Comparison of Day and Night Shooting and Lethality Performance

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ABSTRACT
While Soldiers primarily train marksmanship during the daytime, they are expected to have those same skills during the nighttime, though not at the same level (Toppe, 1986). To our knowledge, there are no published data comparing day and night shooting performance of soldiers while executing a support-by-fire task in the context of a squad live-fire training exercise. Our research team collected shooting performance data including probability of hits and kills, volume of fire, and rates of fire from 18 squads executing the squad attack battle drill. Each squad executed the drill once during the day, and once at night. Shooters engaged robotic pop-up targets at approximately 100m. At night, targets emitted simulated muzzle flashes and were illuminated with chemlights. Soldiers wore night vision devices issued by their units. Targets provided vital and non-vital hit data. Acoustic sensors measured rounds passing near the targets and audio recorders worn by shooters were used to determine rates of fire over time. Data showed that teams delivered higher volumes of fire at night than during the day but, not surprisingly were less accurate at night. Interestingly performance during the day did not predict performance at night. These and other findings are the first objective data comparing day and night collective shooting performance at the fire team level. This research has implications for training for day and night shooting and suggests ways to develop more objective assessments of collective shooting performance during live-fire and simulation training.

ABOUT THE AUTHORS

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BACKGROUND

Soldier lethality is one of the key focus areas in the U.S. Army's modernization efforts (Purtiman, 2018). Commonly cited as the building block of the Army, the infantry rifle squad's performance and lethality are critical to the military's foundation (Powell, 2018). Lethality is exhibited when the enemy is eliminated or when they are hindered or prevented from executing their mission. In either case, the enemy is debilitated and incapacitated. Soldier lethality encompasses more than the sophistication of weapons since a weapon can only be as powerful as the Soldier who wields it. Lethality also implicates both the competencies of the individual Soldier as well as his team, reinforcing the notion that Soldier training is still critical despite advancements in weapon technology. Infantry rifle squads hone their lethality through rigorous and intensive training both at the individual and team levels. Individual lethality training includes weapon handling and marksmanship training, while team level lethality training involves executing and rehearsing battle drills. When training on common battle drills, Soldier's learn to work effectively together to perform certain collective tasks such as entering and clearing rooms, conducting an assault, and reacting to direct fire contact (Department of the Army, 2016b). Battle drills are generally procedural in nature, with each squad member performing a series of actions and behaviors according to their designated roles (O'Brien et al., 1982). These behaviors largely relate to how the Soldiers shoot, move, and communicate (Bink et al., 2015). Since the squads are expected to execute the drills in different situations, knowing how such behaviors are affected by various conditions, such as the stark difference in ambient light in the day and night, can have implications on training to ensure that Soldier lethality is maintained at all times.

DAY VS. NIGHT DIFFERENCES

Conducting military operations and battle drills at night is much different than conducting them during the day. For the Soldiers, executing the same drill in the day and night, even in the same battlefield, can be two very different experiences. The differences can largely be attributed to the poorer lighting conditions at nighttime, which have profound impact on Soldiers' vision and cognition (Sampson et al., 2004; Scharine et al., 2009). For this reason, training for both day and night operations is essential.

Vision & cognition

At night, the Soldiers' perception of depth, height, distance, shapes, and outlines is distorted in night lighting, or lack thereof (McBreen, 2005), and they are advised to try to use their peripheral vision when trying to view faintly visible objects (Department of the Army, 1995). Although they do improve Soldiers' vision at night, night vision goggles (NVGs) also result in narrower field of view (FOV) (Task & Pinkus, 2007). Changes in vision at night also affect the Soldiers' other senses, and consequently their cognition. At night, with reduced visibility, Soldiers are more likely to pick up on and exaggerate sounds; they even report hearing sounds that are not present (Toppe, 1986). When under fire, Soldiers may face challenges in identifying the source of fire, adversely impacting their ability to respond appropriately. They may also lose their bearings and sense of direction more easily at night, especially when there are flashes from guns and searchlights (Toppe, 1986). Such effects on perception can play into Soldiers' mental response to situations. Soldiers conducting night operations are more likely to report experiencing feelings of insecurity and panic. Their confidence and ability to perform tasks can be compromised as a result of these changes to their perception and cognition (Toppe, 1986).

Shooting and weapon handling

Soldier lethality is negatively impacted by these perceptual and cognitive factors at night. Although NVGs and aiming lights help with target acquisition, they do not completely eliminate the visual challenges at night. In addition, Soldiers can find NVGs to be difficult to use, especially with a riflescope (McNulty, 1992). The ability to shoot accurately directly impacts lethality and even small impairments in the ability to align weapon sights with the target can lead to misses (Chung & Baker, 2006). Although accuracy is important, it is important to keep in mind that the primary purpose of suppressive fire is to pin the enemy down by maintaining a constant volume of fire over the enemy position.

There are other impacts of reduced visibility. For example, reduced visibility at night can impede Soldiers' ability to change magazines and so they must train to perform this task by feel (Fort Benning, 2011). Soldiers may also find it more difficult to clear weapon malfunctions at the night. This may lead to delays in getting the weapon back in the fight.

BATTLE DRILL 2A

This work was part of a larger Army-sponsored program to better understand the individual and collective performance of infantry rifle squads to inform training and acquisition. Each squad included the squad leader (SL), the Alpha and Bravo team leaders (ATL& BTL). In addition to the team leaders, each team included a grenadier (GRD), a rifleman (RIF), and a squad automatic weapon (SAW) gunner. Squads executed Battle Drill 2A (BD2A), *Conduct a Squad Assault*, which included a movement to contact whereupon the team to first make contact, returns suppressive fire to pin the enemy (see Figure 1, Timepoint 1), while the Squad Leader with the trailing team maneuvers into flanking position (Figure 1, Timepoint 2). The support-by-fire team then shifts fire to the side of the enemy position opposite to the assaulting team (dotted line in Figure 1) and then lifts (ceases) fire as the assaulting team assaults through the enemy position (Figure 1, Timepoint 3). In this report, we focus on the support-by-fire team.

In our data collection, the Alpha team was always the team to make contact first and therefore they were always in the support-by-fire (SBF) role. Upon making contact, the Alpha Team would attempt to form a line perpendicular to the enemy position and lay down suppressive fire. They were facing three robotic targets that were programmed to drop when "killed" but then they would pop back up after few seconds. Upon making contact, the Alpha team employs a maximum rate of fire to suppress the enemy and then reduces their rate of fire to be just sufficient to suppress the enemy so as to keep them pinned while conserving ammunition until the assaulting team is in position. Laying down this suppressive fire requires the M4s and SAW to coordinate their fire. The ATL plays a critical role in regulating the team's rate of suppressive fire throughout the exercise. The other team members must communicate reloads and malfunctions as well as enemy direction, distance, and description.

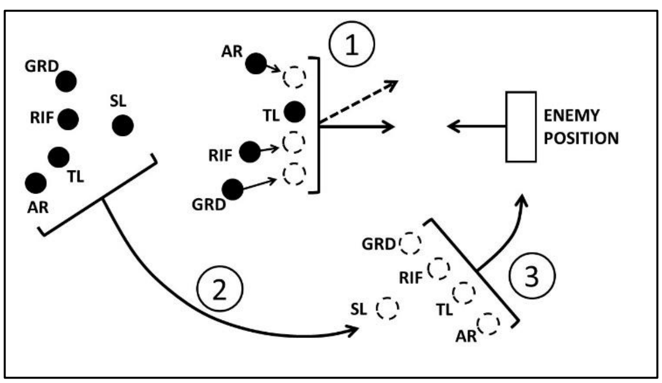

Figure 1: Depiction of BD2A. For both Alpha and Bravo teams, SL: Squad Leader, TL: Team Leader, AR: SAW gunner, GRD: Grenadier, RIF: Rifleman. (Alpha team is directly in front of the enemy position)

HYPOTHESES

Given the decrease in visibility at night compared to the day which is expected to affect how Soldiers perform their shooting and weapon handling tasks, , the following hypotheses were formulated:

Hypothesis 1: Fire volume would be about the same for day and night drills

Hypothesis 2: Accuracy would be poorer in the night drills compared to the day drills
Hypothesis 3: Fire coordination (TG Ratio) would be the same for day and night drills
Hypothesis 4: Weapon Handling Efficiency would be poorer in the night drills compared to the day drills

METHOD

Participants

Study participants comprised the Alpha Fire team Soldiers in 18 infantry rifle squads from Camp Shelby, MS. While the teams' TL, GRD, and RIF were each armed with the M4, the SAW gunner wielded the M249. The GRDs were also equipped with the M320 grenade launcher. They received three training rounds that could be fired with the M320, but this was not included in the analysis.

All squads executed Battle Drill 2A, *Conduct a Squad Assault*, once in the daytime and once in the nighttime. Night drills were always executed after the day drills on the same day. For their night drill, Soldiers wore night vision devices issued by their units. The Soldiers served an average of 76.06 months (SD = 38.24), spent an average of 14.94 months (SD = 11.21) in their current squad, and had an average time in their position of 11.67 months (SD = 10.15). For the present study, only data from the Alpha team was collected analyzed.

Measures

The following constructs were implicated in the present study. They were operationalized by the measures included in their respective descriptions (also see **Table 1**).

Fire Volume
This referred to the level of firing activity. Measures pertained to shot counts and included average rate of fire, number of M4 shots, and number of SAW shots.

Accuracy
Accuracy of a shot pertains to target hits. Total number of hits and kills across all targets, as well as the probability of hits and kills were the measures of accuracy. Hits are shots on non-vital areas of the target, while kills occurred when a vital area of the target is shot, i.e., the head, neck, and chest, or when there are three consecutive hits.

Fire Coordination
Fire coordination relates to the extent to which firing from the different weapons was synchronized and well-timed. The measure of fire coordination was a novel measure that assessed the extent of "talking the guns" (TG). A high level of TG occurred when the team's firing activity was synchronized such that whenever one weapon was out of the fight due to a reload or malfunction, the other team members would compensate for the decrease in firing to maintain the overall volume of fire. The measure of fire coordination required assessing the amount of time in the drill where there were no shots from the Alpha team, i.e., "dead space" in the drill. The TG ratio reflected the proportion of the drill where there was "dead space".

Weapon Handling Efficiency
A less frequently cited, but nevertheless related notion in Soldier lethality, is their ability to operate and handle their weapons effectively and efficiently. A possible indicator of this is the duration it took for them to reload their weapons. For the present study, this was obtained from the Soldiers' verbal communications where they called out "Reload" or "Reloading", and whenever they followed that with reload update of "Reloaded" or "I'm up" or similar utterance. The reload duration was calculated as the time interval between a reload callout and the follow-up notification that the reload was complete. This measure is only an approximate as it self-reported and assumed that both the reload callouts and reload updates were made without delay. It was also only available when Soldiers followed up their reload callouts with updates, hence the average reload duration for the squad would only be based on reload durations of Soldiers who notified others of their reloads and followed that with an update.

Table 1: Constructs and measures

Construct	Measures
Fire Volume	Average rate of fire (ROF)
	No. of M4 shots
	No. of SAW shots
Direction of Shots: Accuracy	Number of hits
	Number of kills
	Probability of hits, P(Hits)
	Probability of kills, P(Kills)
Fire Coordination	"Talking the Guns" ratio (TG ratio). High scores corresponded to better fire coordination TG ratio = 1 - ($\frac{Duration\ of\ \text{"dead space"}\ in\ drill}{Duration\ of\ drill}$)
Weapon Handling Efficiency	Average reload duration

Equipment

Targets

Three robotic pop-up targets (Marathon Targets, 2015) simulated hostile enemy forces and were positioned in open terrain roughly 120 meters from a wood line. As the squad moved through the woods towards the open field, the Marathon targets, which are on armored, wheeled platforms, moved to pre-programmed, specified positions about 100 meters away from the Alpha team's firing line. Once in this location, the targets did not move until the *Shift Fire* command was issued.

The targets "dropped" when shot once in a vital region or three consecutive times in a non-vital region, but popped back up after seven seconds when the "kill" threshold was reset. Shots to the head, neck, or chest were deemed vital and produced "kills," while shots to other parts of the target were deemed non-vital "hits."

Right after *Shift Fire*, the targets reoriented to face the assaulting Bravo team. Most Squads chose to flank to the left due to the lay of the terrain. The three targets were numbered 1-3 from left to right from the SBF position. At night, the targets produced simulated muzzle flashes and were illuminated with chemlights.

Weapons

The weapons used by Alpha team in the present study were the M4 Carbine and the M249 Squad Automatic Weapon. The M4 Carbine is a lightweight, shoulder fired weapon that is the standard issue firearm for the TL, GRD, and RIF in the infantry rifle squad. The rapid rate of fire is about 45 rounds per minute while the sustain rate of fire is approximately 12-15 rounds per minute (Department of the Army, 2016a). The M249 combines the high rate of fire of a machine gun and the portability of a rifle. Its rapid rate of fire is approximately 100 rounds per minute while the sustained rate of fire is about 50 rounds per minute (Department of the Army, 2017).

Audio recorder

Each Soldier was fitted with the TASCAM DR-40Xportable audio recorder (TASCAM, n.d.), which was placed in a magazine pouch, secured, and fastened onto the webbing worn by the Soldier. The TASCAM DR-40X recorded Soldiers' verbal communications as well as the sounds of the shots during the drill. Timestamps of the reload callouts and reload updates from transcriptions of the verbal communications were used to obtain the reload durations, a measure of weapon handling efficiency. The audio recordings of the shots were processed by a software script that differentiated M4 from SAW shots by their peak frequencies. Another script was then executed that determined the number and timestamps of each M4 and SAW shot. . While the software script was able to distinguish single M4 shots from SAW bursts, it was not possible to differentiate among individual M4 shooters. Inter-shot intervals were determined from the M4s and SAW and were used to compute the TG ratio, which served as the measure of fire coordination and to calculate rates of fire over time.

Procedure

Soldiers were briefed on the study exercise after they completed a preliminary demographic questionnaire. Prior to the study exercise, each of the squads had been in a four-day training event at their respective home stations for three weeks. On the day of the drill, the Soldiers confirmed zero on their weapons and proceeded to practice BD2A using training munitions. Each squad was given a certain training munition and a bolt carrier assembly customized for their equipment. During the practice, each squad executed a maximum of four runs of exercise BD2A, while observer controllers (OCs) evaluated the squad on whether it was capable of conducting the drill safely with live fire. If deemed otherwise, the squad executed the drill with training munitions. Of the 18 squads, only one squad was disqualified from using live rounds and used training munitions for the drill. The rest used live ammo.

The soldiers then worked through their combat checklists and collected their ammo before they left for the drill site. Every squad member received seven, 30-round magazines, but the SAW gunners, were issued three, 200-round polypropylene drums with linked 5.56 ammunition. Three M320 training rounds were also provided to the grenadiers. Prior to their departure for the range, the study team secured an audio recorder to each Soldier of the Alpha team. For the night drills, the squad used their own night vision devices.

Each squad executed the BD2A drill once in the day then once at night. The terrain selected for the live fire assessment was unfamiliar to the squads when they first encountered it in the day drill. They had no prior knowledge of the layout or surroundings for the day drill. For safety reasons, the night drill was conducted in the same location *after* the daytime drill, giving the Soldiers some level of familiarity with the drill site, although they had no experience performing the drill at night in that location. As every squad performed the day drill before they conducted the same drill at night, there was no counterbalancing of conditions. When they completed the drill, the Soldiers exited the range, turned in any unspent ammunition, and the research team collected the audio recorders. After returning their equipment, a short after-action review was held.

RESULTS

The composition of the Alpha teams from the 18 squads varied. Eleven squads had Alpha teams with all four members while seven squads had three-member Alpha teams, mostly missing the RIF or GRD. This was the case for both day and night drills. Data from incomplete teams were not omitted since the teams would still proceed with the mission even when not at full strength. To compare the shooting performance of the Alpha team during the day and night, paired sample t-tests were utilized. Since this test compared the differences between the day and night conditions instead of differences between squads, the unequal team sizes are not expected to unduly influence the analyses. Nonetheless, results should still be interpreted with caution. The sample sizes for some of the following analyses were also less than 18 due to incomplete or unusable data from some squads.

Initial examination of the data suggested that there were differences in Soldiers' shooting performance and weapon handling between drills executed in the day and night. The rate of fire from the Alpha team averaged 65.47 shots/min in the day compared to 79.46 shots/min at night. Compared to the day drills, the average number of M4 shots from the TL, GRD, and RIF for the squads increased by about 20% at night, while the average number of SAW shots increased by almost 50% (Table 2).

Table 2: Means and Standard Deviations from Day and Night Drills

Construct	**Measures**	**Day**		**Night**	
		M	***SD***	***M***	***SD***
Fire Volume	Average ROF	65.47	26.86	79.46	31.58
	No. of M4 Shots	122.31	65.94	181.00	50.97
	No. of SAW Shots	199.17	99.08	241.09	115.39
Accuracy	Total Hits	42.31	16.50	14.13	7.49
	Total Kills	16.81	6.92	7.67	6.21
	Probability of Hits	0.15	0.10	0.03	0.02
	Probability of Kills	0.05	0.02	0.02	0.01
Fire Coordination	TG Ratio	0.26	0.09	0.30	0.08
Weapon Handling Efficiency	Average Reload Duration	16.10	9.61	24.66	12.51

Shot accuracy was drastically poorer at night with the average total number of hits at night being only a third of that during the day, $t(13) = 5.07$, $p<.001$ (Day: M=42.31, SD=16.50; Night: M=14.13, SD=7.49). Average total kills at night was about half that number of kills made in the day, $t(13) = 3.23$, p=.007 (Day: M=16.81, SD=6.92; Night: M=7.67, SD=6.21). The probability of hits and kills were likewise poorer at night. Probability of hits at night was only a fifth of their rate in the day, $t(9) = 3.99$, p=.003 (Day: M=0.15, SD=0.10; Night: M=0.03, SD=0.02), while their kill probability decreased by more than 50%, $t(9) = 5.07$, $p<.001$ (Day: M=0.05, SD=0.02; Night: M=0.02, SD=0.01) (Table 3).

Although all three measures of fire volume showed more at night, only the M4 shots were significantly higher at night, $t(8) = -4.06$, p=.004 (Day: M=122.31, SD=65.94; Night: M=181.00, SD=50.97). The levels of fire coordination, assessed by the extent to which there was "dead space" during the drill (i.e., TG ratio), was not significantly different across day and night. It seemed that the increased number of M4 shots fired at night did not necessarily improve fire coordination as might be expected. That is, more rounds fired did not result in less dead space. Average reload duration, was significantly longer at night compared to the day, $t(7) = -3.97$, p=.005 (Day: M=16.10s, SD=9.61s; Night: M=24.66s, SD=12.51s) suggesting Soldiers found it more difficult at night.

Table 3: Analyses of the differences of measures between Day and Night drills

	Paired Samples t-statistic	***p***	***Cohen's d***
Fire Volume			
Average Rate of Fire (ROF)	-1.23	0.25	-0.39
No. of M4 Shots	-4.06	0.004	-0.70
No. of SAW Shots	-1.98	0.089	-1.35
Accuracy			
Total Hits	5.07	<0.01	1.36
Total Kills	3.23	0.01	0.86
Probability of Hits	3.99	<0.01	1.26
Probability of Kills	5.07	<0.01	1.60
Fire Coordination			
TG Ratio	-1.17	0.28	-0.39
Weapon Handling Efficiency			
Average Reload Duration	-3.97	0.01	-1.40

Although there were no specific hypotheses about the relationships among measures from the day and night data, correlational analyses of these measures were conducted to examine interrelationships among measures during day and night performance (see table 4). Some interrelationships were significant both for the day and night drills, while others were significant only during the day or only at night.

For example, during the day, rate of fire measures were positively correlated. The greater the number of M4 shots, the greater the number of SAW shots, $r = 0.89$, $p<0.01$. Both M4 ($r = 0.69$, $p<0.01$) and SAW ($r = 0.84$, $p<0.01$) shots also correlated with average ROF. However, none of these rate of fire measures were significantly correlated at night. The TG ratio (higher values indicate greater coverage of fire over time) were significantly correlated with the overall rate of fire and the number of M4 shots both day and night. However, the TG ratio was positively correlated with the number of SAW shots only during the day.

In both day and night, the higher the number of total hits, the higher the number of total kills, and the greater the probability of hits, the greater the probability of kills. When looking at the relationship between shots by weapon and lethality measures, neither the number of SAW shots nor the average rate of fire were related to total hits or total kills day or night. Total Hits and total kills however were significantly correlated with the number of M4 shots during the day but not at night. This perhaps indicates a greater accuracy of M4 fire during the day. A lower probability of hits was significantly related to a higher overall rate of fire during the day and a higher number of M4 shots at night. Finally, longer reload times were significantly correlated with total number of hits, $r = 0.78$, p=0.013, and kills, $r = 0.72$, p=0.028, but only during the day (Table 4).

Table 4: Intercorrelations of measures for Day and Night drills

Day= D Night= N	**Avg. ROF**	**No. M4 shots**	**No. SAW shots**	**Total Hits**	**Total Kills**	**P(Hits)**	**P(Kills)**	**TG Ratio**
No. M4 shots	D: 0.69† N: 0.41							
No. SAW shots	D: 0.84† N: 0.50	D: 0.89† N:0.001						
Total Hits	D: 0.16 N: 0.25	D: 0.65* N: -0.34	D: 0.32 N: 0.12					
Total Kills	D: 0.42 N: 0.21	D: 0.64* N: -0.27	D: 0.52 N: 0.004	D: 0.71† N: 0.87†				
P(Hits)	D: -0.65* N: -0.32	D: -0.18 N: -0.62*	D: -0.46 N: -0.35	D: 0.31 N: 0.71†	D: -0.26 N: 0.53			
P(Kills)	D: -0.51 N: -0.06	D: -0.20 N: 0.44	D: -0.48 N: -0.21	D: 0.48 N: 78†	D: 0.36 N: 0.91†	D: 0.58* N: 0.75†		
TG Ratio	D: 0.87† N: 0.82†	D: 0.71* N: 0.60*	D: 0.78* N: 0.19	D: 0.21 N: 0.12	D: 0.22 N: 0.03	D: -0.24 N: -0.34	D: -0.46 N: -0.20	
Avg. Reload Duration	D: 0.06 N: 0.23	D: 0.26 N: 0.06	D: 0.23 N:0.35	D: 0.78* N: -0.42	D: 0.72* N: -0.36	D: 0.62 N: -0.50	D: 0.56 N: -0.33	D: 0.03 N: -0.07

*p<0.05, †p<0.01. D=Day, N=Night

To examine trends across day and night shooting, correlations between corresponding measures from day and night drills were examined (Table **5**). Interestingly, results did not reveal any significant relationships, indicating that better performing teams in day were not necessarily better at night. Similarly, higher rates of fire during the day were not significantly associated with higher rates at night, although the number of SAW shots came close (r = 0.70, p = 0.06).

Table 5: Correlations of the corresponding measures for day and night

Construct	**Measures**	**Correlation between Day and Night**
1. Fire Volume	Average Rate of Fire	r = 0.47, p = 0.17
	No. of M4 Shots	r = 0.21, p = 0.60
	No. of SAW Shots	r = 0.70, p = 0.06
2. Accuracy	Total Hits	r = -0.27, p = 0.34
	Total Kills	r = -0.02, p = 0.94
	Probability of Hits	r = 0.24, p = 0.50
	Probability of Kills	r = 0.14, p = 0.70
3. Fire Coordination	TG Ratio	r = 0.47, p = 0.20
4. Weapon handling	Average Reload Duration	r = 0.67, p = 0.07

DISCUSSION

Findings from the present study supported the hypotheses about shooting accuracy across day and night. All measures of accuracy revealed poorer accuracy at night. This was anticipated because of the greater challenges of seeing and aiming at targets at night. While there were fewer hits and kills at night, the probability of hits and kills declined to an even greater degree because of the higher number of shots fired at night, especially by the M4s.

These higher shot counts were not expected since Soldiers are not trained to fire more at night. It is possible that the higher shot counts were a response to the greater difficulty Soldiers had in hitting/killing targets. In other words, if they were aware that they were getting fewer kills, they may have fired more in an attempt to compensate with the consequence being an even greater decrease in the PH/PK. If that is true, it was primarily the M4 gunners who were attempting to compensate because the SAW gunners did not significantly increase their shot counts at night.

Fire coordination (TG ratio) did not differ significantly from day to night. A higher TG ratio indicates that the team is more effectively coordinating their fire by insuring there are fewer breaks in firing. As might be expected, higher overall rates of fire would tend to increase the TG ratio and indeed for both day and night, higher rates of fire are correlated with higher TG ratios. Interestingly, different weapons seem to contribute to the TG ratio in the day compared to the night. In the day, better TG ratios were seen in teams with more SAW and M4 shots, whereas at night, higher TG ratios were seen in teams with only more M4 shots. Compared to the day, the night SAW shots were not as effective in establishing fire coordination. Without well-timed SAW shots, the increase in M4 shots at night only served to maintain the TG ratio rather than improve it since TG ratios were similar for the day and night drills. Together, these measures of accuracy, volume of fire and coordination of fire, paint a picture of squads at night firing more, but with less accurately.

A few intercorrelations observed in the day data were also seen with the night data. Total hits and kills showed strong positive correlations, as did probability of hits and probability of kills. However, there were several significant intercorrelations observed in the day drills that were not significant in the night drills. The day data indicated that all measures of fire volume intercorrelated significantly. Both M4 and SAW rates of fire correlated with the overall rate of fire and with each other. At night, neither the M4 nor SAW rates of fire correlated with overall rates of fire, nor did they correlate with each other. This suggests that at night, these relationships were not as direct because there were high ROF teams with different combinations of low and high M4 and SAW shots.

There is indirect evidence that M4 shots were more accurate during the day but that SAW shots were equally accurate day and night. During the day, total hits and kills correlated with number of M4 shots but not with number of SAW shots. At night, hits and kills were not correlated with the number of shots taken by either the SAW or M4 guns. In addition, the number of SAW shots did not significantly correlate with the probability of hits during the day or night, but at night more M4 shots were significantly related to a lower probability of hit at night.

As expected, average reload duration, a measure of weapon handling efficiency, was significantly longer at night, indicating that Soldiers were less proficient at this task in the dark. Keep in mind that reload durations were measured indirectly from the callouts of Soldiers. In addition to taking longer at night, reload duration at night did not correlate with hits and kills as it did during the day. It is not clear what this means though it is yet another example of a measure that is less predictive of performance at night than during the day.

Finally, performance during the day did not generally predict performance at night. None of the measures of accuracy or lethality were significantly correlated across day and night. In other words, teams that had high hit or kill rates during the day did not necessarily do better at night and vice versa. Measures of volume of fire were also uncorrelated across day and night with the exception of the number of SAW gunner shots which was positively correlated. High rates of fire during the day were correlated with higher rates at night for the SAW gunner. The only other correlation between day and night performance was reload duration, also positively correlated. Teams that took longer to reload during the day, tended to take longer at night too.

CONCLUSIONS

While the decrease in accuracy at night was not surprising, these findings suggest that shooting at night has other unanticipated effects on performance. Specifically, squads elevated their rates of fire and coordination of fire seemed to vary in an interesting way with both M4 and SAW contributing to higher coordination during the day but only M4s contributing at night. This is unexpected because Soldiers are trained to regulate rates of fire and coordinate fire the same way during conditions of day and night. While it is possible that employing a higher volume of less coordinated fire may be an effective response when Soldiers are in low visibility conditions, this would appear to be an untrained reaction rather than a deliberate strategy. High rates of fire deplete ammunition faster and risk overheating weapons. If the assaulting team is also moving more slowly at night, the higher volume of fire could cause the SBF team to deplete their ammo before the assaulting team is in position and/or leave them with too little ammunition to respond to a counterattack. These findings suggest that training for night shooting should place a greater emphasis on consistently controlling rates of fire and on improving fire coordination.

Finally, Soldiers should practice magazine changes at night and perhaps practice using their night vision devices during night shoots. Future research is needed to understand why Soldiers were less effective at hitting targets at night to identify the specific problems that led to decreased accuracy so that training can be targeted to those problems.

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