



**MOUNTAIN
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INSTITUTE**

The Effect of Trigger Pull Weight on Marksmanship

MOUNTAIN/TACTICAL

MISSION-DIRECT RESEARCH



The Effects of Trigger Pull Weight of Marksmanship

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SUMMARY

PURPOSE: The purpose of this study was to assess the effect of trigger pull resistance on non-stressed and stressed tactical marksmanship at three distances: 15 yards, 50 yards and 100 yards.

SUBJECTS: Ten experienced, part-time members of a medium-sized city (Fresno, CA) SWAT team (ages 32-45) participated in the study.

DESIGN: Athletes were randomly divided into 2 groups. Group 1 (G1) used stock triggers during two sets of marksmanship trials. Group 2 (G2) used stock triggers during the initial trial, then switched to a new, lighter-resistance *Hiperfire "Hipertouch EDT2"* trigger for the second trial (TABLE 1).

TABLE 1: Study Groups and Triggers

	Marksmanship Trial 1	Marksmanship Trial 2	% Change
Group 1	Stock Triggers 7.9 +/- 0.44lbs	Stock Triggers 7.9 +/- 0.44lbs	None
Group 2	Stock Triggers 7.4 +/- 0.72lbs	Light Triggers 5.1 +/- 0.26lbs	-32%

The study compared differences in group performances at the three study distances: 15, 50 and 100 yards (FIGURE 1).

FIGURE 1: STUDY DESIGN AND SET-UP



RESULTS: The Stock Trigger Group and the Light Trigger Group each out-performed the other in 3 of the 6 marksmanship trials (TABLE 2). The Stock Trigger Group performed better in 15-yard non-stressed, 15-yard stressed and 100-yard non-stressed marksmanship. The Light Trigger Group performed better Stock in 50-yard non-stressed, 50-yard stressed and 100-yard stressed marksmanship.

TABLE 2: Trigger Pull Group Performance during Trial 2
(X = Better Marksmanship Improvement)

Group	Pull Wgt	15-Yard		50-Yard		100-Yard	
		Non-Stress	Stress	Non-Stress	Stress	Non-Stress	Stress
Stock Triggers	7.9+/- 0.4lb	X	X			X	
Light Triggers	5.1+/- 0.3lb			X	X		X

DISCUSSION: Prior to the study we hypothesized that the lighter triggers would improve marksmanship performance, and that this effect would increase as distances increased. Although our results were not statistically significant (due to large individual variation and a small sample size), our results seem to hint at possible support for the hypothesis. The Lighter Trigger Group showed superior performance at both 50-yard measures and one of the 100-yard measures. However, since the Lighter Trigger Group failed to out-perform the Stock Trigger Group during 100-yard non-stressed shooting it is difficult to make any firm conclusions concerning the overall effect of the lighter triggers.

RECOMMENDATIONS: Based on the findings from this initial study we believe that further research is needed to make conclusive determinations and recommendations. That notwithstanding, we offer the following suggestions:

1. At a cost of less than \$100 and an install time of less than 5 minutes, after-market, lighter-resistance triggers offer relatively low cost options which may help improve marksmanship at distance greater than 15 yards.
2. The large variation measured between individual marksmanship scores shows a need for increased marksmanship training. Like most units of similar size this SWAT team is given extremely limited training time (1-2 days per month). We recommend units increase training time as much as their schedule allows. This will hopefully lead to better marksmanship consistency and safety in tactical situations.

FURTHER RESEARCH RECOMMENDATIONS

Based on the results from the current study we offer the following recommendations for further research:

1. The study seemed to hint that lighter trigger pulls could have a positive impact on marksmanship. However, because of marksmanship variability we ultimately found the effect to be inconclusive. Thus, we recommend the study be repeated with either a larger sample (20+ athletes) or with more consistent marksman.
2. Although we didn't track data on the athlete's optics we did notice the large impact optics had on our athlete's performance. We recommend conducting a study to specifically quantify the impact that optics have on tactical marksmanship (especially the difference between iron sights and "red dot" sights).
3. We understand that most units, especially part-time LE tactical units, have limited time to train. However, based on the inconsistency we observed in the current study we believe that units would be well served with additional training. Therefore we recommend a study examining the impact of various forms of training (like dry-fire, simulated, range, stressed, etc.) in order to determine effective and efficient ways that units can improve their marksmanship.
4. The current study only examined trigger-pull resistance in tactical assault rifles. It is likely that trigger resistance would have a much different effect on handgun marksmanship due to the different biomechanics used support and fire the weapon. We recommend a separate study to examine trigger pull resistance and handguns.
5. The commonly cited concern associated with lighter trigger pulls is safety. We are aware of a few research projects and testing procedures which use drop-test protocols to assess trigger pull safety (14,15,16). We have also heard that some individual departments have anecdotal minimum trigger pull resistances for assault rifles. However, we are unaware of any national standards or recommendations which exists outside of the US Army (11). Therefore we recommend a study which specifically assess trigger pull weight, safety (based on the validated drop test) and our current findings. A study of this nature could help produce nationally recognized guidelines for tactical assault rifles based on safety and accuracy.



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1. SUBJECTS, PURPOSE & DESIGN:

1-1. Subjects

Ten part-time members of a medium-sized city SWAT team (ages 32-45) participated in the study. Participants were all experienced marksmen with an average of 15.2 years of law enforcement experience and 7.2 years on the department's SWAT team.

TABLE 3: Subject Data (In years)

	Average	SD
Age	41.1	+/- 4.72
Tactical Team Experience	7.2	+/- 5.62
LE Experience	15.2	+/- 4.31

1-2. Purpose & Design

The purpose of this study was to assess the effect of trigger pull resistance on non-stressed and stressed tactical marksmanship at three distances: 15 yards, 50 yards and 100 yards.

To accomplish this we randomly divided the ten athletes into 2 groups. Group 1 (G1) used stock triggers during two sets of marksmanship trials. Group 2 (G2) used stock triggers during the initial trial, then switched to a new, lighter-resistance trigger during the second trial.

Thus, the sole difference between trial one and trial two was the trigger used by the groups. In this way, Group 1 acted as a "control group", restricting the differences between the trials to only trigger resistance. This experimental design means that any differences should be attributable to the triggers, and not to other experimental factors.

TABLE 4: Study Groups and Triggers

	Marksmanship Trial 1	Marksmanship Trial 2	% Change in Trigger Pull
Group 1	Stock Triggers 7.9 +/- 0.44lbs	Same as Trial 1	None
Group 2	Stock Triggers 7.4 +/- 0.72lbs	Light Triggers 5.1 +/- 0.26lbs	-32%

After completing the trials, we compared the differences between trial one and trial two for each group - giving us a change in marksmanship performance for the stock triggers and the light triggers (% change). We then compared the two groups. This allowed us to see how changes in the stock trigger group (G1) compared to changes in the lighter trigger group (G2).

Thus, if we found that the lighter trigger group (G2) improved significantly more than the stock trigger group (G1) then we could conclude that lighter triggers help to improve marksmanship. If the stock trigger (G1) group improved significantly more than the light trigger group (G2) then we would be able to conclude that the lighter triggers had a negative impact on performance. Finally, if both groups showed similar levels of change then we should be able to conclude that the lighter triggers had no significant effect.

2. RESULTS & DISCUSSION:

2-1. Fifteen (15) Yards

At 15-yards we found that the stock trigger group out-performed the light trigger group on both non-stressed (TABLE 5) and stressed (TABLE 6) marksmanship trials.

However, based on a paired T-Test analysis neither group’s changes were statistically significant. Variations between the individual scores kept the measurements from being statistically significant.

To test statistical significance we used paired T-Test analysis of group marksmanship scores. This statistical test takes into consideration changes and variations to determine if the changes are greater than would be expected by random chance. Unfortunately because of our small sample size and large variation the changes assessed at 15 yards did not meet the threshold we established ($p < .10$). Our T-Test revealed much weaker significance scores: $p = 0.56$ and $p = 0.45$, respectively.

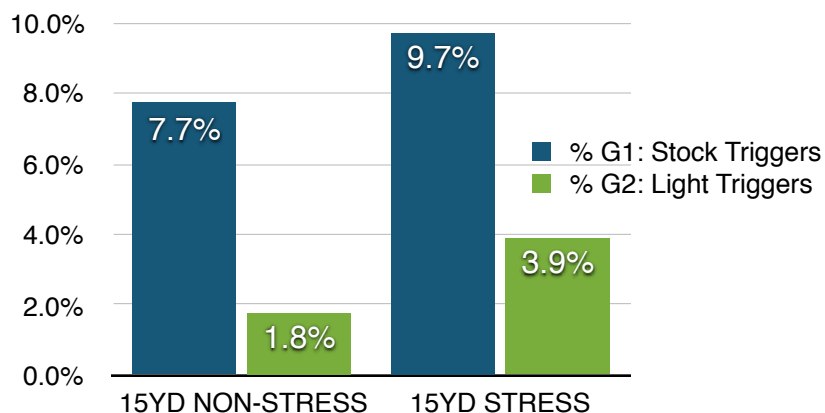
TABLE 5: 15-Yard Non-Stressed Marksmanship

	Trial 1 G1 = Stock G2 = Stock	Trial 2 G1 = Stock G2 = Light*	% Change
Group 1	111.2	119.8	7.7%
Group 2	111.0	113.0	1.8%

TABLE 6: 15-Yard Stressed Marksmanship

	Trial 1 G1 = Stock G2 = Stock	Trial 2 G1 = Stock G2 = Light*	% Change
Group 1	98.6	108.2	9.7%
Group 2	97.8	101.6	3.9%

FIGURE 2: 15-Yard Percent Differences between Trial 1 and Trial 2



Although not statistically significant, these results were not all that surprising. Based on our experience, we expected the lighter triggers to have less effect at shorter distances, when smaller marksmanship errors would have less impact on marksmanship scores. However, we expected to see more significant differences as the distance increased.

2-2. Fifty (50) Yards

As we expected, differences at the 50-yard interval were far more pronounced. The lighter trigger group showed considerably more improvement than the stock trigger group in both non-Stressed (TABLE 7) and stressed (TABLE 8) marksmanship.

However, although the differences were much larger at the 50 yard distance we still did not find the measurements to be statistically significant. Again, our small sample size and large variations in the individual scores was likely the cause. T-Test values between groups for the 50 Yard trials were $p > 0.70$ and $p > 0.55$, respectively.

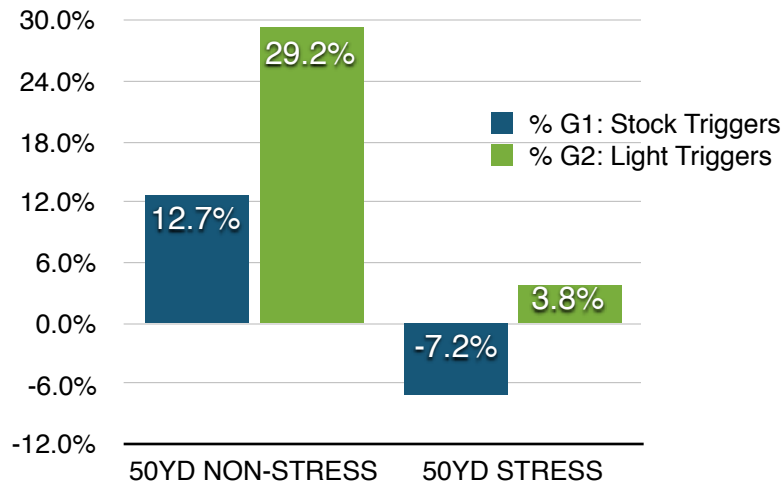
TABLE 7: 50-Yard Non-Stressed Marksmanship

	Trial 1 G1 = Stock G2 = Stock	Trial 2 G1 = Stock G2 = Light*	% Change
Group 1	42.6	48.0	12.7%
Group 2	42.4	54.8	29.2%

TABLE 8: 50-Yard Stressed Marksmanship

	Trial 1 G1 = Stock G2 = Stock	Trial 2 G1 = Stock G2 = Light*	% Change
Group 1	44.4	41.2	-7.2%
Group 2	42.4	44.0	3.8%

FIGURE 3: 50-Yard Percent Differences between Trail 1 and Trial 2



Although not statistically significant, the large improvement measured in the Light Trigger Group seems to offer support to our hypothesis that lighter trigger-pulls might aid in marksmanship performance.

2-3. One Hundred (100) Yards

Our findings at 100 yards were extremely confounding. During non-stressed marksmanship the Stock Trigger Group (G1) showed considerably more improvement than the Light Trigger Group (G2) (TABLE 9). While, during stressed marksmanship the Light Trigger Group (G2) improved more (TABLE 10).

At 100 yards the variation in individual scores was, by far, the most drastic. Non-stressed scores varied from 3 points to 56 points. Stressed scores at 100 yards varied from 0 points to 49 points. This, undoubtedly caused the extremely confusing results seen in FIGURE 4.

Again, due to the small sample size and extremely large variations between the individual scores at 100 yards none of the changes was found to be significant.

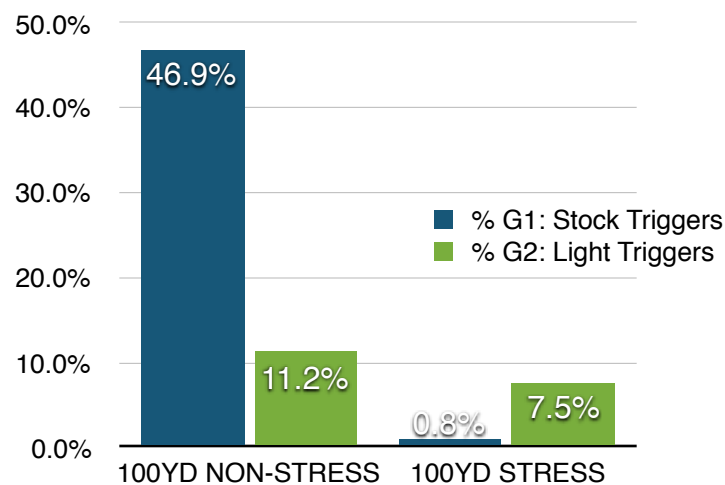
TABLE 9: 100-Yard Non-Stressed Marksmanship

	Trial 1 G1 = Stock G2 = Stock	Trial 2 G1 = Stock G2 = Light*	% Change
Group 1	16.2	23.8	46.9%
Group 2	30.4	33.8	11.2%

TABLE 10: 100-Yard Stressed Marksmanship

	Trial 1 G1 = Stock G2 = Stock	Trial 2 G1 = Stock G2 = Light*	% Change
Group 1	25.0	25.2	0.8%
Group 2	26.6	28.6	7.5%

FIGURE 4: 100-Yard Percent Differences between Trail 1 and Trial 2

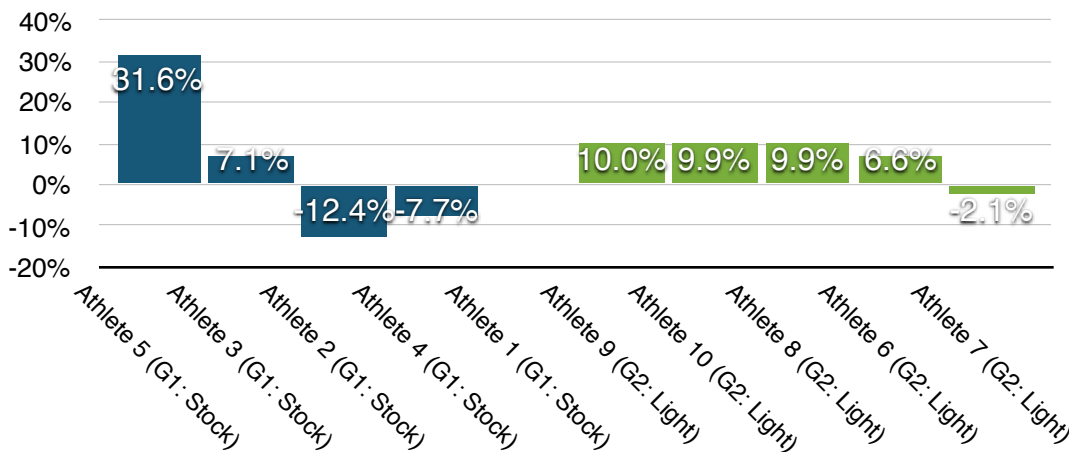


It is extremely difficult to make sense of the 100 yard data due to the variations mentioned above. Because of this we consider the effect of trigger pull resistance at 100 yards to be inconclusive.

2-4. All Distances (15, 50 and 100 Yards)

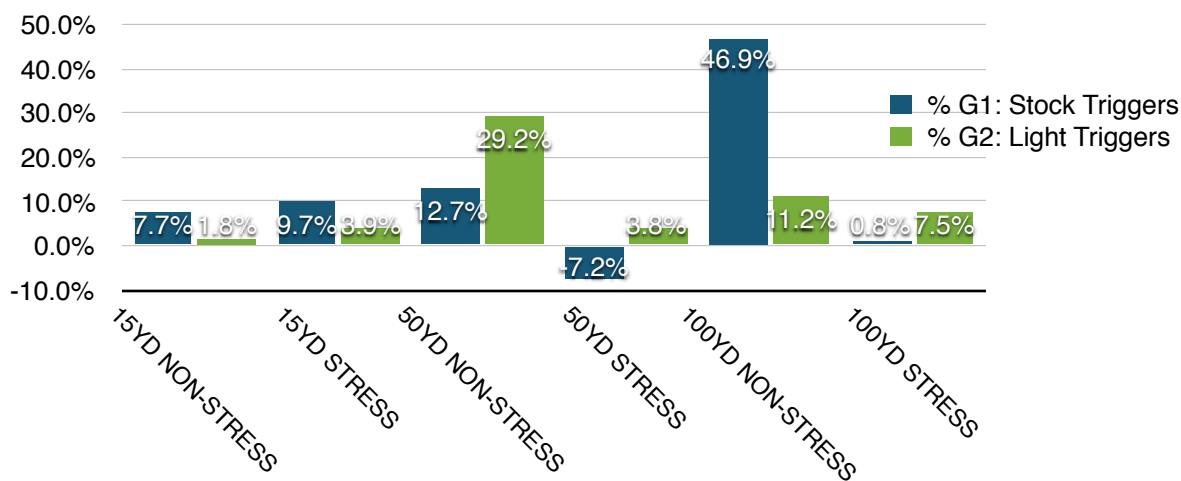
Across all distances and shooting types, only 2 out of 4 athletes in the Stock Trigger Group (G1) improved their marksmanship from trial 1 to trail 2 (Note: One athlete had to be removed from the data for failing to complete an event). In contrast, across all distances and shooting types, 4 out of 5 athletes in the Light Trigger Group (G2) improved their marksmanship from trial 1 to trail 2. This can be seen in FIGURE 5 below:

FIGURE 5: Average Percent Improvement for Each Individual Marksman from Trial 1 to Trial 2



When we compared the results at all three distances The Stock Trigger Group and the Light Trigger Group each showed more improvement during 3 of the 6 trial types (FIGURE 6). The Stock Trigger Group out-improved the Light Trigger Group in 15-yard Non-Stressed, 15-yard Stressed and 100-yard Non-Stressed marksmanship. The Light Trigger Group out-improved the Stock Trigger Group in 50-yard Non-Stressed, 50-yard Stressed and 100-yard Stressed marksmanship.

FIGURE 6: Comparison of Improvement Between G1 and G2 at All 3 Distances



3. RECOMMENDATIONS:

Based on the findings from this initial study we believe that further research is needed to make conclusive determinations and recommendations. That not withstanding, we offer the following suggestions:

1. At a cost of less than \$100 and an install time of less than 5 minutes, after-market, lighter-resistance triggers offer relatively low cost options which may help improve marksmanship at distance greater than 15 yards.
2. The large variation measured between individual marksmanship scores shows a need for increased marksmanship training. Like most units of similar size this SWAT team is given extremely limited training time (1-2 days per month). We recommend units increase training time as much as their schedule allows. This will hopefully lead to better consistency in training and safety in tactical situations - both of which can be a matter of life or death.

4. PRIOR RESEARCH

Trigger-pull resistance or trigger-pull weight is the amount of force required to release or “break” a trigger, causing the hammer or striker to release and fire the weapon (10). The general consensus among experts seems to be that lighter trigger pull poundages can aid in marksmanship (6-8). Two pieces of anecdotal evidence are often cited for this conclusion: First, lighter triggers are almost universally preferred by the best competitive marksman (7). Second, and more generally, lighter resistance should, according to most marksmanship professionals, lead to easier manipulation of the fine motor skills involved in trigger control (4-6, 10). However, to the researcher’s knowledge, no formal study has yet directly examined the effect of trigger pull resistance on marksmanship performance.

According to a 1993 Study by the US Army Small Arms Branch, based a 1% failure rate, the recommended trigger-pull resistance of a M16A2 rifle is between 5.5 to 10.0 pounds. Based on the same study and same failure rate, the recommended trigger-pull resistance for a M4 Carabines is between 6.5 to 12.3 pounds (11). Of note, typically, any trigger-pull which is lighter than 3.5 pounds is, for whatever reason, anointed a “competitive trigger” (8). We were unable to find any standard for LE Officers or other military services.

The argument against lighter trigger resistance is almost universally centered around the perceived safety concerns of the lower resistance - especially in handguns (6-9). These concerns are what led New York City law enforcement officers to carry sidearms with a 12-pound trigger (7,10). A June 2015 article from the Los Angeles Times seems to anecdotally support this change. According to the author, L.A. Country sheriff’s deputies have experienced a nearly two-fold increase in accidental gunshots since switching to firearms with a lighter trigger-pull resistance. Many individuals inside the department directly attribute the increase in accidental discharges to the new weapon’s lower trigger pull weight (12).

Despite the changes made by New York City law enforcement and the criticism offered by the LA Country sheriff’s deputies many experts point to a lack of training as the real cause for safety concerns - specifically in terms of trigger discipline and trigger control (6,7). Some experienced marksman claim that heavier triggers are actually more dangerous because the increased resistance negatively effects trigger control and accuracy (6,7).

According to United States Marine Corps Reference Publication (MCRP 3-01A), Rifle Marksmanship, “Trigger control is the skillful manipulation of the trigger that causes the rifle to fire without disturbing sight alignment or sight picture. Controlling the trigger is a mental process, while pulling the trigger is a mechanical process.”

The importance of trigger control in marksmanship performance is cited everywhere from the US Army, to the US Marine Corps, to the Federal Law Enforcement Training Center (FLETC) (1-4, 6). MCRP 3-01A identifies it as one of three major factors which contribute to marksmanship: “the fundamentals of marksmanship are aiming, breath control, and trigger control” (2). Although it would seem to align, whether or not lighter trigger-pull resistances could contribute to trigger control has yet to be determined in a scientific study.

Most previous scientific studies on marksmanship have focused on “aiming” aspect of accuracy. This includes a study from the US Army Aeromedical Research Laboratory which found that visual skills and attention were the most important contributors to marksmanship (3). Other studies have also found that eye dominance and hand dominance can effect marksmanship (4), as can grip strength (13) and physical stress (5).

Interestingly, the same LA Times article which cited the increases in accidental discharges also reported significant increases in accuracy measures during trainee qualifications (12). Prior to changing to the new weapon, some recruit classes saw as many as 60% of their trainees requiring additional firearms training to meet the accuracy standard. Training with the previous weapons also resulted in 10 out of 80 cadets flunking out because of firearms failures. With the new weapon both of those numbers have dropped - only about 17% are now requiring additional training and less than 3 are flunking out because of firearms failures (12).

5. DETAILED METHODS

5-1. Subjects

Ten healthy male subjects (32-45 years) who were all full-time Law Enforcement officers and part time SWAT team members of a mid-sized city SWAT team participated in the study. Participants were all experienced marksman with at least 9.0 years of LE experience and a minimum of 2.5 years of SWAT experience.

TABLE 11: Subject Data by Group

	Control Group		Treatment Group	
	Average	SD	Average	SD
Age (years)	39.8	+/- 5.22	42.4	+/- 4.34
Tactical Team Experience (years)	4.4	+/- 3.17	10.0	+/- 6.44
LE Experience (years)	12.7	+/- 7.90	7.4	+/- 0.72

5-2. Marksmanship Trials

The ten athletes were randomly divided into 2 groups. Group 1 (G1) used stock triggers during two sets of identical marksmanship trials. Group 2 (G2) used stock triggers during the initial trial, then switched to the new, lighter-resistance, Hiperfire “Hipertouch EDT2” trigger during the second trial (TABLE 12)

TABLE 12: Study Groups and Triggers

	Marksmanship Trial 1	Marksmanship Trial 2	Percent Change Trigger Pull
Group 1	Stock Triggers 7.9 +/- 0.44lb	Stock Triggers 7.9 +/- 0.44lb	None
Group 2	Stock Triggers 7.4 +/- 0.72lb	Light Triggers 5.1 +/- 0.26lb	-32%

Trials:

Each trial consisted of 30 marksmanship events, each event consisted of 6 rounds (or single bullets). Thus, **1 Trial** = 30 Events and **1 Event** = 6 Rounds (5.56mm bullets) for a total of 180 rounds per trial.

Trials required subjects to shot at three different distances: 15 yards, 50 yards and 100 yards. Events used two marksmanship category types: non-stressed and stressed. Therefore each trial consisted of 180 total 5.56mm rounds. A complete breakdown can be seen in TABLE 13 on page 13.

Marksmanship category type:

1. Each Non-Stress drill required athletes to assume a standing position (15 and 50 yards) and kneeling position (100 yards) and fire 3 rounds each at two B-29 targets, separated by 3 feet (total of 6 rounds). The drill was not timed.
2. Each Stress drill required athletes to complete two 15-yard shuttle runs, retrieve their weapon from a tabled location, assume a standing position (15 & 50 yards) or kneeling position (100 yards) and fire 3 rounds each at two B-29 targets, separated by 3 feet (6 rounds total). Time limit varied by distance: 15-yards (20 seconds); 50-yards (25 seconds); 100 yards (30 seconds).

TABLE 13: Marksmanship Trial by Events and Rounds (5.56mm)

Events	Target Distance	Trial Type	Rounds per event	Total Rounds
1-5	15 Yards	Non-Stress	6	30
6-10	15 Yards	Stressed	6	30
11-15	50 Yards	Non-Stress	6	30
16-20	50 yards	Stressed	6	30
21-25	100 Yards	Non-Stress	6	30
26-30	100 Yards	Stressed	6	30
				180

Targets: All trials utilized B-29 Law Enforcement Targets (FIGURE 7).

FIGURE 7: Example of B-29 Law Enforcement Targets



5-3. Weapons.

All subjects used their issued long rifles during the study - Colt M4's (5.56mm). There were no research controls applied to individual weapons. Athletes were allowed to use their preferred configurations and optics.

5-4. Data Collections.

Study participants scored their marksmanship based on bullet hits on the B-29 targets following each event. The study participants scored their hits, and the used targets were replaced with fresh B-29 targets.

5-5. Analytical Method.

All data analytics and statistical modeling were completed using Apple Numbers 2015 (3.5.3 - 2150), Microsoft Excel Online 2016 (15.14.0), released 15 September 2015 and IBM Watson Analytics Online Program 2015.

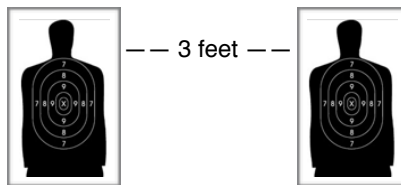
6. MISSION DIRECT APPROACH & LIMITATIONS

6-1. Mission Direct Approach.

Our Commitment to *Mission Direct Research* means that we attempt to balance the rigorous academic demands of clinical research with the practicality needed to make research applicable in the real-world. This balance means that we may sometimes need to sacrifice research controls for functionality. For the current project the following approaches were used to make the research *Mission Direct*.

1. **Weapons:** Instead of confining our athletes to a standardized weapon configuration we allowed them to use their individual duty weapon. Thus, some athletes outfitted their weapons with accessories like forehand grips and red-dot optics while others used stock configurations and iron sights. In our study, no weapon was the same and certain weapon configurations undoubtedly gave some athletes an advantage. However this advantage was true to real life tactical situations.
2. **Marksmanship Trials:**
 - a. **Distances:** Most tactical athletes have one weapon that they use for every tactical situation. Thus it is crucial that their weapon be able to operate effectively at multiple distances. We used three distances in study (15, 50 and 100 yards) in order to evaluate marksmanship across three common tactical distances. This design added complexity to the research, but we believe this complexity is necessary in order to establish a wholistic picture of tactical marksmanship.
 - b. **Targets:** During each marksmanship event (6 continuous rounds) athletes fired at two targets separated by three feet (FIGURE 8). Thus athletes fired three rounds at one target then had to acquire and engage a second target with three rounds. Again, while this design added complexity to the research, we believe the complexity was needed to mimic a possible real-life tactical situation.

FIGURE 8: Target Set-Up



- c. **Stress:** Stress is going to be present in any real life tactical situation. Mimicking this stress in training is difficult. We have developed and tested protocols which we believe can safely and effectively be used to create physical and psychological stress. For this study stress was applied stress through a single drill which manipulated three variables: (1) Physical Activity, (2) Time, and (3) Limited Resources (ammunition). These three variables were selected because they can easily and safely be adjusted by tactical professions. These variables can also be scaled for an individual athlete and progressed as a means of training.

6-2. Limitations.

1. The first major limitation of the study was the small sample size. Because each group only contained five tactical professionals the threshold to achieve statistical significance was extremely high. For correlations the requirement for statistical significance was over $r = 0.87$.
2. Another limitation of the study was the large variability measured between athlete individual trials. This variation was particularly noticeable as distances increased. For non-stressed shooting at 50 yards, scores ranged from 17 to 67 points (standard deviation >20 points). At 100 yards, scores ranged from 3 to 56 points (standard deviation >20 points). This large variation made it difficult to compare individual and group scores.
3. Another limitation was the timeframe allowed for the Light Trigger Group to familiarize themselves with the new triggers. Following the lighter trigger installation the group was only allowed to fire 30 rounds at 15 yards to familiarize themselves with the new configuration. It is possible that more familiarization time would have helped the Treatment Group's performance during the second trial of the study - especially during the stressed events when athletes lacked the luxury of time.

7. FURTHER RESEARCH RECOMMENDATIONS

Based on the results from the current study we offer the following recommendations for further research:

1. The study seemed to hint that lighter trigger pulls could have a positive impact on marksmanship. However, because of marksmanship variability we ultimately found the effect to be inconclusive. Thus, we recommend the study be repeated with either a larger sample (20+ athletes) or with more consistent marksman.
2. Although we didn't track data on the athlete's optics we did notice the large impact optics had on our athlete's performance. We recommend conducting a study to specifically quantify the impact that optics have on tactical marksmanship (especially the difference between iron sights and "red dot" sights).
3. We understand that most units, especially part-time LE tactical units, have limited time to train. However, based on the inconsistency we observed in the current study we believe that units would be well served with additional training. Therefore we recommend a study examining the impact of various forms of training (like dry-fire, simulated, range, stressed, etc.) in order to determine effective and efficient ways that units can improve their marksmanship.
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