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Effectiveness of the Engagement Skills Trainer 2000

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Author Note: CDT Rachael Schloo is a senior at the United States Military Academy (USMA) pursuing a Bachelor of Science degree in Systems Engineering with Honors distinction. Upon graduating on May 23, 2020, Rachael will commission as a 2LT in the United States Army as a Military Intelligence Officer. Dr. Vikram Mittal is an Assistant Professor in USMA's Department of Systems Engineering. *This paper was selected as a "Top 10" paper for the proceedings.*

Abstract: The purpose of this article and study is to analyze the effectiveness of the Engagement Skills Trainer 2000 (EST2000), which is the program of record for Army marksmanship training. The EST2000 has only been used for training with the actual marksmanship qualification being done on live ranges. However, the newest version of the rifle qualification course will include a component of shooting on the EST2000. Thus, this study is designed to evaluate the effectiveness of the EST2000 in capturing real-world performance. USMA cadets were recruited to complete the Basic Rifle Marksmanship (BRM) course on the EST2000, and these results were compared to the shooter's performance on a live BRM course. A paired t-test was conducted to determine whether the EST2000 scores and the BRM scores were statistically different, and an R^2 value was calculated to determine the relationship between the soldier's performance on the EST2000 and real-world performance.

Keywords: EST2000, BRM, Marksmanship, Training

1. Introduction

Every soldier in the United States Army is expected to be proficient in rifle marksmanship. As such, a significant amount of time goes into training soldiers to ensure that they can accurately and quickly shoot a target over a range of distances. Historically, much of this training has been done on actual ranges with live weapons and ammunition. However, in 2000, the Army began incorporating the Engagement Skills Trainer 2000 (EST2000) into rifle training. The EST2000 is a simulated rifle range that allows soldiers to train on marksmanship without requiring a range, a weapon, or ammunition.

U.S. Army Field Manual (FM) 3-22.9 describes the EST2000 as a training aid that supports rifle marksmanship training, especially for initial entry soldiers. As the EST2000 system has evolved, its usage has significantly increased with many units now relying on the EST2000 to provide tactical collective training, although its primary objective has remained for preliminary marksmanship instruction and weapon familiarization. Meanwhile, soldiers must also annually pass the Basic Rifle Marksmanship (BRM) course to qualify with their weapons on an actual range with actual rounds. However, the newest version of the rifle qualification course will include a component of shooting on the EST2000 prior to shooting on a live range.

If the EST2000 is to be expected to play a major role in the future of weapon qualification, soldier performance on the EST2000 should align with real-world performance. This paper sets out to explore this relationship by comparing soldiers shooting performance on a simulated BRM course on the EST2000 with their real-world performance. Specifically, this paper describes the experimental methodology, the data collection, and the data analysis for this study.

2. Background Information

2.1. Basic Rifle Marksmanship

Soldiers undergo significant training to ensure that they can accurately shoot the enemy. Though the U.S. Army includes a large array of different weaponry, most soldiers use an M4 or M16 assault rifle, which can engage enemies at a range up to 500 meters. Soldiers must pass the BRM course annually with their M4 or M16 to qualify to use their weapon and remain

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in good standing in the Army. Failing the qualification course results in soldiers needing additional training, while also making them ineligible for promotions and other incentives. Repeated failures can result in the soldier being separated from the Army.

The course consists of two stages. The first stage involves zeroing the weapon. Soldiers fire six rounds at a paper target that is located 25 meters away. They must achieve a shot group within a circle that is 4 cm in diameter (Department of the Army, 2008). The zero of the weapon is adjusted to align the center of the soldier's shot group with the center of the weapon. The soldier then fires another three rounds to confirm that the weapon has been appropriately adjusted.

The second stage is the downrange feedback, which involves the actual testing of the shooter. A soldier assumes a prone, supported firing position where the soldier lays on the ground and rests the barrel of the rifle on sandbags or blocks. The soldier then shoots at 20 human-sized targets that pop-up sequentially at varying ranges between 50 m and 300 m. The soldier must then remove the sandbags or blocks and fire from a prone, unsupported position while fully bearing the weight of the weapon. In this phase, the soldier engages 10 targets that pop-up sequentially at ranges between 150 m and 300 m. The soldier then assumes a kneeling position and engages a final 10 targets that pop-up sequentially at ranges between 50 m and 150 m. Altogether, the soldier will have forty rounds to shoot at the forty targets. For the soldier to pass the course, they must hit 23 of the targets. Soldiers achieve the designation of marksman if they hit between 23 and 29 targets, sharpshooter if they hit between 30 and 35 targets, or expert if they hit 36 or more targets.

This course has undergone variations over the years with the prone, supported position replacing a foxhole firing position in 2008 (Department of the Army, 2003; Department of the Army, 2008). However, it still has numerous issues, most significantly that it does not represent firing in actual combat situations. An article from the Belfast Telegraph by Buncombe found that U.S. forces fired approximately 250,000 rounds for every insurgent killed in Iraq and Afghanistan (Buncombe, 2011). Despite this problem being known for years, the BRM course remains the primary metric for evaluating whether a soldier is qualified with their weapon.

Another key issue is the resources involved in the BRM course. The course requires a minimum of 9 rounds for zeroing a weapon and 40 rounds for completing the qualification course. Many National Guard and Reserve units are allocated only 100 rounds of ammunition per soldier per year. Since units want to ensure that they have enough ammunition to allow each soldier rounds to attempt the qualification course twice, they have few rounds for other collective training.

2.2. Engagement Skills Trainer 2000

Figure 1. EST2000 Range vs. Actual Rifle Range (Geribay, 2014 & Ashley, 2014)

The EST2000 is a simulator developed by Meggitt Defense Systems that provides marksmanship training and trains soldiers on many aspects of weapon training from calibrating weapons, to weapons qualification, to collective fire scenarios. The EST2000 consists of a video screen and simulated weapons to include the M4, M16, and most other small arms used by the U.S. Army as shown in Figure 1. The rifles have a pneumatic line running to them to provide a recoil effect. Additionally, the rifles have a barrel mounted laser that provides the point of aim for the rifle. Based on where the weapon is aimed when the trigger is squeezed, the system can determine where the round would hit and modifies the video on the screen accordingly.

When the EST2000 was first introduced to units in 1994, soldiers did not feel that the system was realistic. Many soldiers complained that the system did not replicate the actual feel of a weapon. Leaders also complained that the EST2000

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felt too much like a video game and not training. In order to increase its acceptance, the system underwent numerous upgrades to include more realistic recoils, better video displays, and more weapons. The current version of the EST2000 integrates with Virtual Battlespace 3.0, the primary games-for-training software used throughout the Army. It also includes every major small-arm, crew-served, and shoulder-launched weapon in the U.S. weapon arsenal. Though many soldiers still feel that the EST2000 does not fully replicate the shooting experience, units have come to rely very heavily on the EST2000 for shooting practice and training. The EST2000 is currently available on every major military installation.

Since the introduction of the EST2000, studies have been conducted to evaluate how well the EST2000 aligns with actual shooting performance. Studies by Hagman and the TRADOC Analysis Center compared real BRM scores to those with the early versions of the EST2000 using M16 assault rifles (Hagman, 2007; TRADOC Analysis Center, 1994). Both studies concluded that performance on the EST2000 can predict performance on a real range qualification course with M16 assault rifles. Note that these studies used earlier versions of the EST2000, a different variant of the BRM course, and M16 assault rifles.

2.3. New Rifle Qualification Course

The Army is currently adopting a new qualification course to address the issues with the existing BRM course. The new course is intended to be more representative of actual combat scenarios, where a soldier must engage multiple targets from different positions. Similar to the standard course, the soldier will initially group and zero their weapon. The qualification course then begins with the soldier in a standing position to replicate a react-to-contact scenario. The soldier then transitions to a prone, supported position to continue engaging the target. The soldier then goes to an unsupported, prone position, followed by the kneeling, supported position. Finally, the soldier returns to a standing position where they will be behind a barricade that can provide support to the weapon.

Though this new qualification course is expected to better replicate combat scenarios, it has several issues. The first issue is safety. Soldiers will be moving and changing positions more during the new course than the old course, increasing the likelihood for a negligent discharge. The second issue is resources. It is expected that with a harder course, there will be a higher number of failures, which in turn increases the amount of ammunition required to support retesting.

The Army is addressing these issues by utilizing the EST2000. Prior to the soldier being allowed on the range, they must complete and pass a course on the EST2000 that replicates the qualification course. In doing so, they can ensure that soldiers have the necessary degree of proficiency to avoid a negligent discharge and to qualify on the first try. However, it is unclear as to whether the EST2000 would adequately predict shooting performance on the BRM course.

3. Experimental Setup

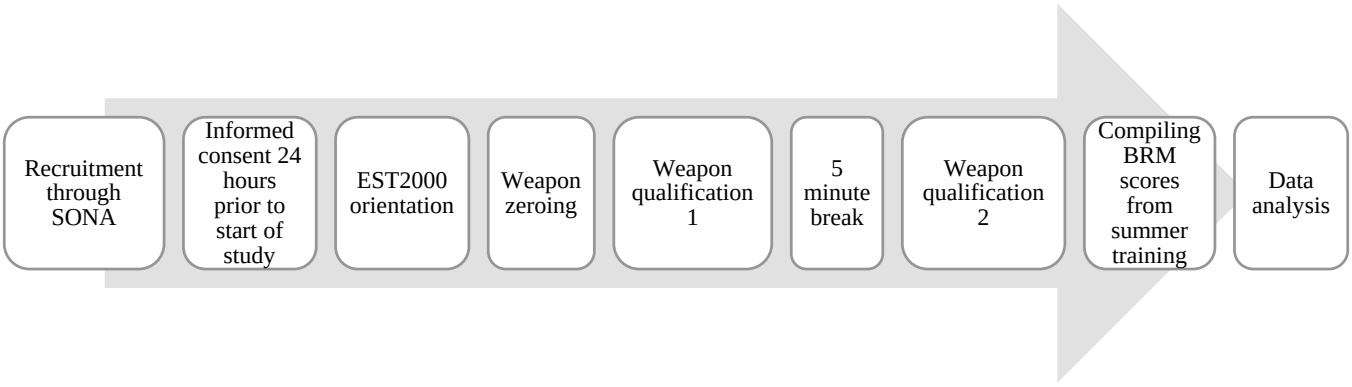

Figure 2. Data Collection Process

This study evaluates how well the EST2000 replicates shooting in an actual qualification course by comparing actual BRM scores to those achieved by soldiers on an EST2000 range. A very strong correlation would indicate that the EST2000 could potentially serve as a replacement for the actual BRM course, resulting in saving money and resources. No correlation

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would indicate that the EST2000 in its current form is not a good indicator for performance on the range; as such, the Army should reconsider the role that the EST2000 will play in the new rifle qualification course. Specifically, if there is a poor correlation, the Army needs to investigate the required upgrades to the EST2000 to allow the system to be more accurate.

The study was conducted in accordance with Institutional Review Board (IRB) CA20-002 submitted through the Human Protections Office at the United States Military Academy (USMA). The IRB outlined the experiment's objectives, benefits, risks, research plan, target population, recruitment procedures, and privacy measures. The IRB board reviewed the research protocol and assessed an overall low risk to the test participants. The process for data collection is shown in Figure 2.

Cadets from USMA were recruited for participation in the study through a student research participation program, SONA. SONA allows the specification for stipulations on participation. For this study, the stipulation was that potential participants have qualified with a rifle during summer training in 2019. SONA-recruited cadets enrolled in certain courses were able to participate in research to earn extra credit in that course. The cadets were allotted five extra credit points for participating in this study. The IRB allowed for up to fifty cadets to be recruited through SONA.

Test subjects would arrive in groups to the West Point Simulation Center, which houses an EST2000. The test subjects were given a quick overview lesson on the EST2000 and the experiment. They proceeded to zero their weapons; the EST2000 automatically adjusted the weapon based on groupings of three rounds. Once the cadets in the iteration were comfortable with zeroing their weapon, they proceeded to the qualification course. A weapon status check was conducted prior to the start of the prone supported, prone unsupported, and kneeling phases to ensure a round was chambered and the weapon was ready to fire. Commands were given to the cadets on the firing line like those given during actual range activities. After completing the qualification course, the subjects were given a five-minute rest period before they completed the qualification course again.

Shooting scores were recorded after each phase, and the best overall qualification score was used for analysis. Additionally, each test subject's name, class year, and gender were recorded to attain their BRM scores from summer training. After adding each test subject's BRM score from summer training, the names were removed from the data collection sheet to ensure anonymity in accordance with the IRB.

4. Data Collection

The experiment was conducted on January 29, 2020 at the EST2000 range in the West Point Simulation Center, with the informed consent being done the day prior. Since the EST2000 can accommodate 10 firing lanes, there were five iterations each lasting 45 minutes. Eight of the lanes contained M4s and two contained M16s due to a lack of available M4s. Since many of the iterations did not have the full ten firers, priority was given to the lanes with the M4s.

Though the IRB allowed for fifty test subjects, only thirty-six slots were filled. Additionally, three test subjects signed up for slots but did not arrive to take part in the experiment. One test subject's score was also removed due to his self-admittance that he intentionally shot poorly "to create an outlier." As such, data was collected on only thirty-two cadets. An analysis of BRM scores across Army units found that the mean score was 28 with a standard deviation of 6 (Byers et al., 2018). The thirty-two test subjects had an average real-world BRM score of 27 with a standard deviation of 4.1. As such, the sample size was still large enough to reflect the distribution of real units.

The demographic breakdowns for the test subjects are shown in Figure 3. Figure 3 shows that the cadets were primarily from the freshman class with the study being comprised of twenty freshman, one sophomore, seven juniors, and four seniors. Figure 3 also shows that the cadets were primarily male with the study being compromised of twenty-three males and eight females, which is 26%. In the Army Officer Corps, the percentage of females is 18%, which is lower than the pool of applicants for this study (Reynolds et al., 2018). Lastly, Figure 3 shows that the cadets were primarily marksman, shooting between 23 and 29 targets during summer training. Specifically, the study was comprised of twenty-six marksman, three sharpshooters, and two experts. As stated earlier, the sample size was still large enough to reflect the distribution of real units regarding BRM scores.

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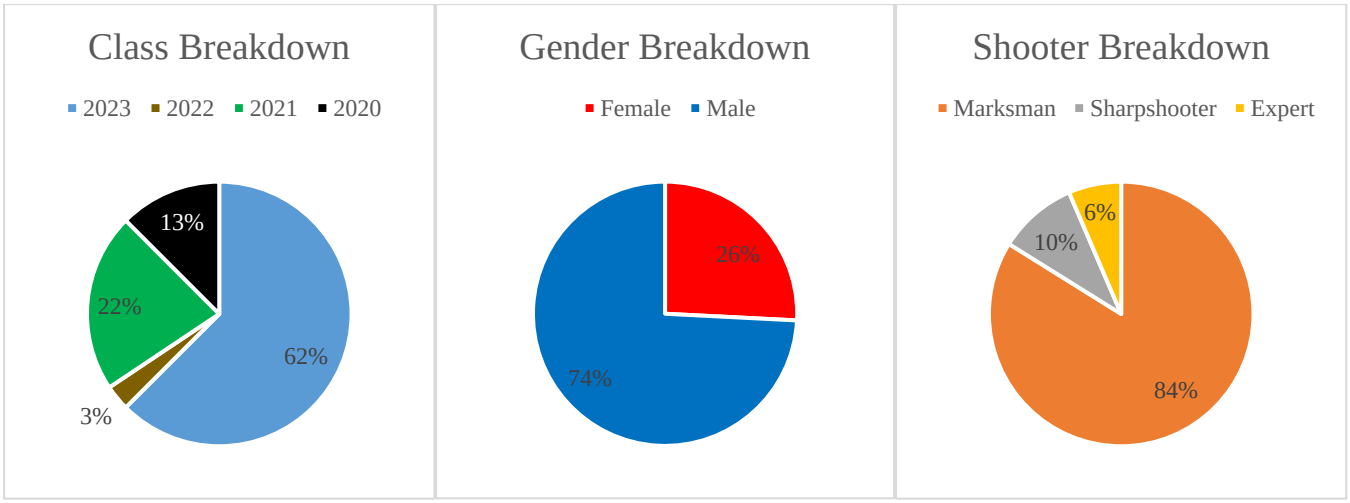

Figure 3. Test Subject Breakdown

5. Data Analysis

5.1. Data Analysis

The EST2000 scores and BRM scores were analyzed using a paired t-test to determine if the shooters' EST2000 scores were statistically different from their BRM scores. The null hypothesis is that there is no statistical difference between the means of the paired EST2000 scores and BRM scores. R Studio was utilized to calculate the p-value, which was 0.3431. The p-value is not less than the alpha, which is 0.05 for a confidence of 95%. Thus, the null hypothesis fails to be rejected, meaning there are no statistical differences between the means of the paired EST2000 scores and BRM scores. A scatterplot is displayed in Figure 4 showing the differences between EST2000 scores and BRM scores for each of the thirty-two cadets. In Figure 4, cadets 1-27 shot marksman, cadets 28-30 shot sharpshooter, and cadets 31-32 shot expert on a live BRM range. Seventeen cadets shot better on the EST2000 range, while thirteen cadets shot better on a live range. Two cadets achieved the same score on the EST2000 range and a live range. The largest difference between the EST2000 scores and BRM scores was eleven, and the cadet scored higher on the EST2000 range.

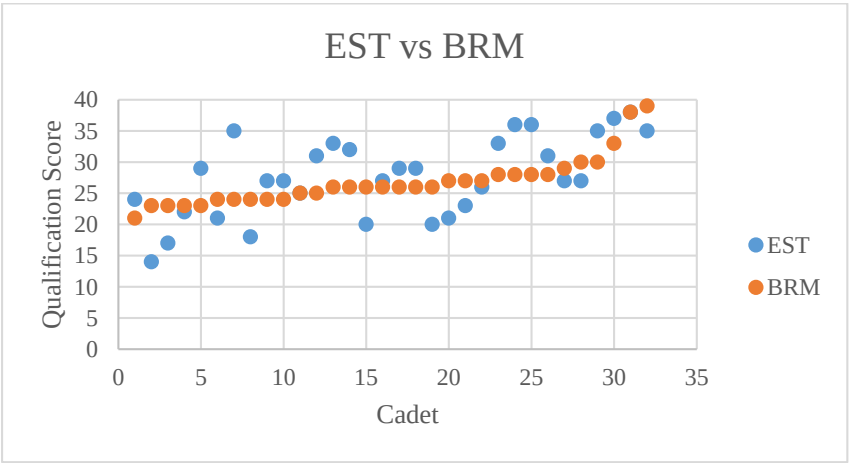

Figure 4. EST200 Scores vs BRM Scores

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```
Call:
lm(formula = BRM.Score ~ EST.Score, data = df)

Residuals:
    Min      1Q  Median      3Q     Max
-5.4928 -1.9928 -0.4312  1.9649  9.5072

Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept) 16.56960    2.55719   6.480 3.68e-07 ***
EST.Score    0.36923    0.09014   4.096 0.000293 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 3.221 on 30 degrees of freedom
Multiple R-squared:  0.3587,    Adjusted R-squared:  0.3373
F-statistic: 16.78 on 1 and 30 DF,  p-value: 0.000293
```

Figure 5. Linear Regression Model

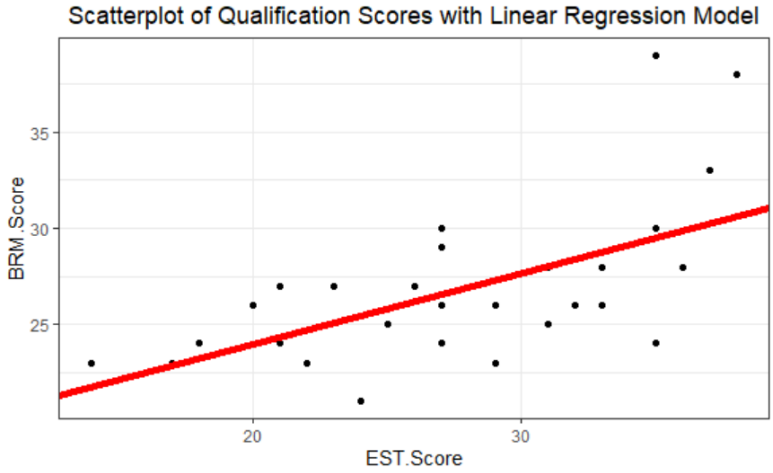

Figure 6. Scatterplot with Linear Regression Model

The study then set out to determine if a linear regression model would be appropriate for this data set. The dependent variable is BRM score, and the independent variable is EST2000 score. When solving for the linear regression model, the p-values of the coefficient and y-intercept were both less than 0.05, alpha, as shown in Figure 5. Thus, the null hypothesis that the coefficient and y-intercept are equal to zero is rejected, meaning the linear regression is significant. A scatterplot is shown in Figure 6 above with the linear regression model. Although the linear regression model appears to fit the data well, the adjusted R^2 value is 0.3373, as shown in Figure 5. This means that 33.73% of variation can be explained by the model and suggests that the model is insufficient.

Four assumptions of the residuals are made to test the validity of linear regression models: independence, normality, homoscedasticity, and linearity. Independence was achieved because data collection was random on a volunteer basis. The data appeared normal in the residual plot with a large majority of the residuals of all the factors being within two standard deviations of the mean. The residual plot appeared to display homoscedasticity with generally consistent variance. Most of the factors' residuals followed a linear trend. However, the EST2000 score residual plot showed a slightly parabolic trendline as shown in the left plot in Figure 7 below. To achieve the linearity assumption, a poly transformation was used, which made the EST2000 score residual plot linear as shown in the right plot in Figure 7 below. After transforming the EST2000 score and confirming all four of the assumptions, the modified model was analyzed and is displayed below in Figure 8. To include a significant coefficient for the independent variable, the alpha was increased to 0.10. The adjusted R^2 value for the modified model is 0.395. This means that 39.5% of variation can be explained by the model and suggests that the modified model is insufficient, and after analyzing the scatterplot with the overlaid modified model, it was clear that the model did not fit the data well.

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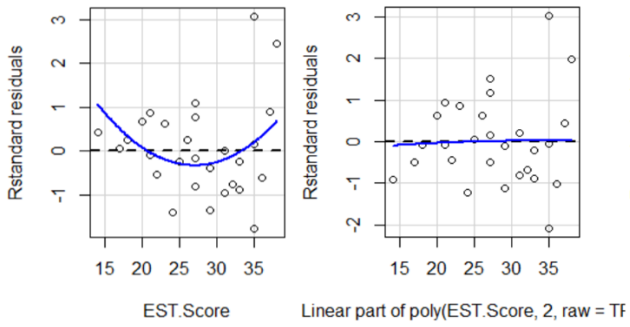

Figure 7. Residual Plots

```
Call:
lm(formula = BRM.Score ~ poly(EST.Score, 2, raw = TRUE), data = df)

Residuals:
    Min      1Q  Median      3Q     Max
-6.1139 -2.0050 -0.2952  1.8356  8.8861

Coefficients:
                                Estimate Std. Error t value Pr(>|t|)
(Intercept)                     34.25032    9.32168   3.674 0.000961
poly(EST.Score, 2, raw = TRUE)1 -1.01911    0.71161  -1.432 0.162800
poly(EST.Score, 2, raw = TRUE)2  0.02574    0.01310   1.965 0.059005

(Intercept)                     ***
poly(EST.Score, 2, raw = TRUE)1
poly(EST.Score, 2, raw = TRUE)2 .
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 3.078 on 29 degrees of freedom
Multiple R-squared:  0.4341,    Adjusted R-squared:  0.395
F-statistic: 11.12 on 2 and 29 DF,  p-value: 0.0002601
```

Figure 8. Modified linear regression model

To analyze the data further, the performance of the shooters during each of the phases on the EST2000 range was compared to average performance during BRM. Shooters shot slightly worse by one shot during the prone supported phase than what is normally expected. There was no change in shooter performance for the prone unsupported phase. Shooters shot slightly better by one shot for the kneeling phase. Initially, there was concerns regarding the tether of the weapon affecting unsupported positions. However, it is likely that the system either compensates for the tether or the weapon’s tether prevented shooters from getting into a good prone, supported firing position.

Although the paired means between the two data sets of EST2000 scores and BRM scores were not statistically different, an adequate linear regression model could not be found. Thus, it cannot be concluded that the EST2000 effectively reflects shooting on a live range. The weapon’s tether could be preventing shooters from establishing a stable prone, supported position. Before the new rifle marksmanship qualification course is implemented, the Army should conduct further research to ensure the EST2000 either effectively reflects shooting on a live range or enhances a soldier’s performance on a live range, since the Army intends on utilizing the EST2000 to maximize the number of soldiers who qualify on an actual range the first time. Ensuring that the EST2000 either effectively reflects shooting on a live range or enhances a soldier’s performance on a live range will end up saving time, money, and ammunition.

5.2. Limitations of the Study and Future Work

Of note, this study is limited to the number of volunteers with a sample size of thirty-two cadets. Testing more cadets may provide better insight to determine if the EST2000 range scores correlate with BRM scores from a live range. Most of the volunteers were freshman, so testing a sample that is more representative of the population would also be beneficial.

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Additionally, testing cadets on the EST2000 a maximum of a month prior to shooting on a live range may provide a more accurate assessment of the effectiveness of the EST2000 because it will decrease the time between the two ranges and utilize the EST2000 range prior to a live range like the new rifle qualification course. For this study, the approximate time from summer training 2019 and the EST2000 data collection was about six months. Cadets, specifically those who did not have experience with shooting prior to attending USMA, may not have been shooting as well due to the amount of time between their last fundamental marksmanship course. For future studies, it is recommended that the number of cadets recruited for the study is larger and more representative of the population, the time between shooting on the two ranges is minimized, and the EST2000 range is utilized prior to a live range. Additionally, further studies could also focus on shooter performance during the different phases to determine if the EST2000 weapon tethers significantly affect performance.

6. Conclusion

In conclusion, the results are inconclusive. Although the difference between the paired means of the EST2000 scores and the BRM scores was not statistically different, an adequate linear regression model could not be found because overall, cadets did not consistently shoot better on the EST2000 range or a live range. At best, 39.5% of variation could be explained with the second model, which was insufficient. Thus, the effectiveness of the EST2000 range to reflect shooting on a live range could not be determined. There were a significant number of variables that may have contributed to the inconclusive results. Some of the variables include the time between shooting an M4 on a live range and shooting an M4 on the EST2000 range, experience shooting an M4, experience with the EST2000 range, and differing class years. To modify the study in future, it is recommended that a larger sample size that is more representative of the population be tested, the time between shooting on an EST2000 range and on a live range be no greater than a month, the EST2000 range be utilized prior to a live range, and shooter performance on the different phases be analyzed.

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