EFFECTS OF CONTACTLESS SUPPRESSORS ON ACCURACY IN SHOOTING

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Summary: *The changes in the security environment of today are characterized by the process of globalization and its effects. Those changes often lead to crises of different scales in which the frequency of use of specialized units is rising. The operations this type of unit conducts are highly dynamic and regularly require the use of suppressed firearms. In such scenarios, the accuracy of every shot fired is of extreme importance. The article presents the results of a study including a small-scale practical experiment on the effects of shooting with and without contactless suppressors on the grouping and accuracy of shots of a popular weapon system.*

Key words: *Contactless suppressors, shooting, accuracy, dispersion.*

INTRODUCTION

The effects of globalization are part of modern times. Globalization as a process is always seen in both positive and negative aspects. Security threats go hand in hand with the easier movement of people, goods, capital, and information transfer. They affect both large regions and small groups or individuals. The role of specialized military and police formations in non-military crises, such as the elimination of terrorists, the release of hostages, the fight against piracy, the capture of high-value targets, etc., is growing. High dynamics characterize this type of operation, while precision and efficiency of execution are crucial to success. This is also the reason these formations adopt weapons, gear, and equipment enabling stealth during convergence, concealment of positions during covered actions, and speed during infiltration and exfiltration.

The technological progress of mankind dictates innovations in the means of striking targets and objects. New technologies in the arms industry lead to competition to improve the quality and performance of both weapon platforms and other components of the gear and equipment of the security forces. As a result of these processes, the efficiency and accuracy of firearms reaches new levels. However, the postulates in ballistics do not lose their significance.

In physical space, there are many factors affecting the processes and phenomena studied by ballistics. Numerous models of short-barreled and long-barreled firearms use systems to reduce the sound of a shot, commonly known as suppressors. They have become standard equipment for many of the dedicated direct-action units.

Suppressors are generally categorized into two separate groups – contact and contactless. The main characteristic of the suppressors of the first group is the use of obturators, which are rubber plugs locked in a metal bracelet through which the projectile passes. Their function is to reduce the main amount of gunpowder gases accelerating the bullet, as a result of which the noise level during the firing of a shot is reduced.

In the second group, constructive solutions do not include the use of obturators to achieve the desired effect. It is achieved by gradually increasing the volume of space behind the projectile after it leaves the barrel. This is accomplished through a series of mechanical elements in the limited volume of the suppressor. An essential characteristic of this group is the option of using both subsonic and supersonic ammunition. In modern operations, systems with contactless suppressors are preferred, because during its movement, after leaving the channel of the barrel, the bullet does not contact the components of the suppressor, limiting its influence on the trajectory of the projectile.

In contactless suppressors, the main phenomenon affecting projectile movement is the changes (drops) in the pressure of the gunpowder gases in the last period of the shot. Technical data on the changes in gas pressure in suppressors is not publicly available, due to the manufacturers' need to keep the production secrets. Obtaining such data through experiments outside a specially equipped laboratory is problematic, and this makes it difficult to theoretically determine the suppressors' influence on the results of shooting.

From a theoretical point of view, it is impossible for sudden changes in the pressure of the gunpowder gases not to affect the bullet's flight, which is scientifically proven by external ballistics. This publication addresses the question of whether the impact that contactless suppressors have on grouping and firing accuracy is essential in real-world weapon use in operations that seek high precision and performance efficiency.

To find an answer to this question, it is necessary to conduct a practical experiment. The actions for its implementation are divided into three stages – planning and preparation, collection of empirical data, and processing and analysis of the results.

The purpose of the presented study is to practically verify the degree of influence of contactless suppressors on the accuracy and grouping of hits when suppressed weapons are used at short distances. A key factor in such firing conditions is the increased duration of the powder gases affecting the projectile, which leads to an increase in its initial velocity, changing its trajectory.

1. PLANNING AND PREPARATION

To achieve a theoretically valid result, the experimental process adheres to a certain methodology. The first step comes down to choosing a specific weapon configuration. Subsequently, the parameters of the weapon platform that are significant for the researched phenomenon are derived. On their basis, the shooting distance is determined and a target suitable to the purposes of the experiment is developed. The necessary requisites of the target are an easily distinguishable image for aiming the weapon at the target, as well as a coordinate system for pinpointing the location of hits. The dimensions of the target are in accordance with the expected magnitudes of natural dispersion when shooting at short distances, which is typical for specialized units. The dimensions of the targeting image are in direct correlation with the covering value of the weapon platform's aiming devices. This value is calculated with the use of the following formula[1]:

$$K = \frac{L \times p}{l} \tag{1}$$

where:
K – covering value of the front sight measured in mm
L – distance to the target measured in mm
p – the size (width/diameter) of the front sight measured in mm
l – distance from the shooter's eye to the tip of the front sight measured in mm

The distance from the shooter's eye to the tip of the front sight (l) depends on the physical characteristics of the shooter.

In order to limit the tearing of the target upon contact with the projectile and to accurately record the results of the shooting, the target is mounted on a stand with suitable padding.

The next step consists of firing with and without a suppressor on the target created for that purpose. The number of rounds fired in each series needs to be sufficient to determine a central point of impact (CPI), while the resulting perforations do not occupy a significant part of the target area, causing difficulties in processing the results.

After conducting the shooting, each of the experimental targets is digitalized for the purpose of using precision software measuring tools in the processing of the obtained results.

The determination of the value of the grouping of the hits is performed by generating the circle with the smallest possible diameter, accommodating all the perforations. The accuracy of the shooting is determined depending

[1] *Наставление по правила за стрелба със стрелково оръжие*. (1973). Държавно военно издателство, 12. // *Nastavlenie po pravila za strelba sas strelkovo orazhie*. (1973). Darzhavno voenno izdatelstvo, 12.

on the values of the average deviation from the dispersion axes. It is calculated with the use of following formula[2]:

$$\sigma = 0{,}67\sqrt{\frac{|c_1^2 + c_2^2 + \cdots + c_z^2|}{n-1}} \tag{2}$$

where:
0,67 – value based on the correlation between σ and Root Mean Square
σ – mean deviation in mm
c – deviation value from a given dispersion axis in mm
n – number of measured values

In processing the results, the methodology allows the exclusion of hits that do not fit within a circle with a diameter specified by the weapon platform manufacturer. For the purposes of this publication, when determining the CPI, the analytical method was adopted as the most accurate. In its application, the coordinates of each of the perforations along the abscissa and ordinate axes constructed on the target are taken. Their average values determine the location of the CPI.

The analysis of results is based on the mean of the experimental data obtained from the number of firings conducted and the number of perforations generated.

2. COLLECTION OF EMPIRICAL DATA

The choice of weapon configuration for conducting the experiment was based on the worldwide confidence in the qualities and characteristics of the Heckler & Koch MP5 submachine gun. It has a decade-long history with the specialized formations of almost all countries occupying leading positions in the area of security. The following weapon configuration was used in the present experiment:

- Heckler & Koch MP5 K submachine gun with barrel length of 115 mm and distance between the front and rear sights of 260 mm
- 208 mm SD MP5 contactless suppressor made by Brügger & Thomet
- 9x19 Luger/Parabellum Arsenal ammunition with bullet weight of 7,45 gr

Achieving the objective of the study is essentially done by applying the above-described methodology adjusted to the characteristics of the chosen weapon platform.

[2] *Наставление по стрелково дело. Основи на стрелбата със стрелково оръжие.* (1985). Военно издателство, 68. // *Nastavlenie po strelkovo delo. Osnovi na strelbata sas strelkovo orazhie.* (1985). Voenno izdatelstvo, 68.

A distance of 25 m was chosen for the placement of the experimental target. This distance corresponds to the distance used by the manufacturer when zeroing the weapon. The distance ***l*** in this particular case is equal to 400 mm. Based on these parameters, the experimental target (see Figure 1) has dimensions of 250 x 250 mm. It includes a coordinate system with two axes along the bottom edge (x) and the left edge (y) plotted in 5 mm intervals. Places for fixing the target to a stand are depicted outside its outline with a "+" sign. In the center of the target is an easily distinguishable square-shaped image, the upper half of which is solidly filled, and the lower half is framed. This image is used to aim the weapon at the target using the iron (open) aiming devices (front and rear sights). The size of the depicted square is 100 x 100 mm in accordance with the covering value of the front sight for the selected distance. It is determined using Formula 1. After substitution in the formula, the following result is obtained:

$$K = \frac{L \times p}{l} = \frac{25000 \times 1{,}6}{400} = 100\ mm$$

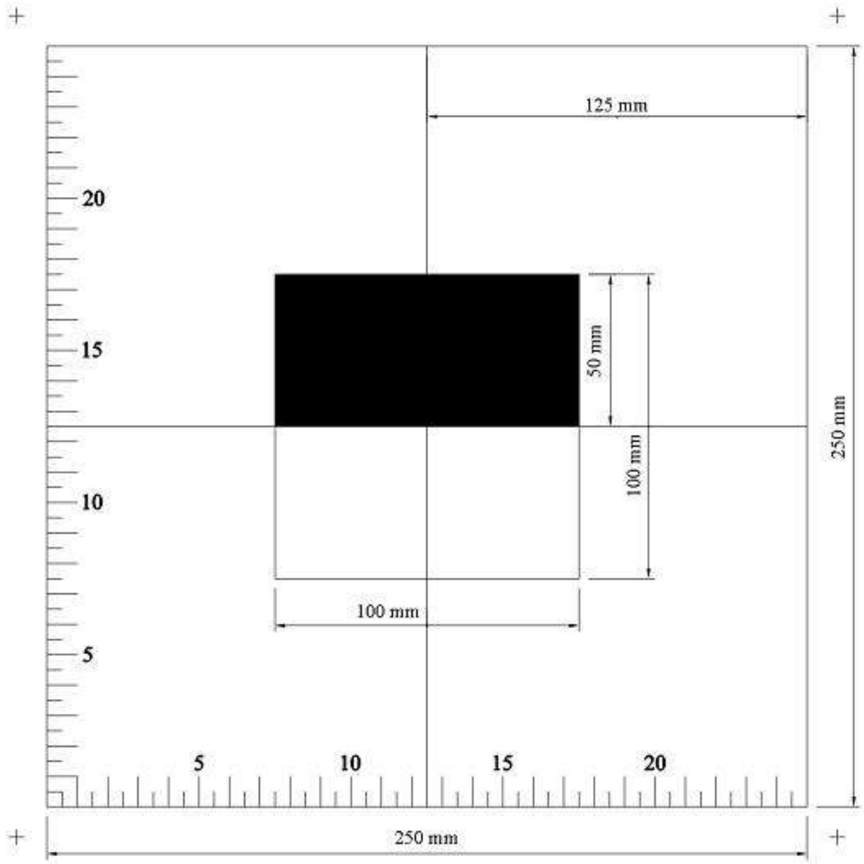

Figure 1. Experimental target.

Minimizing errors during shooting and creating approximately the same conditions for each shot is essential for the reliability and objectivity of the obtained results. This goal is achieved by conducting the shooting at a semi-closed shooting range, which minimizes the impact of the effect of the movement of air masses on the projectile.

Ensuring uniform placement of the target is achieved using screws passing through the fixing points (+) depicted on the target and the openings in the stand intended for that purpose. The target is placed at the specified distance on the stand padded with extruded polystyrene with a bulk density of 32 kg/m^3, which allows the projectile to pass through the target without hindrance while at the same time preserving its structural integrity. This results in limiting the tearing of the target upon contact with the projectile, resulting in a precise reading of the firing result.

The uniform aiming of the submachine gun at the target is assisted by the use of a single-point mount, limiting its displacement from the desired position when firing. Verification of the target's location relative to the horizon of the weapon is carried out using a laser level.

Ammunition from a single batch is used when conducting the experiment, which leads to a reduction in the differences in the ballistic indicators of the projectile.

The practical aspect of the data collection consists of ten series divided into two groups – five with and five without the contactless suppressor, each series includes five rounds fired with the weapon platform in a single-shot mode. Before firing the shots of each group, the barrel is warmed up with a single shot that is not part of the series to ensure approximately the same conditions for subsequent shots.

Before conducting the actual shooting, designed to determine the grouping and accuracy of hits, two test series are conducted. Their purpose is to check the hold of the weapon's mount, to confirm that the target is secured on the stand, and to verify that all perforations are inside the target borders. In these test series, the differences in the initial velocity of the projectiles are measured, which is accomplished using a ballistic chronograph[3].

3. PROCESSING AND ANALYSIS OF THE RESULTS

The results of the projectiles' velocity measurements taken during the two test series are shown in Table 1.

The results of the measurements show that on average the initial velocity of the projectile is higher when the shots are fired with a contactless suppressor. The higher velocity gives the projectile a flatter trajectory which should improve accuracy on short distances.

[3] Ballistic chronograph – a technical device used in shooting practice to measure the projectiles' velocity.

Table 1. Projectiles muzzle velocity

№	With contactless suppressor (m/s)	Without contactless suppressor (m/s)
1	358	363
2	339	355
3	346	329
4	359	354
5	352	342
Average	**350,8**	**348,6**

In accordance with the adopted methodology, perforations that do not fall within the determined by the weapon platform manufacturer diameter of 80 mm are not included in the raw data for the analysis.

The determination of the grouping of the hits is done by measuring the diameter (***d***) of the circle containing the perforations of every series. The value of ***d*** is determined by constructing a circumscribed circle around the centers of the two mutually most distant perforations, as shown in Figure 2.

The measurement of the circles' diameters as well as their average values by groups are shown in Table 2.

Table 2. Dimensions of the circle (d) containing all the perforations.

Series	With contactless suppressor (mm)	Without contactless suppressor (mm)
1	49	41
2	61	55
3	74	67
4	71	75
5	67	63
Average	**64,4**	**60,2**

The grouping of the hits is directly dependent on the size of the circle containing all the perforations. The lower the value of ***d***, the greater the level of grouping. The analysis of the data presented in Table 2 shows that when shooting with a contactless suppressor, the grouping worsens, and in this particular case the average difference is 4.2 mm.

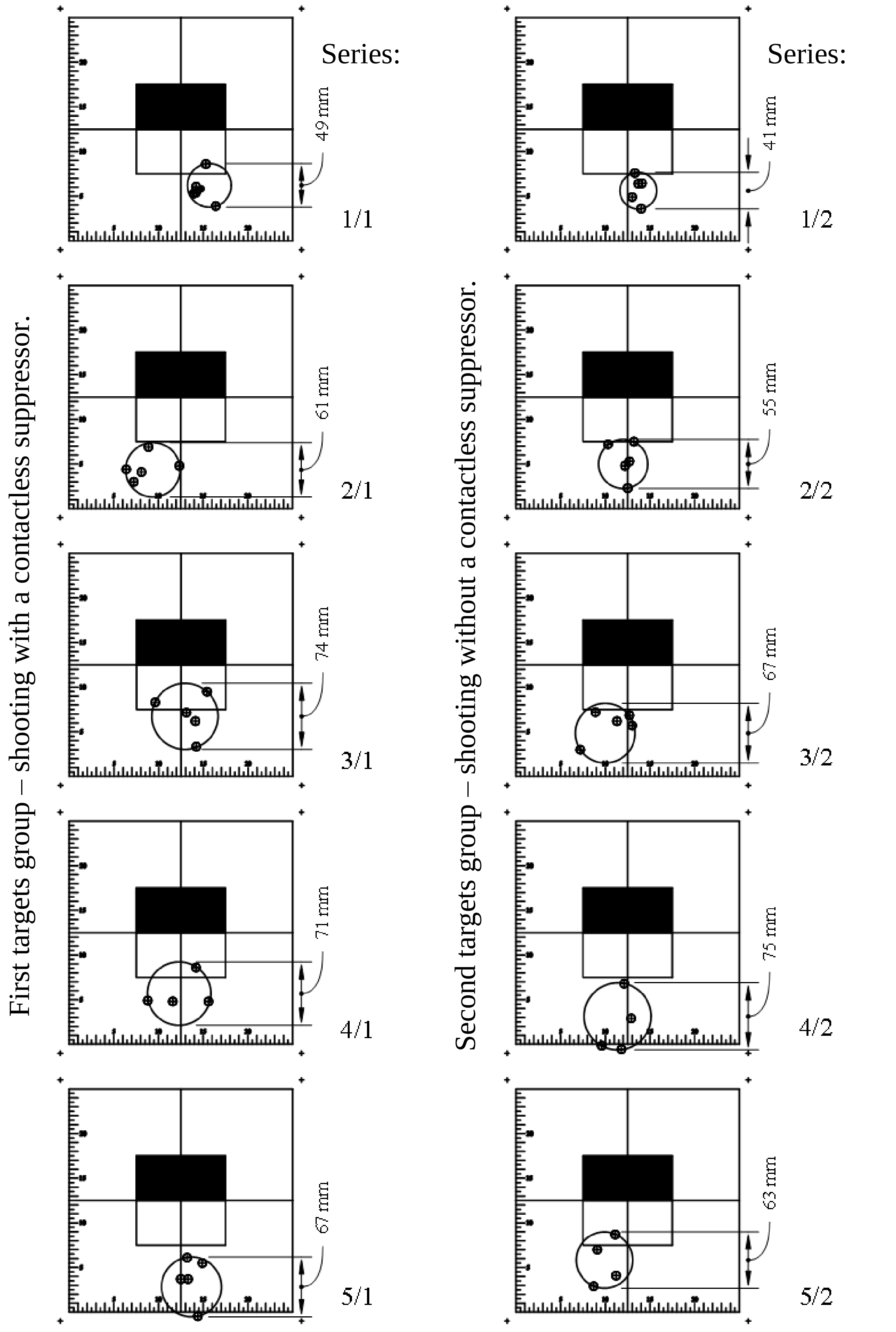

Figure 2. Dimensions of the circle (d) containing all the perforations.

The dispersion of bullets when firing with the same weapon in practically the same conditions is a natural phenomenon, which is called dispersion of the trajectories of the projectiles as they move through the air. The most reliable indicator of the scale of dispersion is the values of the average deviation (**σ**) of the perforations relative to the dispersion axes that run horizontally and vertically through the CPI. According to the applied methodology, the shooting accuracy is determined by the values of the average deviation from the dispersion axes (**σ**). The closer **σ** is to zero, the greater the shooting accuracy.

The dispersion axes generated after processing the results of all series in both groups are depicted as dashed lines in Figure 3.

The measurement of each deviation from the dispersion axes are in absolute values. In the first series of the first group, the magnitude of the average deviation relative to the X-axis (σ_{x1}) is calculated after substitution in Formula 2 with the measured values, as shown:

$$\sigma_{x1} = 0{,}67\sqrt{\frac{|c_1^2 + c_2^2 + \cdots + c_z^2|}{n-1}} = 0{,}67\sqrt{\frac{5{,}5^2 + 5^2 + 2^2 + 28^2 + 19^2}{5-1}} = 11{,}57$$

This calculation is performed the same way with the values of the measured deviation from the Y-axis (σ_{y1}). The process is repeated for all series of both groups. The summarized results are presented in Table 3 and are graphically depicted in Figure 4.

Table 3. Mean deviation values relative to the dispersion axes.

First group – shooting with a contactless suppressor.			Second group – shooting without a contactless suppressor.		
Series	$\boldsymbol{\sigma_x}$	$\boldsymbol{\sigma_y}$	**Series**	$\boldsymbol{\sigma_x}$	$\boldsymbol{\sigma_y}$
1/1	11,57	6,81	1/2	10,35	3,11
2/1	9,54	15,22	2/2	14,00	7,42
3/1	15,71	14,76	3/2	11,15	16,71
4/1	12,57	20,08	4/2	22,52	9,42
5/1	16,94	6,41	5/2	17,68	8,74
Average	**13,27**	**12,66**	**Average**	**15,14**	**9,08**

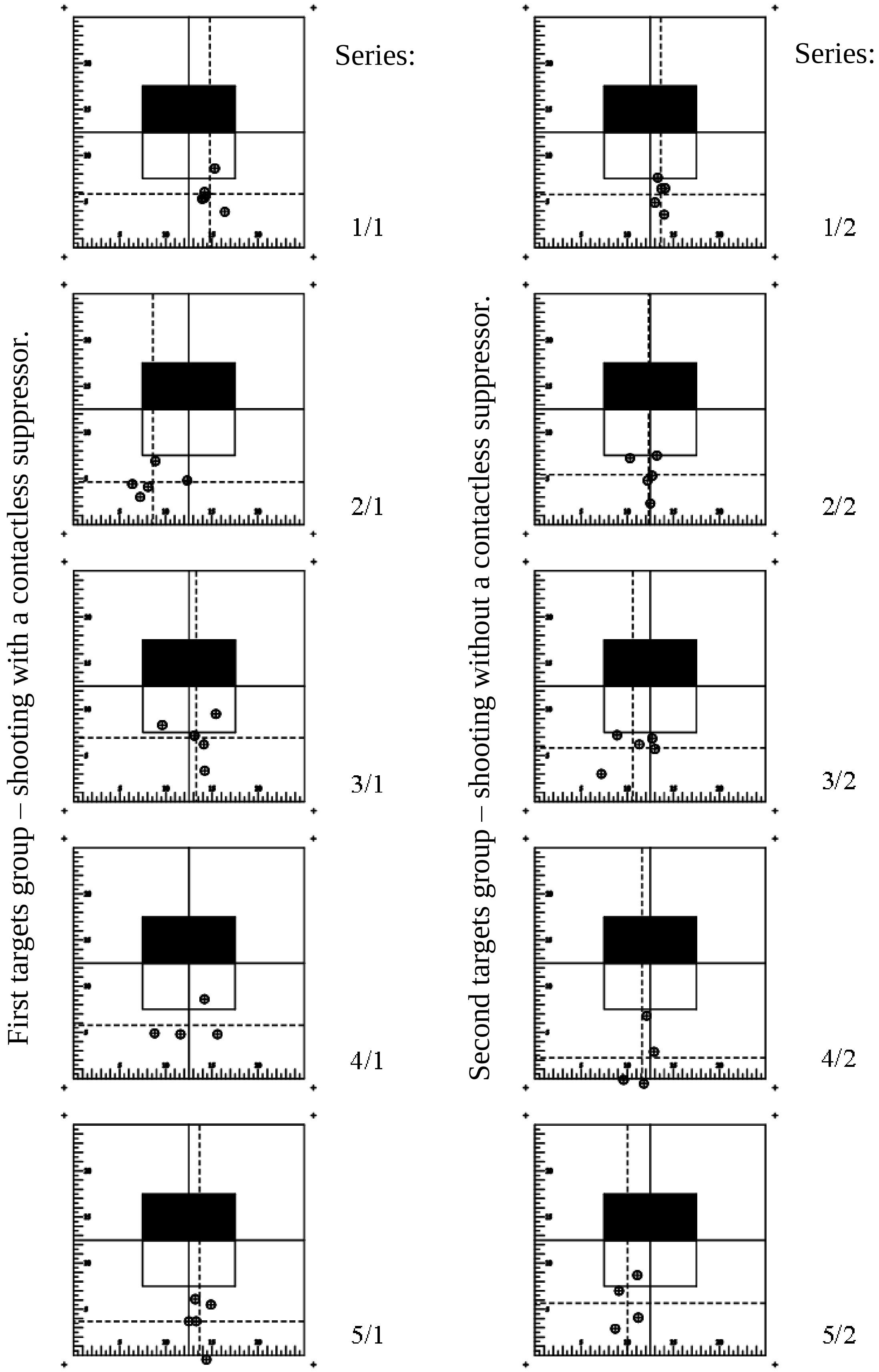

Figure 3. Axes of dispersion.

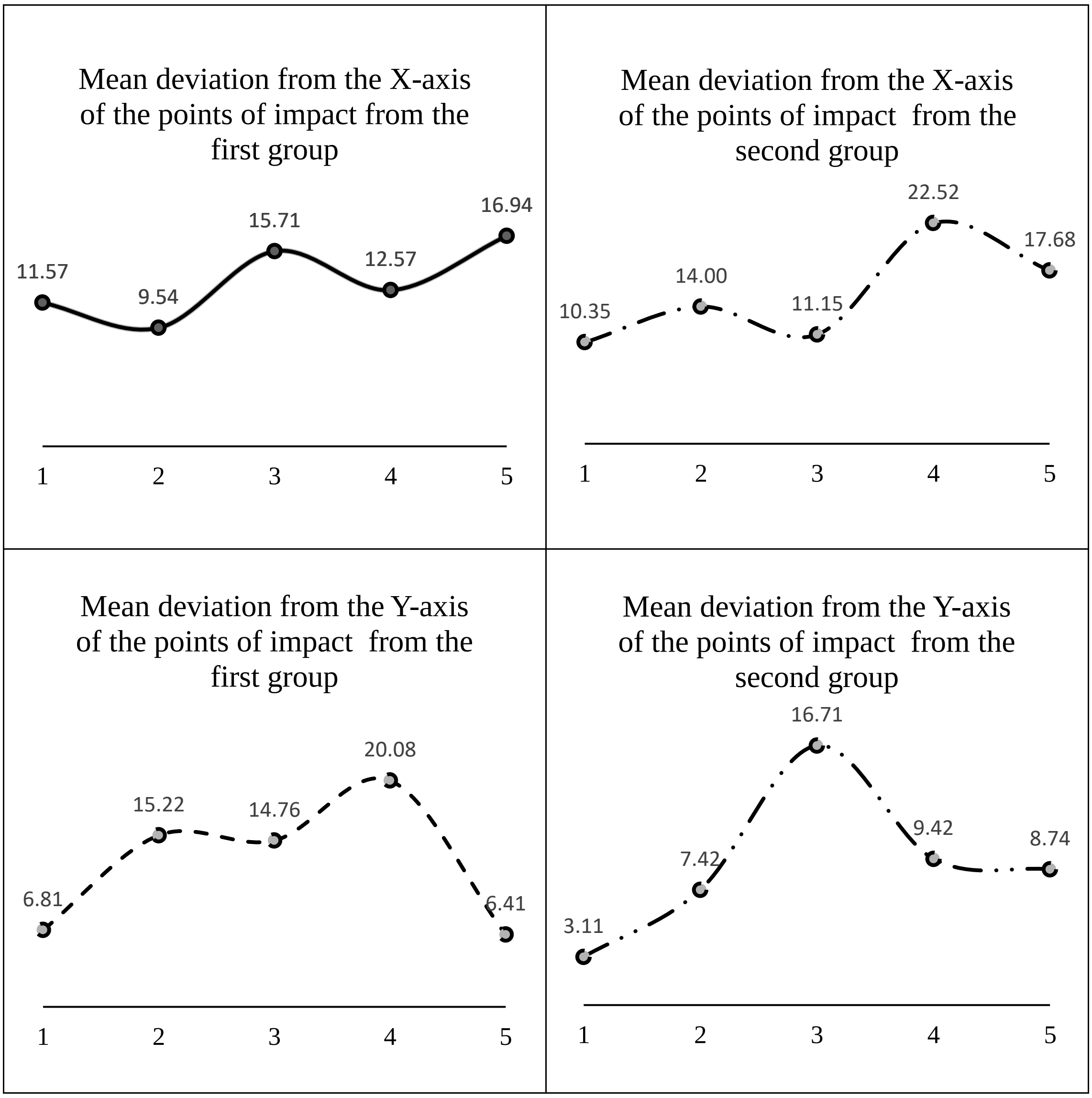

Figure 4. Variation in the mean of deviation values.

The analysis of the obtained results shows that when firing with a contactless suppressor, the value of the average group deviation along the abscissa axis is lower by 1.87 mm, and its numerical value in relation to the ordinate axis is 3.58 mm. This shows that when shooting with a contactless suppressor the accuracy on the horizontal axis deteriorates, while on the vertical axis, the opposite trend is observed.

When the average deviation of the two groups against the dispersion axes is graphically depicted, the ellipses shown in Figure 5 are generated.

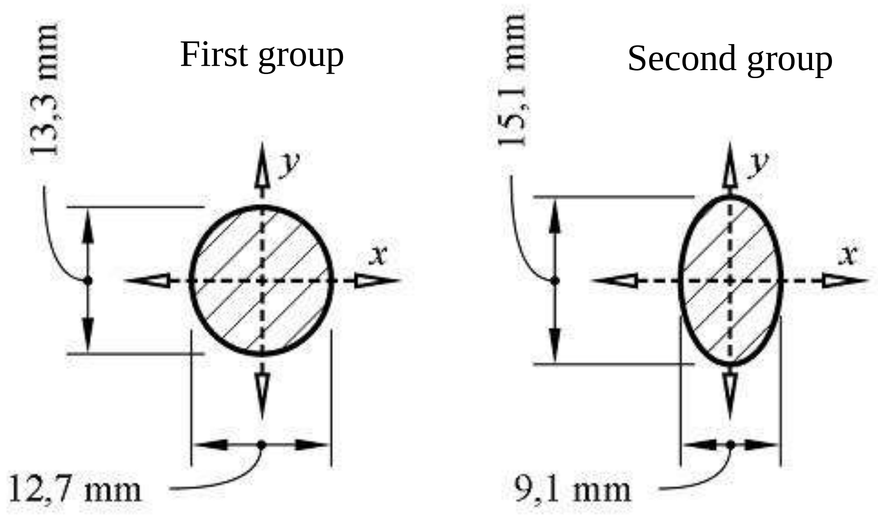

Figure 5. A graphical representation of the mean values of the deviation from the dispersion axes for the two groups.

The area of the generated ovals is used for accurate comparison between them. The area is calculated using the formula:

$$A = \pi ab \tag{3}$$

where:
A – area of the ellipse in mm^2
a – horizontal axis of the ellipse in mm
b – vertical axis of the ellipse in mm

After substitution in Formula 3 the area of the ellipse showing the average deviation when firing with a contactless suppressor (***A₁***), is calculated as shown:

$$A_1 = \pi ab = 3{,}14 \times 12{,}66 \times 13{,}24 = 527{,}2\ mm^2$$

The area of the second oval ($\boldsymbol{A_2}$) representing the average deviation of the perforations when firing without a suppressor has the following value:

$$A_2 = \pi ab = 3{,}14 \times 9{,}08 \times 15{,}14 = 431{,}7\ mm^2$$

A comparison of the obtained values shows that the accuracy of shooting with a contactless suppressor deteriorates, albeit by a minimal margin.

The analysis of the results shows a deterioration of grouping when firing with a contactless suppressor to an extent not exceeding the diameter of the projectile. The measured values of the average deviation from the dispersion axes reveal a negative influence on the results of shooting with a suppressor when using this weapon configuration.

The fact that in such experiments, with a limited amount of experimental data, the value of each individual measurement is essential to the final result, increasing the magnitude of anthropogenic factors in the experimental process should not be overlooked.

CONCLUSION

Based on the obtained results, it is clear that the use of contactless suppressors affects the accuracy and grouping of the shooting. However, taking into account the intended use and operational firing distances for the chosen weapon platform, the conclusion that in practical terms, these effects are negligibly small is reached.

The present study is limited to the use of one specific weapon configuration, which does not allow the authors to claim that the obtained results are generally valid for all shooting scenarios using contactless suppressors. However, there is enough reason to assume that other weapon configurations with comparable parameters will have a similar result in testing the accuracy and grouping of fire.

The presented research and the achieved results can serve as a basis for future research in the field, both using different platforms and at different distances. The developed methodology allows it to be applied in a number of experimental setups, which could lead to an increase in the amount of data, supplementing practical-applied knowledge in the field of shooting.

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