are relatively common, most of them are preventable. Protective eyewear is particularly effective, with research suggesting that 90% of such injuries can be avoided through its use [15, 16]. However, certain sports, such as baseball and basketball, are more frequently associated with eye injuries among athletes aged 5 to 24 years. Despite this, the lack of comprehensive data on participation rates and injury severity prevents a precise determination of the relative risks across various sports [14, 17].

In the context of performance, research on protective goggles reveals mixed results. For example, a study investigating seven different types of protective goggles concluded that while all of them restricted the visual field, none significantly impacted overall performance [18]. Additionally, the effect of sunglass lens colors on visual performance was studied, showing that grey filters caused the least distortion in color vision, which may benefit users, whereas green filters led to reduced contrast sensitivity and greater deficiencies in color perception [19].

Some studies emphasize the protective benefits of goggles without examining performance outcomes. For instance, a study on football players demonstrated that protective goggles effectively reduce eye stress and strain by absorbing and redirecting ball impact energy, lowering the maximum strain on the retina by 69% [20]. Similarly, other researchers highlighted that while goggles protect against eye injuries, they may have unintended effects on sensory and motor responses. For example, the use of goggles negatively affected postural stability and sensory input from the visual system, potentially compromising balance recovery [21].

In addition to balance and sensory impacts, the use of sports goggles was reported to impair environmental visual perception in female athletes [22]. Similarly, studies on ski goggles found that their use with helmets significantly reduced peripheral vision and slowed reaction times [23]. These findings collectively suggest that while protective eyewear is crucial for safety, its design and implementation should consider potential trade-offs in athletic performance and sensory functions.

Comparing these findings with the results of this study, it is evident that wearing protective goggles can negatively influence basketball shooting accuracy, particularly under fatigue-inducing conditions. This aligns with prior studies showing that goggles can restrict visual and sensory functions, though specific impacts on basketball performance have not been extensively documented.

Limitations and Future Directions

This study has several limitations that should be addressed in future research. First, the sample size was relatively small, and all participants were male basketball players without refractive errors. This limits the generalizability of the findings to other sports, genders, or individuals with visual impairments. Expanding the sample to include a more diverse group of athletes could provide broader insights into the effects of protective eyewear.

Second, the study primarily focused on shooting accuracy and did not assess other critical aspects of basketball performance, such as reaction time, peripheral vision, or balance. Future research could explore these factors to provide a more comprehensive understanding of how protective eyewear influences athletic performance.

Finally, the design and material properties of the protective goggles used in this study may not represent all types of sports eyewear. Investigating the effects of different designs, materials, and lens technologies could help optimize the balance between safety and performance.

These limitations underscore the need for continued research to develop protective eyewear that minimizes adverse effects on performance while ensuring athlete safety.

Conclusions

Protective eyewear plays a critical role in preventing sports-related eye injuries, particularly in high-risk activities like basketball. However, its influence on athletic performance cannot be overlooked. The findings of this study emphasize the need for a balanced approach to sports eyewear design, prioritizing both safety and functional performance.

Optimizing protective eyewear requires a multidisciplinary effort that considers the unique demands of each sport, the specific needs of athletes, and the trade-offs between protection and sensory performance. By addressing the challenges identified in this and other studies, future innovations in sports eyewear can enhance athlete safety without compromising their ability to perform at the highest level.

Conflict of interests

The authors declare that there is no conflict of interests.

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