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EGR 342

Take Your Best Shot

Intro:

In the field of marksmanship, an inch can make a difference between success and failure. Many factors can influence a shooter, but position is one of the most important. With so many positions to choose from, which is the best? This project investigated seven different shooting positions, to determine which had the most accuracy and precision.

Method:

The project addressed a range of shooting positions. The best-case scenario position was the rifle supported on a table with the shooter kneeling beside it. The other positions analyzed were standing freehanded, standing with the sling around the left elbow to create tension, kneeling, sitting in an open-leg position, prone, and kneeling with a bipod.

a) Kneeling b) Sitting

Figure 1 – Example Shooting Positions

This project used a Ruger 10/22 .22 Caliber rifle with Remington "Thunderbolt" ammunition, both readily available. The target was placed at approximately 30 yards from the shooter's position, and 15 shots were fired for each position to allow enough shots for statistical analysis. The shots on the target were then transferred to graph paper for measurement. The position of each shot was measured with a caliper in x and y coordinates.

Analysis Method:

Accuracy

Accuracy is the distance of each shot from the center of the target. To analyze accuracy, the average shot location of each position and its distance from the center was measured. A radial standard deviation was calculated by combining the standard deviations of the x and y coordinates. Using this data and a Student t-test, it was possible to determine if there was an actual difference in the

average location and thus accuracy for each shooting position. Figure 2a shows a spread pattern obtained using the freehand position and would be considered accurate as the average location of all shots is close to the bulls-eye.

Precision

Precision is the distance of each shot from the mean location. Essentially this was to measure how tight of a grouping each position had. For this the radial deviation of each point from its mean location was calculated. These were then compared using Student's t-test to determine if there were measurable differences between different positions. The spread pattern in Figure 2b was obtained in the supported position and would be considered both accurate and precise as the average shot location is close the bulls-eye and no shot deviates a great deal from this location.

a) Accurate b) Both Accurate and Precise

Figure 2 - Sample Spread Patterns

Results:

Accuracy

Below is a table that compares the different positions based on accuracy. To construct this table, a Student t-test was performed between the two positions corresponding to each cell using a 90% confidence level. This test shows if there is a difference in their mean locations beyond statistical noise. If confident that a true difference existed, the mean locations could then be used to determine which was more accurate. The "winner" in each comparison is listed in the box. An orange box means a win that is between 80% and 90% confidence. A bar means the test was inconclusive.

Head-to-head Accuracy Comparisons

	Supported	Freehand	Elbow	Sitting	Kneeling	Prone	Bipod
Supported							
Freehand	-						
Elbow	-	-					
Sitting	-	Sitting	-				
Kneeling	-	-	-	-			
Prone	Supported	Freehand	Elbow	Sitting	Kneeling		
Bipod	Supported	Freehand	Elbow	Sitting	Kneeling	Bipod	

* Orange signifies 80-90% confidence level

Precision

Results for precision were obtained in manner similar to that for accuracy. The table below compares these using t-tests to determine whether a true statistical difference exists between the average deviation from the mean location for each position. If a difference was found, the method with the lower average deviation was chosen as the winner.

Head-to-head Precision Comparisons

	Supported	Freehand	Elbow	Sitting	Kneeling	Prone	Bipod
Supported							
Freehand	Supported						
Elbow	Supported	-					
Sitting	Supported	Sitting	Sitting				
Kneeling	Supported	Kneeling	Kneeling	Sitting			
Prone	Supported	Prone	Prone	-	Prone		
Bipod	Supported	Bipod	Bipod	Bipod	Bipod	-	

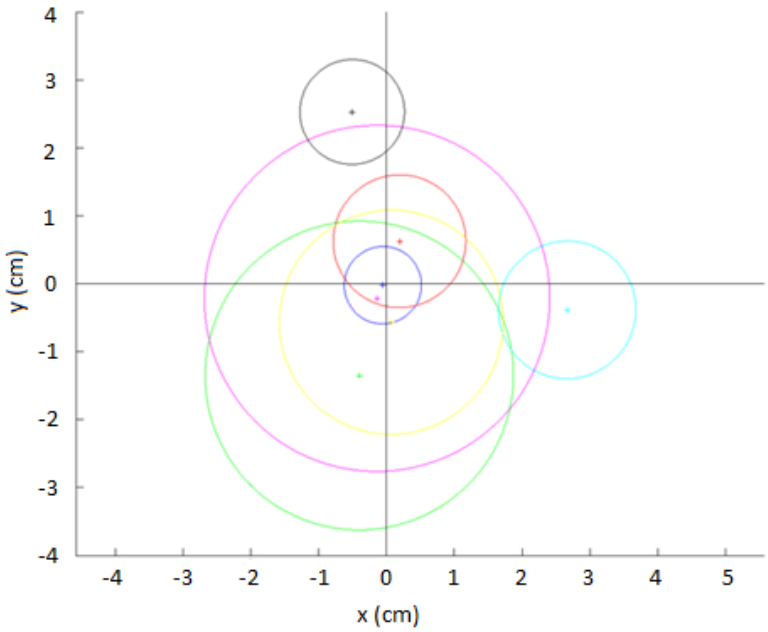
* Orange signifies 80-90% confidence level
* Red signifies 70-80% confidence level

Results for Each Position

	Mean Location (cm)		Average Deviation (cm)
	x	y	
Supported	-0.053	-0.022	1.136
Freehand	-0.401	-1.351	2.527
Elbow	-0.139	-0.216	4.703
Sitting	0.193	0.625	1.980
Kneeling	0.071	-0.567	3.476
Prone	2.665	-0.385	1.908
Bipod	-0.505	2.528	1.513

Below is a graph of the mean location of each position with a circle created by the standard deviation from the mean. The circles represent the 90% confidence interval of each position's mean location. Because the size of this confidence interval depends on how precise the shots were, this illustrates visually the differences in precision for each of the different positions. In other words, a larger circle is indicative of lower precision. As this graph shows, there are noticeable differences in precision in the different positions.

Data Map



Blue – Supported
Green – Freehand
Purple – Elbow
Red – Sitting
Yellow – Kneeling
Light Blue – Prone
Black – Bipod

Discussion

In order to determine relative rankings between positions, it was deemed that precision should be a more important factor than accuracy, as it can be compensated for if the deviation from the target is known. Consistency is preferred over random shots scattered around the target. Taking this into account, supported, bipod, and prone would be the methods of choice even though the accuracy analysis might suggest differently, particularly for the prone and kneeling with bipod positions.

Sources of Error

Over the course of the experiment, we encountered multiple sources of error. Two of these were unstable winds and slight differences in the geometry of each bullet. For our analysis, we considered these effects to be small enough to be neglected. Also, after the shots were fired in a position being tested, we decided to transfer the location of the shots from the target to graph paper to increase the accuracy of the measurements. While it did increase the accuracy of the measurements it also brought uncertainty to the location of the bullet holes. While the accuracy of the measurements was increased, human error was still present because we had to manually measure the bullet locations with a caliper. Based on the diameter of the bullet, we determined an approximate uncertainty for this process and concluded that it had little effect on our overall results.

Conclusion

The best case scenario for a shooter is to have the gun supported, and to remove the human influence from the shot as much as possible. From a statistical perspective, being prone, using a bipod, and sitting down were all effective and should be implemented if possible-prone being the best option. We also found that there is no statistical improvement in accuracy and precision for a shooter who shoots freehand or uses the elbow strap. We also took into consideration that a given shooter will perform better in a more comfortable position. For our experiment, the shooter preferred supported, prone, and kneeling with the bipod.