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**Original Article**

# Modeling of skeet shooting technique with using of simulation exercises

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**Abstract:**
The article explains the approaches to modeling technique of well-aimed shot in shotgun shooting. The aim was to develop a model technology at skeet shooting while performing simulation exercises. We used the following methods: data analysis and synthesis of library scientific and methodical resources, pedagogical observations, video analysis method and the method of numerical differentiation. We applied such computer technologies as MS Office Paint and Excel.
We have developed special hardware and software systems to create a moving picture of the target and the aiming point placed vertically on the screen, which allows training in the form of dry shooting at skeet. It has been shown that to evaluate the simulation exercises technique you should determine the distance from aiming point to the center of the target, its horizontal and vertical components, and appropriate velocity relative and absolute values.
We have given the ground to need of using of special simulation exercises in the training process at skeet.
**Key words:** shooting, skeet, simulation exercises, target, model.

**Introduction**

According to the analysis of the scientific and technical library resources, now there is a need to develop new ways to develop shooting technique to improve the outcome of the shot since technical mastery is considered to be one of the most important components for high sports results [1, 2, 10, 18, 19, 22, etc.].

The main components of technical conditioning include simulation exercises, which are used as a training method based on the performance of techniques without the use of cartridges and targets. In this connection, improving shooting technique should be implemented not only by increasing the number of shots, but using simulation exercises or "dry shooting". And this is preferably carried out with the use of technical means (special equipment).

The experts have examined the application of technical means and development of relevant models [4, 9, 11, 14, 20, 22, etc.]. It has been revealed that the trainer devices are widely used as a means of intensification and specification of motor skills improvement, differentiated development of structures and improvement of exercise performance techniques [3]. In particular, simulators for simulating firing: SCATT and Noptel have become widespread in the training process of shooting [25]. They make it possible to identify such indices of technology as arms oscillation in the final phase of the shot, the velocity of projection of arms in the aiming period, and runtime shot stability. These indices, according to many experts are crucial to the implementation of well-aimed shot [10, 21, 23, 24, etc.].

At the same time it was found that during the preparation period of the trap shooters the technical means are used insufficiently [5, 16, 17, 19, etc.]. As the analysis of scientific and methodical literature shows only at the beginning of 2000 scientists formulated the concept of shooting sports. So, V. T. Pyatkov notes that shooting sport is a sphere of human activity, the function of which is to develop knowledge and skills in marksmanship at targets in competitive conditions with rifled, smooth-bore handguns and projectile arms. The very technical and tactical actions are considered as the most important specific manifestation of training and competitive shooting sports activities as well as self-reflexive and self-control analysis [17].

It was determined that the basic technical and tactical elements in shotgun shooting at the skeet are: the shooter's preparedness, command for the target flight, the rifle lifting and handling, aiming and pressing the trigger. The last element is performed in the background of complete rifle handling [12, 13, 16 etc.].

We conducted a preliminary analysis that allows to state that today an important search for different ways to improve the training of shooters is urgent. More complex exercise conditions, due to new regulations, needs increase in training to achieve a high output (maximum number of hit targets) [6, 7].

Therefore, shooting technique improvement should be implemented not only by increasing the number of shots but using simulation exercises. According to the experts [5, 8, 16] most of the training time with


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shooters must be paid to these exercises to create temporary nerve connections that continue to determine the presence of stable conditioned reflex to external stimuli. Of particular importance it is at the initial stage of learning when you should create the correct primary shooting skills. However, with increasing skill level the importance of "blank shots" training is not reduced.

Thus, the modeling of technique of competitive Olympic exercises at the skeet using simulation exercises for training trap shooters is an actual scientific problem of shooting sports theory and practice.

**The research connection with academic programs, plans, themes.**

The work is carried out under the Scientific and Research Department (SRD) topics 2.17 "Modeling of biomechanical systems in complex coordinating sports" as a part of consolidated plan of research work in the field of sport for 2011 - 2015 (state registration number 0111 U 006473).

## Methods and materials

To achieve the objectives we used the following methods: data analysis and synthesis of scientific and methodical library resources, pedagogical observations, video analysis method and the method of numerical differentiation. Office computer technologies Paint and Excel were applied.

The study was conducting during 2013-2015 years at a sports shooting equipment of Lviv School of High Sportsmanship. The study involved qualified marksmen who specialize in shotgun shooting at the skeet.

**The aim of the study** is to develop a model of target hit technology at the skeet while performing simulation exercises.

**The tasks of the study:**

1. To analyze theoretical and methodological approaches to improving shotgun shooting technology.
2. To determine the shot performance kinematic parameters using simulation exercises at the skeet.

## Results

As it was found some scientific information on research concerning mastering the shotgun shooting technique especially using the skeet is insufficient. There were only a few studies conducted: [4, 5, 7, 12, 13 etc.].

At present the problems that arise in the shooting sports, according to the experts [11, 14], are associated with the possibility of improving the interaction of "shooter-gun-target". In addition, on the basis of certain models of "shooter-gun-target" system it is advisable to rely on the use of distributed hierarchical systems theory. That is it should be enough to build accurate models of local subsystems: shooter, arms, projectile motion and target.

The main difficulty in "shooter-gun-target" system modeling is to select the model for the first subsystem, i.e. "shooter". The experts [11] proposed a simpler option that is because the subsystem "gun-target" is an object modeling, everything that is not included in this subsystem, but interact with or affect it can be considered as the external environment. It applies to both a person and the environment which is characterized by temperature, pressure, humidity, the forces of gravity and wind power. So, today it is important to develop shot performance technology model in shotgun shooting.

It should be emphasized that the trainers widely use simulation exercises or "dry shooting" at teaching and training sessions. The exercises depend on the tasks to be performed during the training session, an athlete's technical skill level, etc. But such experiences, in varying degrees, are used by all coaches, which was confirmed by our research [7]. And it is desirable to carry out such exercises using the simulator and special devices.

According to A. Actov [1] the use of the technology can not only detect and correct errors but develop more effective technique of flying target hit. In particular, the scheme of video and computer systems in shotgun shooting indicated that the technique can be provided in all the exercises (Skeet, Trap, and Dabble Trap) both during training and competitions.

Therefore, we improved special device that allowed the modeling of the target perception conditions close to reality. In particular, the athlete during "dry shooting" training is in the state of preparedness and executes the command for release the target and sees imaginary target to hit, lifts the rifle, aims and presses the trigger.

It should be noted that mastering the technique of shooting at the skeet is due to, primarily, training the most technically complex element – rifle lifting, compared to other elements of the whole movement, namely: preparedness, executing the command for release the target, the rifle handling, aiming and pressing the trigger. The complexity of training is a close relationship and dependence of all the shooting techniques, where the division is of conditional character, and fast moving targets in space [13].

In addition, during the training simulation exercises using a special device it is important to stabilize the important process of perception target by a shooter. It is therefore necessary to determine the time from rifle lifting moment to the appearance of the target.

We give more detailed example of "dry shooting" training parameters processing. Thus, the shooter is in the state of preparedness and executes the command to release the target after that, when he sees an imaginary target to be hit, which is projected on the screen (wall) as a red light point (T) performs rifle lifting and handling, which is also fixed in the form of green light dot (G) aims and presses the trigger. The video camera is recording the picture on the screen. Fig. 1 shows the record of a shooter's simulation exercises performance on a special device. Everything was under the control executed according to the video analysis methods.

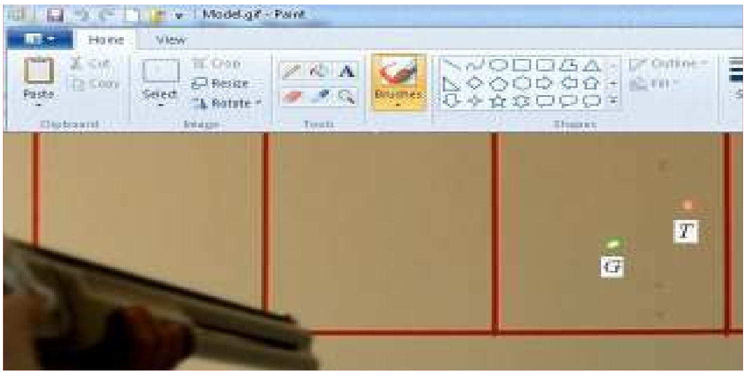


Fig. 1. Recording of video simulation exercises at the desktop of program Paint: G – aiming point (the point of intersection of the rifle axis with the plane of the target motion); T – the center of the target.

When processing the results of simulation training we took countdown method, i.e. from the moment of the shot until lifting of the arms. The corresponding times are indicated by the numbers $i$ = 0, 1, 2 and 3 (Fig. 2).

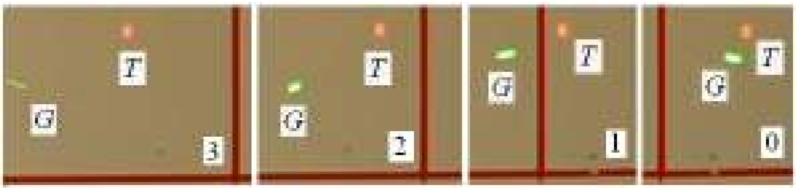


Fig. 2. Four positions of the aiming point and the target center from the rifle lifting (3) and a shot (0).

The accuracy of the point coordinates on the desktop of the program Paint is defined by picture scale (30 cm to 198 pixels): 0.15 cm / pel. Thus, the error in determining the coordinates of the aiming point center and the target is within ± 0,75 mm.

The film frequency $f$ = 25 Hz, the time interval between successive positions $\Delta t = 0.04$ sec. The coordinates of the target center and the aiming point are summarized in the Table. 1. To calculate the coordinates of the aiming point and target center the following formula is used:

$$x = \mu X \; ; \quad , \; y = \mu\left(Yo - Y\right), \qquad (1)$$

where $\mu -$ is the scale of the picture (cm / pixel); $Yo$ – is the distance between the axles $OX$ and $OX$ (for example, 1000 pixels).

Table 1. Results of kinematic analysis (position points)

| Position | Parameter | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | $X_T$ | $Y_T$ | $X_G$ | $Y_G$ | $x_T$ | $y_T$ | $x_G$ | $y_G$ |
| | pel | | | | cm | | | |
| 3 | 913 | 549 | 827 | 510 | 138.3 | 83.2 | 125.3 | 77.3 |
| 2 | 962 | 548 | 896 | 506 | 145.8 | 83.0 | 135.8 | 76.7 |
| 1 | 1011 | 547 | 967 | 529 | 153.2 | 82.9 | 146.5 | 80.2 |
| 0 | 1060 | 546 | 1047 | 526 | 160.6 | 82.7 | 158.6 | 79.7 |

It is important to analyze the trajectory of shots executed by a shooter to identify major errors while performing the rifle lifting and its handling to hit the target. This allows you to identify particular changes in the trajectory of the rifle motion that is performed by a shooter in the course of handling, which is important for the final result of shooting (the largest number of hit targets).

Fig. 3 shows the trajectory the imaginary target to be hit and the shooter's performing of rifle lifting.

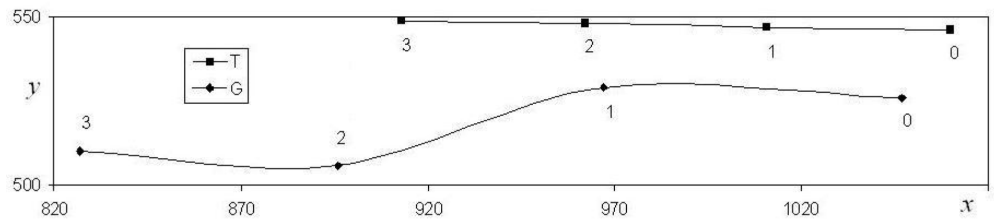


Fig. 3. The trajectories of the target center (T) and the aiming point (G) when performing a simulation exercise 0 – "shot" moment.

Apparently, after the command to release the target a shooter performs the rifle lifting and the distance from this point to the approach of imaginary target flight is 69 pel or 10.5 cm.

The kinematics analysis results, namely: the velocity of the imaginary target and the aiming point is given in the Table 2.

Table 2.The kinematics analysis results (points velocity)

| Positions | Parameters | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | $v_{Tx}$ | $v_{Ty}$ | $v_T$ | $v_{Gx}$ | $v_{Gy}$ | $v_G$ | $\alpha_T$ | $\alpha_G$ |
| | c.u. / s | | | | | | rad | |
| 3 | 615.3 | -12.6 | 615.4 | 853.9 | -219.8 | 881.7 | -0.0204 | -0.2519 |
| 2 | 615.3 | -12.6 | 615.4 | 879.0 | 119.3 | 887.1 | -0.0204 | 0.1349 |
| 1 | 615.3 | -12.6 | 615.4 | 948.1 | 125.6 | 956.4 | -0.0204 | 0.1317 |
| 0 | 615.3 | -12.6 | 615.4 | 1061.1 | -200.9 | 1080.0 | -0.0204 | -0.1871 |

In particular, the velocity of the aiming point movement at the moment of a shot was calculated using the formula:

$$v_{G0} = \sqrt{v_{Gx0}^2 + v_{Gy0}^2}\ , \qquad (2)$$

where: $v_{Gx0} = \dfrac{3x_{G0} - 4x_{G1} + x_{G2}}{2 \times \Delta t}$; $\qquad v_{Gy0} = \dfrac{3y_{G0} - 4y_{G1} + y_{G2}}{2 \times \Delta t}$;

$\Delta t = f^{-1}$ – the time interval between successive positions; $f$ – film rate.

The horizontal and vertical components of the aiming point motion velocity during the time $\Delta t$ to the moment of the shot were determined by the following formula:

$$v_{Gx1} = \frac{x_{G0} - x_{G2}}{2 \times \Delta t}; \qquad v_{Gy1} = \frac{y_{G0} - y_{G2}}{2 \times \Delta t} \qquad (3)$$

The horizontal and vertical components of the velocity of the aiming point in the i-th moment:

$$v_{Gxi} = \frac{x_{G,(i-1)} - x_{G,(i+1)}}{2 \times \Delta t}; \qquad v_{Gyi} = \frac{y_{G,(i-1)} - y_{G,(i+1)}}{2 \times \Delta t} \qquad (4)$$

The direction of movement is defined by the angle to the horizontal $(\alpha)$ of the velocity vector. The tangent of the angle was calculated by the formula:

$$tg\alpha = \frac{v_{Gy}}{v_{Gx}} \qquad (5)$$

The velocity of the aiming point motion at the time of the rifle lifting was calculated by the following formula:

$$v_{Gn} = \sqrt{v_{Gxn}^2 + v_{Gyn}^2} \qquad (6)$$

where: $v_{Txi} = \dfrac{x_{T,(i-1)} - x_{T,(i+1)}}{2 \times \Delta t}$; $\quad v_{Gyi} = \dfrac{y_{T,(i-1)} - y_{T,(i+1)}}{2 \times \Delta t}$.

The velocity of the target center motion at any time was calculated by the formula:

$$v_{Ti} = \sqrt{v_{Txi}^2 + v_{Tyi}^2}\ , \qquad (7)$$

where: $v_{Gx0} = \dfrac{x_{G0} - 4x_{G1} + 3x_{G2}}{2 \times \Delta t}$; $\qquad v_{Gy0} = \dfrac{y_{G0} - 4y_{G1} + 3y_{G2}}{2 \times \Delta t}$.

According to the program of simulation exercises imaginary target motion velocity is the same in all four positions. The absolute value is the velocity of the aiming point during performing of rifle lifting at the beginning of the motion increases slightly - from 881.7c.u. / s to 887.1 c.u. / s. At the point of approach to the imaginary target and the shot moment this value increases to 1080.0 c.u./ sec. The horizontal velocity of the aiming point motion always smoothly increases from 853.9 c.u. / s to 1061.1 c.u. / s. The vertical happens oscillating movement; velocity value of corresponding projections in four of these positions twice changes sign: -219.8; 119.3; 125.6 and -200.9 c.u. / s. That is we can observe the wave-type motion of a shooter at the runtime of the rifle handling.

The distances between the aiming point and target center, and the angle that determines their relative positions from the start of the rifle lifting performing by the shooter to the imaginary target to be hit are systematized in the Table 3.

Table 3. Distances from the aiming point to the target center

| Position | *Dx* | *Dy* | *D* | *β* |
|---|---|---|---|---|
| | | cm | | rad |
| 3 | 13.0 | 5.9 | 14.3 | 0.4258 |
| 2 | 10.0 | 6.4 | 11.9 | 0.5667 |
| 1 | 6.7 | 2.7 | 7.2 | 0.3883 |
| 0 | 2.0 | 3.0 | 3.6 | 0.9944 |

In particular, the distance from the aiming point to the center of the target is calculated using the formula:

$$D = \sqrt{D_x^2 + D_y^2}\,, \qquad (8)$$

where: $D_x = x_T - x_G$, $D_y = y_T - y_G$ − the distances from the aiming point to the center of the target horizontally and vertically.

The slope angle of a straight line passing through the aiming point and the target center was defined by the formula:

$$\beta = arctg\frac{D_y}{D_x}\,, \qquad (9)$$

It was revealed that the total distance during the imaginary shot from the moment of the command to release a target to the performance of rifle lifting to hit the target decreases and is of 14.3; 11.9; 7.2 and 3.6 cm respectively. At the beginning of the movement of the arms the distance to the next video frame position is 2.4 cm; further a shooter slows the movement of the arms and the distance between the video frame positions reaches 4.7 cm and at the distance of 3.6 cm there is a smooth approaching to the center of the target to perform its destruction.

**Discussion**

Considering the fact that the experts regard a motor action as a system which is composed of a set of elements that are interconnected and ensure the implementation of relevant tasks for learning rational technique of motor actions it is expedient to create such conditions that will ensure their relationship. [15]

Today, in sports training, they widely use various simulating devices to improve technology characteristics of sports exercises performance. However, as it was found during the training of the trap shooters there is lack of using of special devices, simulators.

However, it should be noted that the implementation of simulation exercises on a special device helps to model real shooting in which there is no recoil. It is advisable to use widely for beginners to master the technique of shooting, when there is a terror of recoil while performing a shot. Also, there is need for the formation in a shooter of the same reaction on a target, which foresees the keeping to the certain time range after giving commands for the release of a target and performing of the rifle lifting and handling, and well-done hit of the target.

In addition, the performances of simulation exercises will increase the number of shots in the simplified conditions and significantly reduce the proportion of use of rifle ammunition. That is, it is advisable to increase the experience volume through the "dry shooting" training using a special device that will generate a sound shooting technique.

**Conclusions**

1. The use of special hardware and software system to create a moving picture of the target and the aiming point on a vertically placed screen allows training in the form of simulation exercises of shooting at the skeet. This system also allows accelerated and slowed simulation exercises execution regimes to improve the technique of a shot.

2. To determine the kinematic parameters of simulation exercises technique it is recommended to use a comprehensive methodology developed on the basis of the theoretical mechanics methods and MS office computer technologies (Excel, Paint) to coordinate digitization points. The error at the determining the coordinates of the aiming point and target center was within ± 0,75 mm.

3. To evaluate the technique of simulation exercises performance you should determine the distance from the aiming point to the target center, its horizontal and vertical components, and appropriate relative and absolute values of velocity.

**Aknowlegements**

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