Evaluation of the Artificial Lighting Capabilities of Mersin Erdemli Shooting Range

Mersin Erdemli Atış Poligonunun Yapay Aydınlatma Olanaklarının Değerlendirmesi Üzerine

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Abstract

This study focuses on the measurement of artificial lighting levels at the Mersin Erdemli Shooting Range. The lighting levels in the shooting range were evaluated and compared with international standards. The study was carried out in three phases: preparation, fieldwork, and evaluation. A grid system was created for measurement, and then, lighting levels were measured at two different heights (90 cm, 140 cm) and along horizontal and vertical axes. The findings indicate that the existing artificial lighting conditions within the shooting range are inadequate in specific zones, potentially compromising visual comfort, concentration, and overall athletic performance. Such deficiencies may hinder the spatial perception and task accuracy required in shooting sports. The lighting assessment conducted in this study provides critical insights that can inform design decisions aimed at enhancing both safety and user performance. Accordingly, the study not only assesses the current state of the facility but also offers a valuable reference framework for future lighting design improvements in comparable indoor shooting range.

Keywords: Shooting range, artificial lighting, lighting measurement, ISSF standards, range design

Özet

Bu çalışma, Mersin Erdemli Atış Poligonu mevcut yapay aydınlatma olanaklarının incelenmesine odaklanmaktadır. Atış sporlarında doğru aydınlatma, sporcuların performansı üzerinde önemli bir etkiye sahiptir. Poligonlardaki aydınlatma seviyeleri, uluslararası standartlarla karşılaştırılarak değerlendirilmiştir. Çalışma, üç aşamada gerçekleştirilmiştir: hazırlık, saha çalışması ve değerlendirme. Ölçüm için grid sistemleri oluşturularak aydınlatma seviyeleri iki farklı yükseklikten (90 cm, 140 cm) ve yatay ile düşey eksenlerden alınmıştır. Elde edilen veriler, poligonun mevcut yapay aydınlatma koşullarının belirli alanlarda yetersiz kaldığını ortaya koymuştur. Bu durum, atış sporu yapan bireylerin görsel konforunu, odaklanma düzeyini ve performansını olumsuz yönde etkileyebilir. Ayrıca, aydınlatma tasarımına ilişkin bu değerlendirme, hem güvenlik hem de sporcu verimliliği açısından önemli tasarım kararlarına yön verebilir. Bu bağlamda çalışma, sadece mevcut durumu değerlendirmekle kalmayıp, yeni tesisler için yapılacak tasarımlara yol gösterici bir nitelik taşımaktadır.

Anahtar Kelimeler: Atış poligonu, yapay aydınlatma, aydınlatma ölçümü, ISSF standartları, poligon tasarım

1. INTRODUCTION

The importance of optimal lighting conditions in sports facilities, particularly in precision-based disciplines like shooting, is well-documented in existing literature. Visual comfort, attention span, motor coordination, and eye-hand synchronization are critical parameters that can be significantly affected by the quality of artificial lighting (Li et al., 2024; Sport England, 2023). Despite its significance, artificial lighting in shooting sports remains an underexplored topic within the Turkish context. This study addresses this gap by focusing on the Mersin Erdemli Shooting Range, a representative facility where lighting plays a vital role in training and competitive performance.

The Mersin Erdemli Shooting Range was selected as the focal point of this study due to its widespread use in both training and regional competitions, as well as it is the biggest shooting range in Turkey where international competitions are held. Its functional diversity offer a representative environment for assessing how artificial lighting conditions impact shooting performance in practice.

While previous research has evaluated lighting systems in broader sports settings (e.g., stadiums or indoor arenas), few studies have considered the micro-level impacts of illumination quality in environments requiring high precision (Ivanov et al., 2023). To date, there exists no architectural research that systematically examines the spatial and lighting design characteristics of shooting ranges within an evidence-based framework. The absence of such studies indicates a significant void in the field, not only in terms of architectural theory but also in terms of its practical implications for user comfort, safety, and performance. Aslan and Uz Baki (2024) explicitly define this as "a gap in architectural literature", emphasizing that the topic remains critically underrepresented in architectural scholarship and discourse. In this respect, the current study aims to assess whether the existing lighting setup in this shooting range meets international recommendations, such as those proposed by the International Shooting Sport Federation (ISSF).

It is hypothesized that the current artificial lighting setup at the Mersin Erdemli Shooting Range does not fully comply with established international standards such as those defined by the ISSF, and may adversely affect athletes' visual comfort, concentration, and overall performance. This hypothesis underpins the evaluation of lighting quality not merely as a technical attribute but as a factor with direct implications for training efficiency and competition fairness. This study is original in its attempt to evaluate an insufficiently studied aspect of indoor shooting ranges in Turkey. It aims to test the hypothesis that inadequate lighting quality negatively affects both performance and safety in such facilities. The results are intended to guide future lighting designs and contribute to both academic literature and practical implementation.

2. ARTIFICIAL LIGHTING IN INDOOR SHOOTING RANGES

Artificial lighting plays a pivotal role in the functionality, safety, and performance outcomes of indoor shooting ranges. Unlike general-purpose sports facilities, shooting environments demand high levels of visual precision, low glare, consistent luminance, and minimal shadows. These requirements make lighting design both technically and ergonomically complex.

In shooting sports, athletes often focus on targets located at stable distances under strict timing conditions. This requires illumination that supports spatial awareness and sustained visual accuracy (Sapsford, 2022). Current best practices recommend maintaining a minimum of 1000 lx along the firing line, while ensuring an ambient illuminance level of at least 500 lx across the general range area. These specifications support stable visual adaptation and enhance situational awareness, both of which are fundamental to the secure and efficient operation of the facility (ISSF, 2021). Standardized illuminance requirements for enclosed shooting ranges are delineated in Table 1. However, field audits in several countries reveal that many indoor ranges fall short of these standards, either due to outdated lighting technologies or poor spatial distribution (Zhang & Li, 2020).

Type of Indoor Range	General Lighting Recommended Minimum (lux)	Target Lighting	
		Minimum (lux)	Recommended (lux)
10 m	500	1500	>1800
10 m RT	500	1000	>1000
25 m	500	1500	>2500
50 m	500	1500	>3000

Table_1. Indoor shooting range illumination requirements.

Research indicates that improper lighting not only impairs aim and accuracy but also increases visual fatigue and error rates, particularly under high-stakes or long-duration training sessions (Kowalski et al., 2019). Moreover, flicker and color rendering index (CRI) values below optimal thresholds may affect shooters' depth perception and reaction times. As noted by Panero and Zelnik (2023), CRI values above 80 and flicker-free LED systems are essential in maintaining visual comfort and performance consistency in indoor environments.

Recent advancements in LED technology and smart lighting controls have opened up new avenues for improving both energy efficiency and athlete-centered lighting conditions (Gao et al., 2021). Studies from sports lighting audits in Germany and South Korea demonstrate that adjustable lighting scenarios tailored to training or competition modes can enhance shooter concentration while reducing operating costs (Kim & Park, 2022).

Despite growing global interest, the integration of these innovations into Turkish shooting facilities remains limited. To date, very few peer-reviewed studies have investigated the specific lighting challenges in Turkish ranges, leaving a significant knowledge gap regarding compliance with ISSF or EN 12193 standards. Addressing this gap is essential not only for ensuring fair play and safety but also for aligning facility design with evolving global norms in sports architecture and environmental performance.

3. MATERIALS AND METHODS

This study was conducted in three main phases: preparation, fieldwork, and evaluation. In the preparation phase, grid systems for lighting measurements were established on scaled architectural plans that were either obtained from existing documentation. These grid axes were then transferred to the physical environment, marking the starting point of the field measurements. 42 points were determined for the 10 metre shooting range and 36 points for the final shooting range. Three different types of measurements were conducted along the marked axes within the indoor space.

The first measurement was taken at a height of 90 cm, representing the general illumination level of the space in accordance with international standards.

The second measurement was taken horizontally at the target height of 140 cm, capturing the illumination level along the target line.

The third measurement was taken vertically at the same height (140 cm), oriented towards the shooting direction, in order to determine the illuminance (lux values) directly perceived by the shooter's eye along the shooting line.

Figure 1. Measurement apparatus setup.

The measurements were conducted using an LX1010B digital lux meter, which operates in the range of 1–50,000 lx with a measurement accuracy of ±(5%+2d). In order to maintain consistent measurement heights, a custom-built apparatus adjustable to 90 cm and 140 cm heights, as shown in Figure 1, was employed. For security reasons, the measurements made during working hours were carried out during daytime hours. However, all sources of natural daylight were blocked during the artificial lighting measurements to ensure the integrity of data. Photographs of the interior layout and lighting fixtures were taken to document spatial configurations and finalize the fieldwork phase.

In the evaluation phase, measurement data were tabulated and analyzed to determine the distribution of artificial illumination across the interior. Using interpolation techniques, the lighting levels were distributed over each grid axis interval. Based on the obtained lux values, graphical visualizations were generated on the same grid system established during the preparation phase. These visual outputs highlighted zones of varying brightness, providing a visual basis for spatial analysis. The results of brightness level measurements were evaluated according to the CIBSE (Chartered Institution of Building Services Engineers) Code for Interior Lighting Standards (Rea, 2000).

4. MERSİN ERDEMLİ SHOOTING RANGE

The construction of the facility commenced in 2012 and was completed in 2013. Located in the Erdemli district of Mersin Province, the site spans a total area of 306,859 m². The complex includes a seating capacity of 1,550 spectators, 16 locker rooms, and a fully enclosed shooting range comprising 10 m, 25 m, and 50 m units. Additionally, the outdoor section accommodates five Trap-Skeet ranges.

The total built-up area is 21,905.5 m², comprising 19,719.5 m² on the ground floor (including the open-air ranges) and 2,186 m² on the first floor. The internal ceiling height of the shooting ranges is configured at 8 meters below the suspended ceiling system. For acoustic performance and sound insulation, reinforced glass wool panels with both sound absorption and acoustic regulation properties have been installed on the ceilings and walls of all ranges. The flooring throughout the ranges is covered with rubber-based resilient flooring materials, selected for their durability and impact resistance.

Behind each range, athlete-specific locker rooms have been designed and positioned based on functional requirements. Dedicated spaces are also allocated for coaches and referees. Administrative and auxiliary areas—including classrooms, weapon and ammunition storage, weapons inspection room, doping control, first aid, meeting rooms, VIP lounge, and press room—have been spatially integrated to ensure efficient circulation and functional zoning. The VIP and administrative entrances have been deliberately segregated from the main entrance, while direct internal access to the ranges has also been provided. Separate access routes have been designated for equipment delivery and ambulance/stretcher egress. Storage units have been constructed in the open sections of the ranges for material handling and logistics.

The 10-meter air rifle range has been designed to accommodate a total of 12 shooting groups, each comprising five individual lanes. Additionally, a separate final range with a capacity of 2 groups has been integrated into the facility layout. The spectator seating area in this section can host up to 399 individuals, and an elevated gallery level has been incorporated to enhance visibility and provide additional viewing capacity for observers.

The 25-meter range features 8 groups, similarly organized with five lanes per group. A final range, shared with the adjacent 50-meter range, has a capacity of 2 groups. This unit is supported by a spectator tribune offering 234 seats, and like the 10-meter range, it includes an upper gallery floor for extended spectator access.

The 50-meter shooting range is configured to host 12 groups of five shooting lanes each. It also shares the same 2-group final range with the 25-meter facility. Spectator seating in this area has been designed for 390 individuals, and the gallery level offers an additional observation platform for enhanced audience engagement.

The technical drawings and photographic documentation of the facility are presented below. The site layout of the complex, along with the spatial configuration of the shooting ranges within the floor plan, is illustrated in Figure 2.

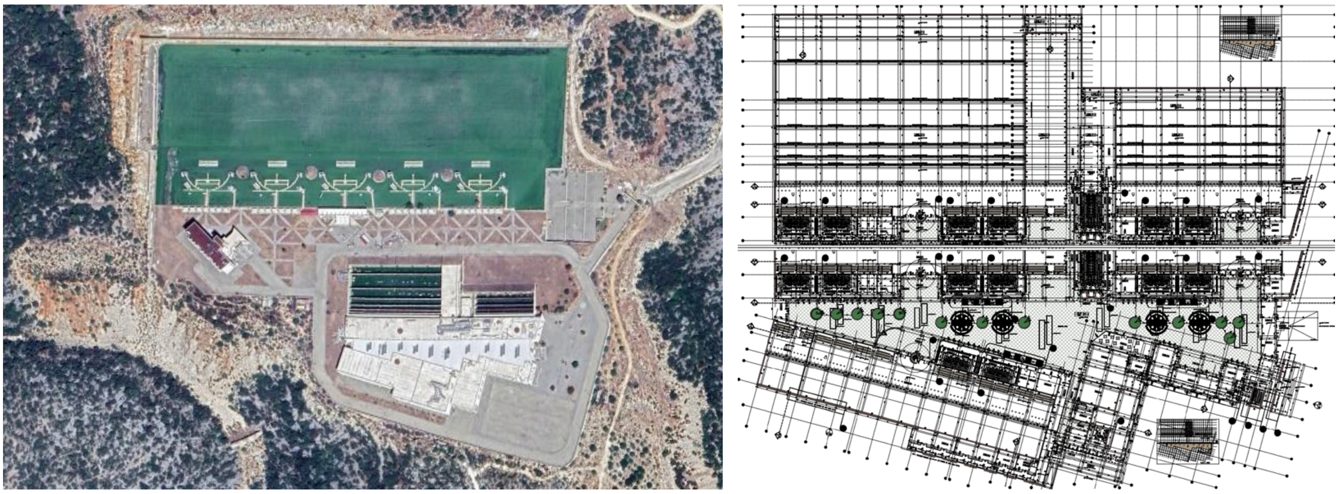


Figure 2. Aerial view and ground floor plan of the Mersin Erdemli Shooting Range complex.

5. ACTIVITIES CONDUCTED WITHIN THE SCOPE OF ARTIFICIAL LIGHTING LEVEL MEASUREMENTS

On September 25, 2023, artificial lighting level measurements were conducted in two indoor spaces located on the ground floor of the Mersin Erdemli Shooting Range complex. The study was executed in three distinct phases: preparation, on-site measurements, and data evaluation.

The measured illuminance levels were evaluated in accordance with the CIBSE Code for Interior Lighting (Chartered Institution of Building Services Engineers, UK, 1994), which provides widely recognized standards for interior lighting. As illustrated in Figure 3, a grid system composed of square cells measuring 200 × 200 cm was applied to define the measurement axes. This grid framework provided a systematic basis for recording the spatial distribution of illuminance values within the interior spaces.

During the preparation phase, grid systems were developed on the architectural floor plans to establish the measurement axes. Once the grid layout and axes were marked, the field measurement phase commenced. Three distinct types of measurements were performed along the marked axes within the interior spaces.

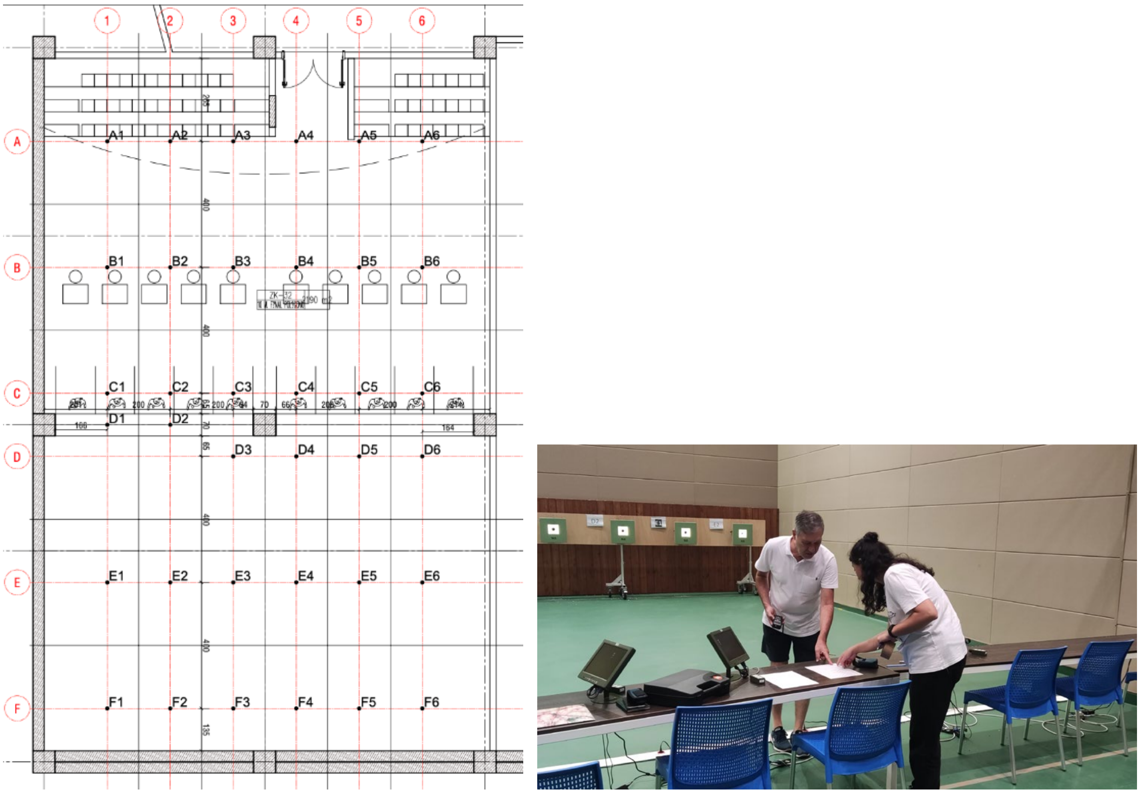
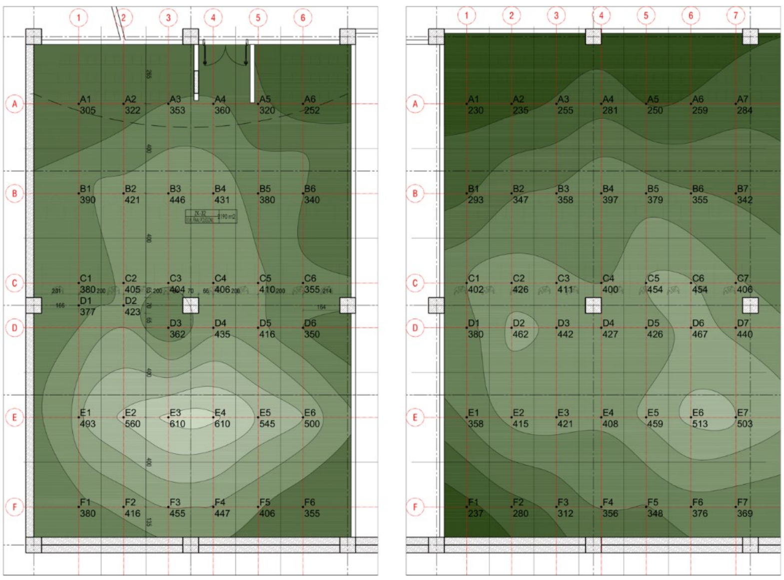


Figure 3. The 200 × 200 cm grid system established on the architectural floor plan during the preparatory phase; comprising the analysis of spatial layouts, on-site marking of the axes, and the subsequent measurement of illuminance values at the intersection points of the marked grid lines using a lux meter.



a. *b.*

Figure 4a and b. Horizontal measurement graph (90 cm).
(a. Final shooting range, b. 10-meter shooting range)

At a height of 90 cm during horizontal measurements, the minimum illuminance value in the 10-meter shooting range was recorded at 230 lx, with a maximum value of 513 lx. In the 10-meter final shooting range, the minimum illuminance was 252 lx, and the maximum value was 610 lx. These values are presented in the graph in Figure 4.

At a height of 140 cm, the horizontal measurements revealed the following illuminance levels: in the 10-meter shooting range, the minimum value was 217 lx and the maximum value was 538 lx, while in the 10-meter final shooting range, the minimum value was 335 lx and the maximum value was 624 lx. These results are illustrated in Figure 5.

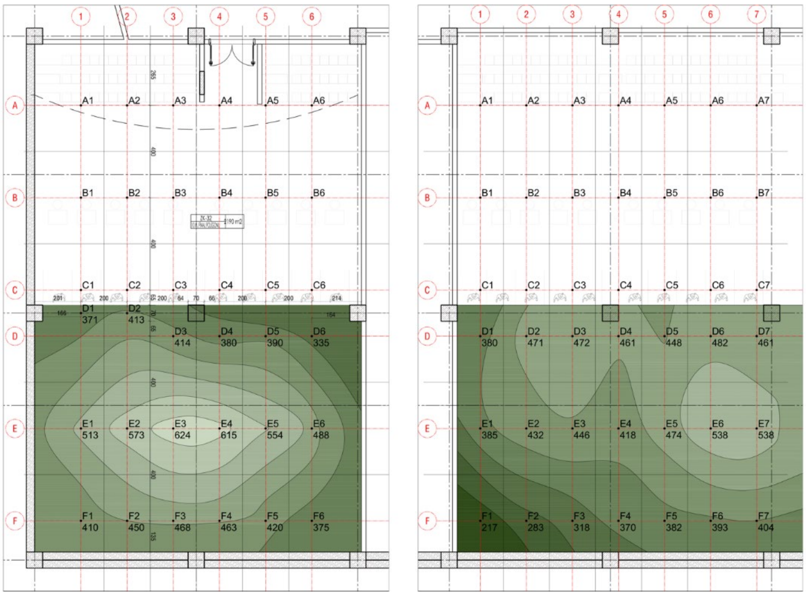


Figure 5a and b. Horizontal measurement graph (140 cm). (a. Final shooting range, b. 10-meter shooting range)

Vertical measurements taken at a height of 140 cm, directed towards the shooting line, showed the following illuminance values: in the 10-meter shooting range, the minimum was 89 lx, with a maximum of 126 lx, and in the 10-meter final shooting range, the minimum was 82 lx and the maximum was 128 lx. These results are depicted in Figure 6.

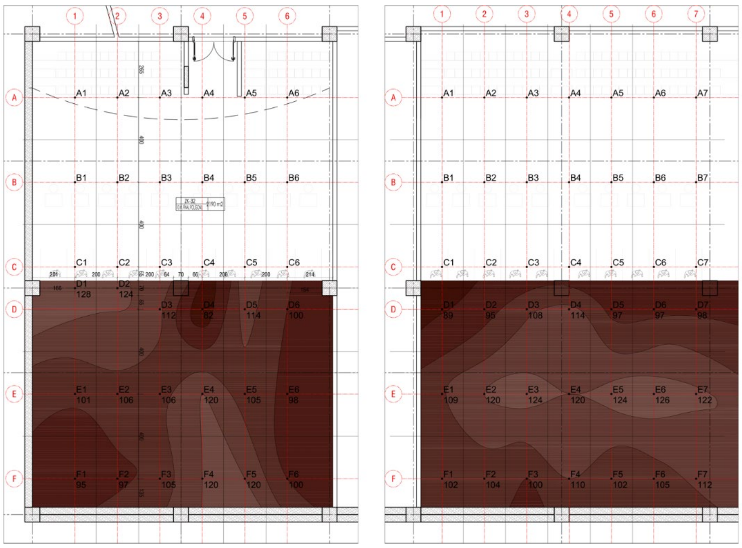
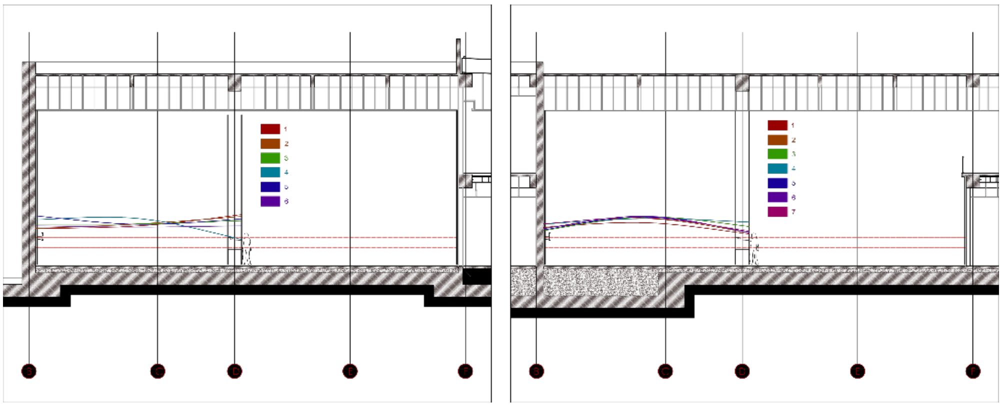


Figure 6a and b. Vertical measurement graph in the shooting direction (140 cm). (a. Final shooting range, b. 10-meter shooting range)

Despite the modern infrastructure of the Mersin Erdemli Shooting Range, certain areas of the shooting range, particularly in terms of general lighting and shooting line illumination, fall below the required standards in some regions. Although the overall lighting levels appear sufficient, the minimum value of 230 lx and maximum value of 513 lx recorded in the 10-meter shooting range do not meet the ISSF standard of a minimum of 500 lx for general illumination. Specifically, as can be observed in Figure 7, the low vertical illuminance values (89–126 lx) adversely affect the clarity of targets and the focus ability of athletes, creating an uneven lighting distribution that undermines fair competition conditions. The higher values recorded in the final shooting range (252–610 lx) are more in line with general lighting standards; however, the low vertical illuminance levels (82–128 lx) along the shooting line present an issue with target clarity. Additionally, when evaluating the lighting along the shooting line, the values recorded in the 10-meter shooting range (minimum 217 lx, maximum 538 lx) fall short of the 1000 lx standard recommended by the ISSF.

In the final shooting range project, 46 ceiling-mounted LED lamps were utilized, with 18 lamps behind the shooting line and 28 lamps along the shooting line. In the design of the 10-meter shooting range, 24 ceiling-mounted LED lamps were planned behind the shooting line along the defined axes, 4 spotlights on the shooting line, and 28 ceiling-mounted LED lamps along the shooting area. As illustrated in Figure 7, the lighting fixtures marked in red were either not installed, not functioning, or damaged. Green markings indicate locations where ceiling-mounted LED lighting elements were added, and yellow markings indicate where the spotlights were replaced with bulbs of different color temperatures.



a. b.

Figure 7. Vertical measurement graph in the shooting direction (140 cm). (a. Final shooting range, b. 10-meter shooting range)

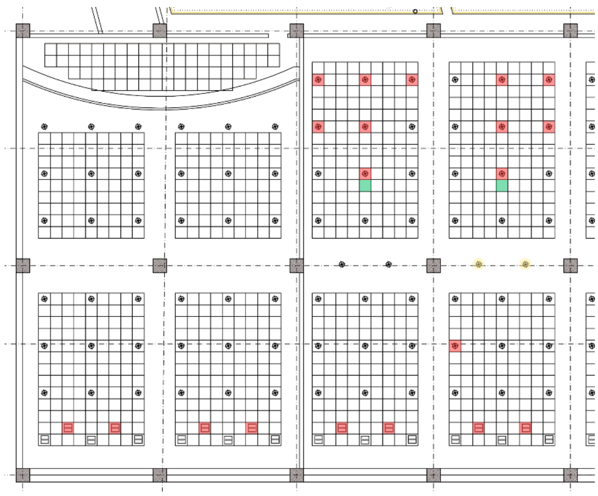


Figure 8. Ceiling plan of Mersin Erdemli Shooting Range. (reds for missing, yellow for different colour temperature, green for extras)

The absence of the lighting fixtures marked in red on the ceiling plan provided in Figure 8—due to non-installation during construction, failure to repair after damage, or malfunctioning—accounts for the current deficiencies in the lighting system. The measured ceiling height of the spaces is 8 meters, which provides a sufficient vertical clearance to allow for uniform distribution of light. The calculated lighting uniformity is approximately 2.48:1, which is very close to the IESNA-recommended limit of 2.5:1. The final shooting range lighting, with illuminance values ranging from 335 lx to 624 lx and a uniformity ratio of 1.86:1, provides a more balanced and equitable competition environment for the athletes. If the appropriate fixture selections and placements are made in both shooting ranges, given that the ceiling height is adequate, the uniformity and illuminance levels can be improved, ensuring that the shooting range remains functional and meets the required lighting standards.

		Minimum (lx)	Maximum (lx)	Average (≈)	Standard Deviation (≈)	CV (Coefficient of Variation)
Final shooting range	90 cm horizantal	252	610	431	126.87	29.4%
	140 cm horizantal	335	624	479.5	102.07	21.3%
	140 cm vertical	82	128	105	16.26	15.5%
10-meter shooting range	90 cm horizantal	230	513	371.5	99.91	26.9%
	140 cm horizantal	217	538	377.5	113.9	30.2%
	140 cm vertical	89	126	107.5	13.Eyl	12.2%

Table_2. Results of basic statistical analyses.

According to the table 2, the statistical evaluation of measured illuminance levels indicates significant variation across different points in both the 10-meter and final shooting ranges. For instance, the coefficient of variation (CV) for horizontal measurements at 140 cm reached 30.2% in the 10-meter range, highlighting a substantial inconsistency in lighting distribution. Similarly, the average horizontal illuminance along the shooting line in both ranges remained significantly below the recommended threshold of 1000 lx, with averages of approximately 479.5 lx and 377.5 lx respectively. Such variability can adversely affect visual uniformity, leading to unequal shooting conditions and potential reductions in accuracy and concentration. These findings emphasize the urgent need for recalibrating lighting systems to ensure standardized performance conditions.

CONCLUSION

This study provides the fundamental principles regarding artificial lighting in 10-meter indoor shooting ranges and evaluates the current artificial lighting conditions at the Erdemli Shooting Range located in the Erdemli district of Mersin. The assessment of the existing lighting conditions in indoor shooting ranges highlights both the aspects that are in alignment with established standards and areas that require improvement.

According to Section 6.4.14 of the ISSF Official Statutes Rules and Regulations, titled "Indoor Range Light Requirements (Lx)," the general lighting requirement for 10-meter, 25-meter, and 50-meter ranges is a minimum of 500 lx. For the 10-meter range, the minimum target illumination is set at 1500 lx, with a recommended target lighting level of >1800 lx. For the 25-meter range, the minimum target lighting is also 1500 lx, with a recommended target level of >2500 lx, and for the 50-meter range, the minimum target lighting requirement is again 1500 lx, with a recommended level of >3000 lx. For final ranges, general ambient lighting of 500 lx is required, along with a shooting line illuminance of over 1000 lx. New shooting ranges require a minimum of 1500 lx for the shooting line lighting.

In the current situation, the general illuminance level measured at the range was found to be 217 lx, which falls short of the ISSF's minimum requirement of 500 lx. Furthermore, the target lighting was measured at 1150 lx, which is below the minimum required value of 1500 lx. Therefore, any necessary improvements should aim to meet or exceed the ISSF's recommended values: 1800 lx for 10-meter ranges, 2500 lx for 25-meter ranges, and 3000 lx for 50-meter ranges. In the existing final ranges, the target line illumination was measured at a minimum of 335 lx and a maximum of 624 lx, both of which are below the 1000 lx minimum required by the ISSF.

Although the lighting design in the examined ranges was correctly planned, the lighting levels were found to fall below the standards. Based on the analysis of the data, it has been determined that by repairing the lighting fixtures that were specified but not installed or were damaged, the shooting range could be brought in compliance with international standards. Given these requirements and recommendations, it is evident that while the lighting standards in the ranges meet the basic requirements, repairs and adjustments should be made to adhere more closely to the original design and specifications. The Erdemli Shooting Range, with its adequate ceiling height and balanced lighting uniformity, presents a generally positive profile, yet it requires the improvements in general and shooting line lighting as outlined.

The findings of this study are not only applicable to sports performance improvement but also bear implications for broader applications such as military training environments, public safety shooting facilities, and athlete education programs. National sports federations and facility designers can utilize this data as a guideline for retrofitting older shooting ranges or constructing new ones that meet global standards.

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