The Effectiveness of Simulation-Based Training in Handgun Shooting: Evidence from an Experimental Study with Law Enforcement Officer Candidates

Emrah ALTINTAS[1*], Aslıhan TÜFEKCİ[2], Vedat YILMAZ[3]

[1]Institute of Informatics, Gazi University, Ankara, Türkiye, emrah.altintas@gazi.edu.tr

[2]Institute of Informatics, Gazi University, Ankara, Türkiye, asli@gazi.edu.tr

[3]Institute of Forensic Sciences, Gendarmerie and Coast Guard Academy, Ankara, Türkiye, vylmz26@gmail.com

Abstract

In the context of enhancing the operational readiness of law enforcement personnel, the development of advanced shooting skills is indispensable. This experimental study aimed to evaluate the efficacy of simulation systems in enhancing the shooting performance of law enforcement candidates. A total of 80 officer candidates, all novices in firearm use, were randomly assigned to test and control groups. After completing the necessary basic pistol shooting training, both groups initially performed shooting exercises without any prior simulation exposure. Subsequently, the test group received simulation training (8 lesson hours, 200 simulation shots), while the control group repeated the same shooting exercises and then both groups fired second rounds of shots. The results indicated that the test group exhibited a significant improvement in accuracy and overall scores, particularly at longer shooting distances (25m), achieving a 94% increase in hit accuracy and a 112% improvement in score, compared to the relatively modest gains observed in the control group. The findings advocate for the systematic integration of simulation-based training within law enforcement academies, not only to elevate performance metrics but also to optimize resource utilization and operational readiness in complex field scenarios.

Keywords: *Simulation, Educational Technology, Shooting Training, Skill Development, Law Enforcement*

INTRODUCTION

The term "law enforcement" is frequently used in legal and security contexts. Law enforcement personnel are public servants who maintain public order, ensure safety and security, and combat crime and criminals (Aydin & Demir, 2022). The powers of law enforcement vary from country to country, shaped by their respective legal systems and national legislations (Conser et al., 2011). Generally, the term "law enforcement" brings to mind personnel from the Gendarmerie, Police, and Coast Guard (Bilgiç, 2019). All duties performed by law enforcement agencies are based on legal frameworks, and they act within the scope of the authorities granted by these laws. One of the authorities that law enforcement is required to exercise while performing their duties is the use of force and firearms (Ünsal, 2023). Law enforcement must adhere to the principle of proportionality while exercising this authority (Gülten, 2014).

A law enforcement officer is obligated to use force ethically against individuals in situations of power asymmetry (Yazar, 2021). The use of force refers to the authority granted to law enforcement under the law to neutralize individuals by using physical force, non-lethal tools, and, ultimately, firearms in a manner that is appropriate to the level of resistance encountered (Kaşlı, 2021). In situations where the use of firearms is necessary, proportionality is essential, and firearms should be used in a manner proportional to the degree and severity of the situation (Rajakaruna et al., 2017). The selection of the target area/aiming point on the target to be neutralized should also be considered within the principle of proportionality. Therefore, it is legally significant that law enforcement personnel can achieve precision in the selected aiming point when they resort to using firearms.

It is a well-known fact that there has been an increase in individual armament worldwide, as well as a corresponding rise in violence and criminal activities over the years (Yasuntimur & Öğünç, 2022). In this context, law enforcement personnel must have excellent shooting skills to succeed in incidents where the legal use of firearms is mandatory, such as preventing the escape of criminals, apprehending them, and protecting their own lives or the lives of others. This emphasizes the importance of the shooting skills of law enforcement personnel and the training methods and stages in their vocational education period that can enhance these skills (Gudzbeler & Struniawski, 2017; Rajakaruna et al., 2017).

Success in shooting training is typically evaluated based on the hit location. Traditionally, any hit on a full target is considered successful (Irhebhude & Kolawole, 2023). However, in real incidents where the authority to use firearms is required, it is legally necessary to neutralize the offender in a non-lethal manner when possible. Therefore, modern training methods that prioritize accuracy in hitting the desired target at the right time and with the appropriate intensity should be preferred over traditional approaches (Rostker, 2008). Shooting training is generally conducted with real equipment and ammunition in open areas at different distances, which requires more time and incurs higher costs. Consequently, the number of actual shots during training is often limited. Additionally, these training sessions are prone to individual errors, which can be a disadvantage (Stringer & Kleine, 2010). Nowadays, shooting training is supported by shooting simulation systems that simulate real shooting and firearms (Fedaravičius et al., 2020). Moreover, shooting training systems utilizing augmented reality with three-dimensional targets are also being employed (Lucero-Urresta et al., 2021). There are also shooting training applications where a camera is integrated into the firearm to track the shooting direction (Soetedjo et al., 2014). Among shooting simulation systems, it is possible to find motion-capture-based systems that serve multiple users simultaneously and model the shooter as well. Systems offering 360-degree training with scenario-based exercises are also available (Júnior et al., 2012).

Simulation systems used in law enforcement marksmanship training primarily simulate proper aiming and weapon control, thereby enhancing marksmanship training levels, saving resources, and enabling law enforcement personnel to practice with their weapons, independently of issued firearms, without using live ammunition when necessary (Davies, 2015). The introduction of shooting simulation systems in law enforcement vocational education has shifted training approaches from acquiring marksmanship skills through live ammunition to developing these skills in simulation systems before transitioning to live shooting (Irhebhude & Kolawole, 2023). This kind of training can provide a valuable opportunity to evaluate competency in the use of force during service (Di Nota et al., 2024). In addition to improving the quality of training, the use of shooting simulation systems offers benefits such as reducing ammunition costs, the need for maintenance and repair of firearms, the need for shooting ranges or polygons, the risk of accidents and fires, and saving time (Saus et al., 2006).

Regarding the benefits of using simulation systems, the studies conducted at the Norwegian Police University College found that the use of simulation systems in shooting training positively impacted students' situational awareness and decision-making (Saus et al., 2006; Stenshol et al., 2024). Another study on marksmanship emphasized the necessity of incorporating and frequently utilizing simulation in shooting training and noted improvements in the performance of shooters subjected to simulation training (Hrybovskyy et al., 2015). A study conducted by Davies (2015) involving police cadets in law enforcement training found that simulation-based training enhanced students' decision-making abilities. A study conducted in China on law enforcement cadets to measure their ability to shoot in crowded environments by simulating real situations concluded that the closer the materials and scenarios used in simulation systems resemble real situations, the more effective the training becomes (Liu et al., 2018). In addition, it can be said that the positive perceptions regarding the use of simulation practices in law enforcement training contribute to the spread of tacit knowledge (Comiskey et al., 2021; Sjöberg, 2024).

This study makes a significant contribution to the existing literature by employing an experimental research design to highlight the critical role of simulation systems in shooting training. Unlike many previous studies, this research uniquely combines the use of real shooting conditions with a focus on handguns as the primary weapon, thereby bridging the gap between simulation training environments and practical firearm applications. The paper aims to address a gap in the literature by examining the impact of simulation systems used in shooting training at higher education institutions that train law enforcement personnel on shooting success and emphasizing the benefits of using simulation systems. To achieve this goal, the following research questions were determined:

RQ1: What is the impact of varying shooting distances on shooting performance and accuracy?

RQ2: How does simulation-based shooting training compare to traditional training in shooting performance?

This study consists of five sections. The first section provides a general overview of law enforcement and shooting training concepts, the aim of the study, and the research questions. The second section details the research methodology and describes the test system. The third section presents the results of the experimental research, followed by the discussion section, which evaluates the outcomes of using simulation in vocational shooting training. The final section offers a general assessment of the experimental research along with recommendations for future studies.

METHOD

In this study, the experimental research method employed is comprehensively described under the following headings.

Participants

The study involved 80 law enforcement officer candidates who had not previously undergone shooting training from one of the law enforcement higher education institutes in Türkiye. Participation was entirely voluntary. The selected students were randomly assigned into two distinct groups of 40 individuals each, designated as the test and control groups. All participants were right-handed.

Experimental Materials and Parameters

In each task, the minimum scores were 0 hits and 0 points, while the maximum scores were 3 hits and 30 points. The Canik TP-9 (Türkiye, 9mm, 810g) handgun model was used for live firing exercises. For simulation training, the light weapon shooting training simulation classroom was utilized. In this classroom, the simulation software (version 2.0, 2021, Ankara, Türkiye) developed by Simsoft Computer Technologies and replica simulation handguns modeled after the Canik TP-9 (with identical trigger mechanism and weight) were used. During this training, students in the test group received simulation-based training and performed 200 simulation shots while the control group was receiving traditional feedback training, after their initial live shots.

Test System

In law enforcement shooting training, shooting tasks with handguns are generally performed with 3 shots. Of the 3 shots fired, 0 and 1 hits are deemed unsuccessful, whereas 2 and 3 hits are classified as successful. In this study, all shots fired by the shooters were taken into account, and no distinction was made between success and failure. Additionally, 10-point targets used in live training exercises were employed. These scoring targets are designed to observe the difference between the aiming point and the hit point and to ensure hitting the desired spot (Kaya, 2019). In this study, 80 law enforcement cadets from the test and control groups who had not previously shot were made to shoot from three different distances (7m, 15m, 25m), progressing from close to far. Considering that the students had no prior shooting experience, the shooting sessions were planned to start from the closest distance. It was determined that starting at a medium distance, such as 25 meters, for handgun shooting could potentially have a demoralizing effect on the participants; therefore, the shooting sessions started at 7 meters.(Abdujalilovich, 2023).

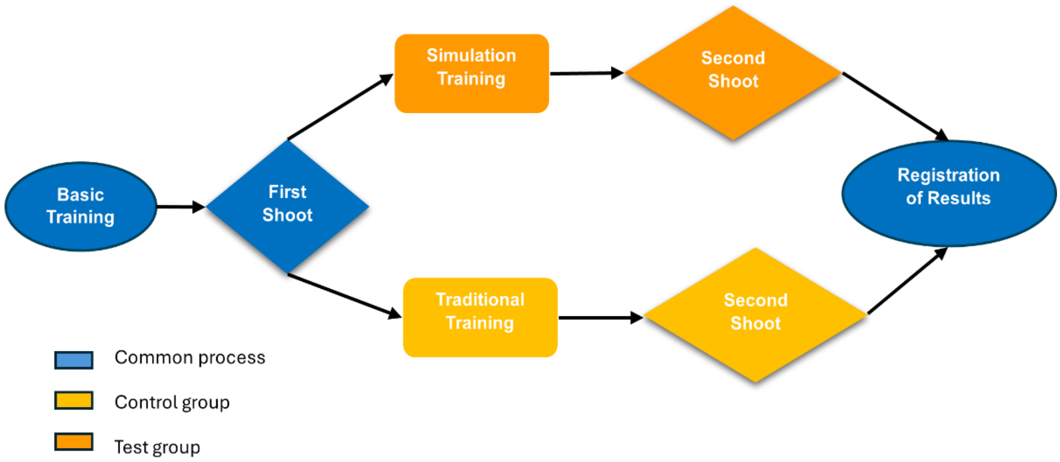

Figure 1: Test Flow Diagram

Before the shooting sessions, both groups received safety and accident prevention training, as well as theoretical instruction in basic marksmanship (Figure 1). Following the training, both groups, who had no prior shooting experience, performed three shots each at a 50 cm-diameter handgun scoring target from 7m, 15m, and 25m. During the shooting exercises at the three specified distances, data were collected by the instructors in two ways. The instructors initially recorded the number of hits on the target for each shooter, followed by the scores for each hit, repeating this process consistently across all distances. Following the initial shots from 7m, 15m, and 25m, the test group completed eight lesson hours of simulation training (each lasting 40 minutes, totaling 200 simulation shots), whereas the control group received traditional shooting training. The shooting sessions were conducted at distances of 7m, 15m, and 25m, in a standing position, using both hands, with the participants wearing composite helmets and clear-lens ballistic goggles. The test group additionally wore composite helmets and ballistic goggles during the simulation shots. In the shooting range, ten shooting lanes were used, while four shooting lanes were used in the simulation classroom. The positions of the shooters in both the shooting range and the simulation classroom were kept constant, while the virtual target's position was adjusted based on the shooting task's distance. The training shots performed by the test group in the simulation classroom were recorded in the simulation software, and the records were utilized as immediate feedback to support the shooters' development. Upon completing the simulation training and shooting sessions, both groups conducted a second round of shooting, firing three shots each from 7m, 15m, and 25m, with the results meticulously recorded.

Statistical Analysis

Statistical analyses for this study were performed using the IBM SPSS Statistics software package (version 23, IBM Corporation, Armonk, NY, USA). In this study, which aimed to investigate whether simulation systems affect shooting success, shooting success was evaluated based on the total number of hits and the total hit scores. An independent samples t-test was employed to determine whether a statistically significant difference existed between the means of the two independent groups. Before conducting the test, data normality was assessed by calculating z-values (obtained by dividing skewness and kurtosis coefficients by their standard errors), with values between -1.96 and +1.96 considered indicative of normality (Uysal & Kılıç, 2022). Additionally, the normality of all data was verified using the Kolmogorov-Smirnov test ($p > 0.05$). A significance level of 0.05 was employed to examine the potential effect of the simulation systems.

EXPERIMENTAL RESULTS

Figures 2 and 3 show the hit and score variations from the initial shots. It was observed that success decreased as the distance increased.

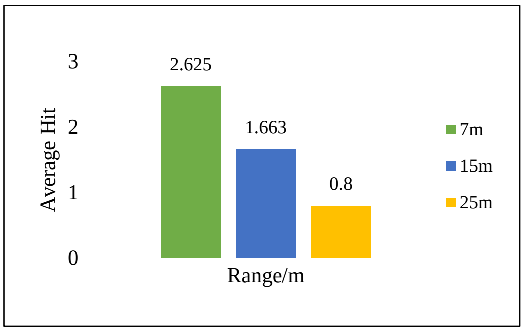

Figure 2: Range-Hit Variation

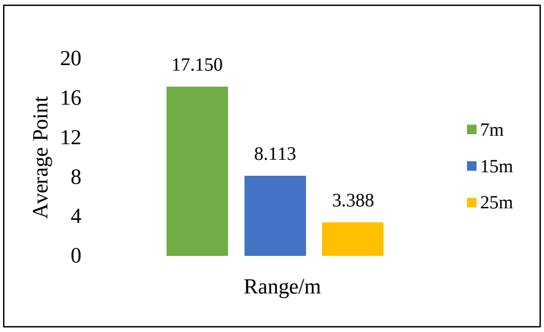

Figure 3: Range-Point Variation

Hit Findings

In the control group, the average hit of the first shots out of 3 from a distance of 7 meters was 2.525, which increased to 2.60 in the second round, reflecting a 3% improvement. At 15 meters, the average hit for the first shots was 1.60, which slightly declined to 1.575 in the second round, indicating a 2% decrease. At 25 meters, the average hit for the first shots was 0.725, rising to 0.750 in the second round, indicating a 3% improvement (Figure 4).

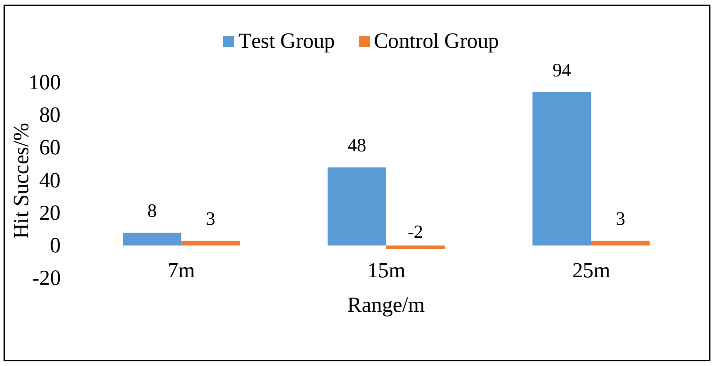

Figure 4: Range-Hit Success Variation (%)

In the test group, the average hit for the first shots at 7 meters was 2.725, which increased to 2.95 in the second round, representing an 8% improvement. At 15 meters, the average hit for the first shots was 1.725, which rose to 2.55 in the second round, marking a 48% improvement. At 25 meters, the average hit for the first shots was 0.875, which significantly increased to 1.70 in the second round, reflecting a 94% improvement.

Table 1. Summary of Hit Statistics in the First Shot Test

Group	Distance (m)	N	Mean	Std. Dev.	Std. Error Mean	F	Sig.
Control	7	40	2,5250	,67889	,10734	3,047	,179
Test	7	40	2,7250	,64001	,10119	3,047	,179
Control	15	40	1,6000	,81019	,12810	9,613	,572
Test	15	40	1,7250	1,13199	,17898	9,613	,572
Control	25	40	,7250	,84694	,13391	2,994	,494
Test	25	40	,8750	1,09046	,17242	2,994	,494

Table 2. Summary of Hit Statistics in the Final Shot Test

Group	Distance (m)	N	Mean	Std. Dev.	Std. Error Mean	F	Sig.
ontrol	7	40	2,6000	,54538	,08623	81,516	0,001
Test	7	40	2,9500	,22072	,03490	81,516	0,001
Control	15	40	1,5750	,84391	,13343	0,465	0,001
Test	15	40	2,5500	,84580	,13373	0,465	0,001
Control	25	40	0,7500	,70711	,11180	12,554	0,001
Test	25	40	1,7000	1,13680	,17974	12,554	0,001

Based on the values in Tables 1 and 2, the control group showed minor changes in shooting accuracy across distances. In contrast, the test group demonstrated significant improvements, particularly at 15 and 25 meters, with increases of up to 94%.

Score Findings

In the control group, the average score of the first shots from a distance of 7 meters was 16.275 out of 30 points, increasing to 17.250 in the second round, reflecting a 6% improvement. From a distance of 15 meters, the average score of the first shots was 8.125, and this value increased to 8.700 in the second round, indicating a 7% increase. However, at 25 meters, the average decreased from 3.475 to 3.350, indicating a 4% decline.

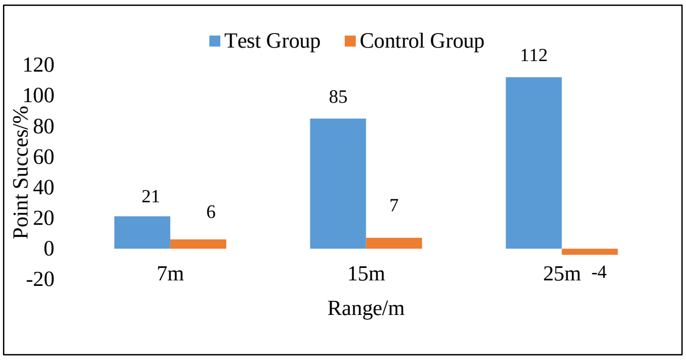

Figure 5: Score Success Variation

In the test group, the average score of the first shots at 7 meters was 18.025, which increased significantly to 21.750 in the second round, indicating a 21% improvement. At 15 meters, the score rose dramatically from 8.100 to 14.95, reflecting an 85% increase. Finally, at 25 meters, the average score increased from 3.30 to 7.00, demonstrating a substantial 112% improvement (Figure 5).

Table 3. Summary of Score Statistics in the First Shot Test

Group	Distance (m)	N	Mean	Std. Dev.	Std. Error Mean	F	Sig.
Control	7	40	16,275	6,36895	1,00702	,113	,258
Test	7	40	18,025	7,34319	1,16106	,113	,258
Control	15	40	8,125	4,57523	,72341	7,777	,985
Test	15	40	8,100	6,82679	1,07941	7,777	,985
Control	25	40	3,475	4,32635	,68406	,002	,861
Test	25	40	3,300	4,58649	,72519	,002	,861

Table 4. Summary of Score Statistics in the Final Shot Test

Group	Distance (m)	N	Mean	Std. Dev.	Std. Error Mean	F	Sig.
Control	7	40	17,2500	5,62845	,88994	1,076	,001
Test	7	40	21,7500	4,64510	,73445	1,076	,001
Control	15	40	8,7000	5,50151	,86987	3,110	,001
Test	15	40	14,9500	7,14663	1,12998	3,110	,001
Control	25	40	3,3500	3,56299	,56336	11,034	,002
Test	25	40	7,0000	6,04258	,95542	11,034	,002

Based on the values in Tables 3 and 4, the control group showed modest improvements or slight declines in shooting scores across distances, while the test group demonstrated substantial improvements, with increases of up to 112% at 25 meters.

DISCUSSION

Ensuring safety is the primary condition in shooting training, and shooting simulators eliminate the risk of accidents caused by live ammunition, thereby reducing potential injuries and fatalities during training (Fedaravičius et al., 2020). In the first phase of this study, the theoretical safety and accident prevention training provided to the participants was briefly reiterated with a shooting briefing before each group's shooting session, and no adverse events were encountered during the shooting exercises. When the first shots of both groups were examined in terms of both hit and score values, no statistically significant difference was found between them, and similar hit and score values were observed ($p > 0.05$).

In the literature, it is noted that shooting with short-barreled firearms becomes more challenging as the distance increases (Figure 6) and that shooting success decreases at longer distances, requiring more practice and skill (Dopsaj et al., 2019; Irhebhude & Kolawole, 2023). In this study, when the first shots of the 80 participants who had not experienced live firearm shooting before were evaluated in terms of hit and score values, the following results were obtained:

- At 7 meters: Average hit rate of 2.625 and average score of 17.15
- At 15 meters: Average hit rate of 1.663 and average score of 8.113

- At 25 meters: Average hit rate of 0.800 and average score of 3.180

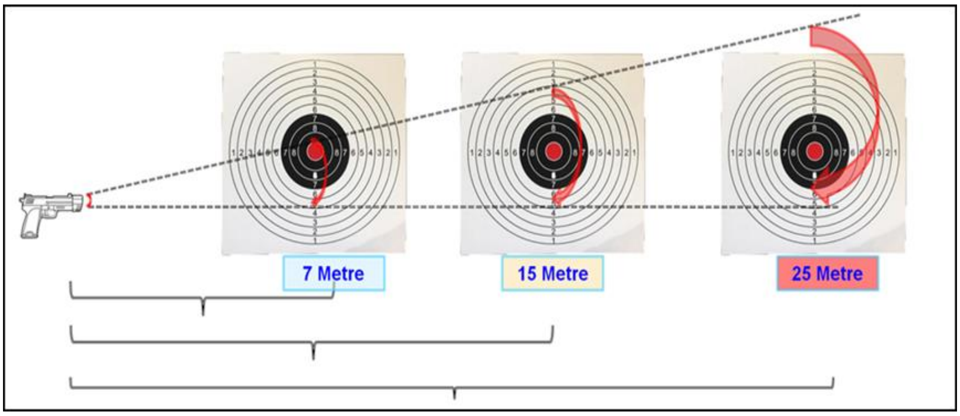

Figure 6: Angular Error in Shooting

These values indicate that the average hits and scores of the participants decreased as the distance increased. One of the research questions of this paper below reached findings consistent with the existing literature.

RQ1: What is the impact of different shooting distances on shooting performance and accuracy?

This is attributed to the difficulty of control with short-barreled firearms like pistols, where the support point and center of gravity are at the rear, making control more difficult, and the angular error increases with distance, causing shots to miss the target (Frazer, 2015).

Analysis of Average Hit Values

A significant difference was observed in the hit values between the two shots of the students in the test group who received simulation training ($p < 0.05$). At a distance of 7 meters, the average hit for the test group's first shots was 2.725. This increased to 2.95 in their final shots. For the control group at the same distance, the average hit for the first shots was 2.525, and for the final shots, it was 2.6. The test group showed an 8% improvement, compared to a 3% improvement in the control group. This increase is attributed to the fact that angular errors can be tolerated at close distances, and the 5% greater increase in the test group compared to the control group is due to the simulation training. Overall, a near-perfect hit success rate of approximately 3 out of 3 was achieved at close range. The increase in hit success may also reflect reduced excitement and hesitation during subsequent shots.

At a distance of 15 meters, the average hit of the test group's first shots was 1.725, while the average hit of their final shots was 2.55. For the control group at the same distance, the average hit for the first shots was 1.6, and for the final shots, it was 1.575. When the difference between the first and last shots was evaluated, a 48% increase was observed in the test group, compared to a 2% decrease in the control group.

At a distance of 25 meters, the average hit of the test group's first shots was 0.875, while the average hit of their final shots was 1.7. For the control group at the same distance, the average hit for the first shots was 0.725, and for the final shots, it was 0.75. When the difference between the first and last shots was evaluated, a 94% increase was observed in the test group, compared to a 3% increase in the control group. Despite the increasing distance, the test group that received simulation training significantly improved their hit success, demonstrating better control of the firearm and forming a more accurate sight picture ($p < 0.05$). The high hit success rate at 7 meters for both groups and the decrease at longer distances, particularly at 25 meters, can be attributed to increased angular errors, leading to greater shot dispersion outside the target. As the distance increased, the hit success of the group that received simulation training nearly doubled at 25 meters, demonstrating that simulation shooting and training focused on marksmanship were more observable at the longer distance of 25 meters than at the closer distance of 7 meters, highlighting the effectiveness of the training ($p < 0.05$).

Analysis of Average Score Values

The score results of the test group that received simulation training showed more noticeable changes in shooting accuracy. At a distance of 7 meters, the test group's average score improved from 18.025 in their first shots to 21.75 in their final shots. For the control group at the same distance, the average score for the first shots was 16.275, and for the final shots, it was 17.25. The test group's scores increased by 21%, compared to a 6% improvement in the control group.

At a distance of 15 meters, the average score of the test group's first shots was 8.1, while the average score of their final shots was 14.95. For the control group at the same distance, the average score for the first shots was 8.125, and for the final shots, it was 8.7. When the difference in scores between the first and last shots was evaluated, an 85% increase was observed in the test group, compared to a 7% increase in the control group.

At a distance of 25 meters, the average score of the test group's first shots was 3.3, while the average score of their final shots was 7. For the control group at the same distance, the average score for the first shots was 3.475, and for the final shots, it was 3.35. When the difference in scores between the first and last shots was evaluated, a 112% increase was observed in the test group, compared to a 4% decrease in the control group. Similar to the hit values, the decline in average scores with increasing distance can be attributed to angular errors. The low scores reflect the increased distance between the hit point and the target center. Thus, the average score of 25 meters is considerably lower than the maximum possible score of 30.

Starting the shooting exercise at 7 meters improved the shooters' success in their first and second shots. It also built confidence by helping them overcome the common fear of shooting (Goonetilleke et al., 2009).

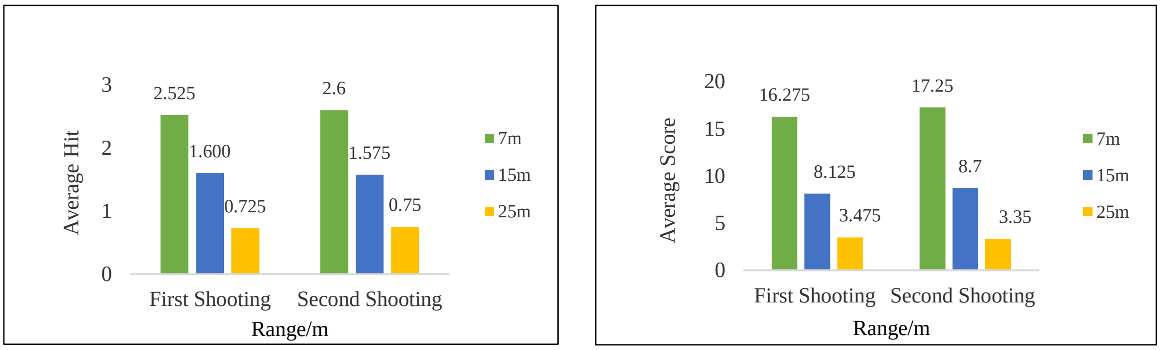

Figure 7: Average Hit-Score Variation Graphs for the Control Group

Figure 7 shows that the control group's performance across the three distances varied between a -4% and a 7% change. This improvement likely reflects reduced initial fear, familiarity with the weapon's recoil, and habituation to the gunshot sound. However, when the shooting results at different distances (7m, 15m, 25m) were evaluated, it could be said that there is no significant difference in terms of the number of hits or accuracy rate.

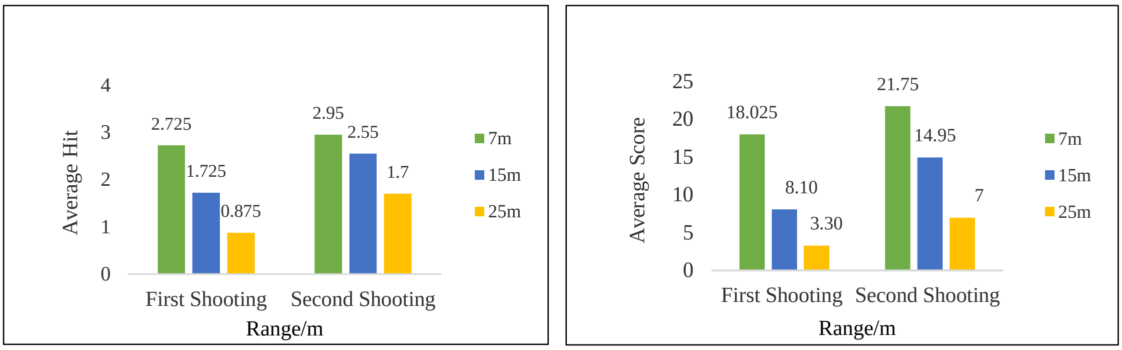

Figure 8: Average Hit-Score Variation Graphs for the Test Group

When considering the values in Figure 8, it was determined that the change between the first and last shots of the test group across the three different distances ranged from 8% to 112%. The test group showed significant improvements in hit rate and accuracy between their first and last shots at each distance ($p < 0.05$). When the shooting results at different distances 7m, 15m, and 25m were examined, a significant difference was found in both the number of hits and accuracy rate for the test group. This improvement can be linked to the 8 hours of training and 200 simulation shots provided to each student. As Figure 8 illustrates, the greatest improvement occurred at 25 meters.

Considering the differences between the shooting performances of the test and control groups in terms of both hit and accuracy rates, within the framework of the findings in the second phase of the study, it was determined that simulation-based training produced better results than traditional shooting training.

RQ2: How does simulation-based shooting training compare to traditional training in shooting performance?

In response to the second research question, simulation-based training demonstrates superior results in handgun shooting training.

Additionally, during a shooting training using virtual reality with 46 participants at the Dutch Police Academy, feedback was provided to the participants after simulation training, and it was found that this feedback enhanced their knowledge acquisition (Hiwat, 2023). In this study, to reduce the risk of accidents and increase the efficiency of simulation training, feedback was provided in two stages. The safety and accident prevention briefings given at the beginning of the process and immediately before the shooting sessions increased the participants' awareness, and no unsafe conditions occurred during the shooting activities. Additionally, during the second shot of the test group, it was observed that they executed commands such as "Insert magazine!", "Load and secure!", "Fire at will!" more quickly and correctly. Furthermore, the feedback given during simulation training was found to be beneficial for the shooters' decision-making processes, similar to the findings of the study conducted by Hiwat (Hiwat, 2023).

Bhagat et al. (2016) assessed the impact of virtual reality on shooting success with 160 participants, demonstrating its positive effects on performance and motivation. Unlike this study, a simulation rifle was used, longer shooting distances were simulated, and in addition to shooting success, participants' motivation was also measured. In the study on military shooting training, it was found that virtual reality-supported training had a positive effect on shooting success, as in this study, and it was also revealed that it added value to participants' learning motivation and learning outcomes.

To summarize the advantages of simulation systems used in law enforcement shooting training, it can be stated that these systems, also known as shooting simulators, provide law enforcement cadets or trainees with a safe and controllable training environment, allowing them to develop their shooting skills (Rankis et al., 2008). This was experienced with the students in the test group within the scope of this study. It was observed that the tension of the students who had not shot before decreased during the simulation training before their second shot, the interaction between the instructor and the student increased, and the instructors were able to make corrections more easily. The absence of live ammunition and the use of a simulation gun minimized risks, enabling shooters to perform more confidently.

Shooting simulations supported by realistic scenarios and materials help students develop their situational awareness and improve their decision-making skills under stress (Leech et al., 2024). Additionally, shooting simulators provide unlimited practice opportunities and offer instant feedback on shooting metrics such as accuracy, precision (Corriveau et al., 2019), and reaction times. This enables students to track their progress effectively (Isoaho, 2023). During the simulation phase of the test group's shooting sessions in this study, the shooting results of the students were instantly recorded by the simulation system, and the shooting results were reflected on the screen. Corrections were made by the instructors regarding possible shooting errors, and feedback was provided to the students in a very short time. It was observed that these quick feedback sessions positively impacted the students' subsequent simulation shots regarding shooting errors.

Thanks to the data collected during the training, shooting simulation systems, which offer instructors the opportunity to create personalized training programs, conduct individual follow-ups, and start training at the desired level, are more accessible due to their independent structure. In addition to the benefits of shooting simulation systems, there are also some limitations. Chief among these limitations is the lack of recoil force (Lukáč et al., 2016). Although simulation systems using the same type of weapons, requiring the same trigger pull force, and weighing the same as real guns are available, the recoil generated by the gunpowder gas cannot be experienced in most shooting simulators due to the absence of live ammunition. This situation may negatively affect the muscle memory of shooters who practice frequently. In this study, gas-powered guns with compressed air were used to simulate the recoil force and the muzzle rise during a real shot.

However, an environment free from danger and without the risk of accidents cannot create real stress and adrenaline levels in the shooter. Additionally, due to technological differences between simulation systems, real-life scenarios may not be fully replicated in some simulators. Shooting simulation systems, generally used in indoor environments, cannot reflect environmental factors such as wind, rain, or weather conditions that affect the bullet's trajectory. Most simulators restrict shooter movement and encourage shooting from a fixed position (Yao & Huang, 2021). In this study, the shooters remained stationary, and the targets were moved. To simulate a real situation, the students were trained and performed shooting with full equipment, but the lack of loud noise and the smell of gunpowder from the weapon and other sources in a real shooting might not have created the real stress level. Despite the limitations mentioned by Yao and Huang (2021), this study has shown that success has increased.

CONCLUSION

In this study, each participant fired 18 shots at three different distances, resulting in a total of 1,440 handgun rounds fired. The students in the test group also performed 200 simulation shots per person during the 8 lesson hours between the two shooting sessions. This study aimed to demonstrate the impact of simulation systems on shooting success using real materials, equipment, and ammunition and provides a unique contribution to the literature by demonstrating the importance of simulation systems in shooting training through an experimental method under real shooting conditions, using a handgun.

The difference in shooting success between the test and control groups demonstrated the necessity of using simulation systems in law enforcement or military shooting training ($p < 0.05$). The fact that the sample group consisted of law enforcement cadets who had no prior shooting experience adds additional value to the study's findings. Moreover, factors such as time and cost savings, as mentioned in the literature regarding the benefits of simulation systems, were experimentally experienced. Shooting simulators are cost-effective and, unlike traditional shooting training, save on factors such as ammunition, shooting range usage and maintenance, transportation, and time (Khantong & Patterson, 2016). Considering that each student in the test group performed 200 simulation shots (40×200=8,000), it can be said that a total of 8,000 live rounds were saved during this study alone.

When the findings were examined, it was observed that the average hits and scores decreased as the distance increased in both the test and control groups. While there were small changes between the first and last shots in the control group, there was a significant score difference between the first shot and the final shot after simulation training in the test group. This outcome demonstrated the impact of simulation training and practicing with a firearm, even in a virtual environment, on real shooting performance. Utilizing simulation systems in shooting training for personnel joining institutions authorized to use firearms, such as law enforcement or armed forces, is highly important for both safety and cost-effectiveness, especially when the initial setup cost is considered. Additionally, the use of shooting simulation systems saves time and resources.

The participants in this study were randomly selected from those who had no prior experience with firearms. In future studies, the sample group could be selected from participants with specific professional and shooting experience to further investigate the impact of shooting simulation systems. Future studies could also help fill the gap in the field by testing the effects of shooting simulation systems on other short- and long-barreled firearms, such as submachine guns and rifles, at different distances. Although the evaluation was based on hitting the target, law enforcement officers need to strike the specific aiming point on the target when using their authority in situations where they must neutralize a target. In this context, simulation systems offer significant opportunities by eliminating limitations such as limited practice frequency, lack of shooting ranges, and other time and cost constraints. The more practice shooters have, the more their shooting skills will improve with proper training. If the limitations of the simulation systems used in the training of law enforcement and armed forces personnel are reduced and their similarity to real shooting is increased, it is believed that the success rates demonstrated in this study could be further improved, and the ability to hit the target at the desired point could be enhanced.

Ethics Statement

This research has taken into account the ethical guidelines specified by the Salus Journal as well as the Gazi University Ethics Commission guidelines for research ethics.

Disclosure Statement

The authors declare that there are no conflicts of interest regarding the publication of this article. This research was conducted independently, and no financial or personal relationships influenced its outcomes.

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Biographical Notes

Emrah Altıntaş is a PhD candidate in Management Information Systems at the Informatics Institute of Gazi University. He graduated from the Military Academy in 2008 as a Systems Engineer and has served as a Gendarmerie Officer for 16 years. He also earned a degree in International Affairs from Anadolu University in 2016 and holds a master's degree in Management and Organizational Behavior. His research focuses on knowledge management, educational technology, simulation, shooting training, decision support systems, and defense technology. He has also worked as an instructor at the Gendarmerie and Coast Guard Academy, specializing in shooting training and coaching.

Prof. Dr. Aslıhan Tüfekci earned her BSc in Computer Education from Gazi University in 1994, her MSc in Computer Education in 1997, and her PhD in Electronics and Computer Education in 2002, all at Gazi University. Her doctoral research focused on developing and evaluating an expert system shell program for computer-aided instruction. Currently a professor, she specializes in science, technology, and society, as well as engineering and technology. With 54 publications, her work has been cited in WoS (2) and Scopus (21), achieving H-Indexes of 1 and 2, respectively. She continues her studies in innovative approaches to education and technology integration.

Vedat YILMAZ (PhD) holds a BSc in Systems Engineering (Military Academy, 2004), an MSc in Management and Organization (Selçuk University, 2007), and a PhD in Biomechanics (Hacettepe University, 2022). He completed Digital Communication Electronics Training at Hacettepe University and received advanced training in communication principles (Cranfield University), cybersecurity (METU), and terrorists' use of cyberspace (Center of Excellence in Combating Terrorism). With extensive experience managing technology projects within the Gendarmerie General Command, his research focuses on cybersecurity, artificial intelligence in cybercrime, and security technologies. His multidisciplinary expertise bridges technology, security, and management.