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# The Effects of Stress on Marksmanship

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MOUNTAIN TACTICAL INSTITUTE, JACKSON, WY

## The Effect of Stress on Marksmanship

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### OBJECTIVE:

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The purpose of this study was to evaluate the effects of stress on marksmanship performance, as applied through four variables: (1) Physical Activity, (2) Time, (3) Resources Constraints (Ammunition) and (4) Competition.

### METHODS:

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Fifteen full-time members of a state law enforcement (LE) tactical unit participated in the study (age 29-43 years). Participants were all experienced marksman with at least 7 years of LE experience and a minimum of 1 year of full-time tactical experience. All subjects completing a series of 24 marksmanship trials. Trials were divided into two categories: (1) Non-stressed ([Video Link](#)) and (2) Stressed ([Video Link](#)). Each trial consisted of one magazine of 5 rounds (5.56mm). Subjects fired a total of 60 rounds during the non-stressed trials and 60 rounds during the stressed trials (120 total rounds). HR data was collected using the iOS Polar Team Training App® and Polar H7® bluetooth heart rate monitors. Marksmanship accuracy was tracked by tactical team members not participating in the study. Accuracy was measured in hits per 5 round magazine.

### KEY FINDINGS:

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- Moderate levels of stress (approximately 70-80% of estimated heart rate max) significantly decrease marksmanship performance (-24.1%).
- Within the individual non-stressed drills, variations in heart rate (+/- 7.7 BPM) did not correlate to significant changes in marksmanship performance.
- Within the individual stressed drills, variations in heart rate (+/- 11.4 BPM) did not correlate to changes in marksmanship performance.

### RECOMMENDATIONS:

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Since most real-world tactical marksmanship situations occur during times of stress, the researchers recommend that all tactical professionals train stressed marksmanship. Training in physiological situations which closely mimic real-world scenarios should help tactical more effectively prepare for their operational requirements. Based on the results presented in this study, drills, similar to the one used by the researcher, represent a simple and safe means of applying stress to marksmanship exercises.

## 1. INTRODUCTION

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### 1.1 Previous Research

Marksmanship is a skill which requires an athlete to coordinate their visual system, autonomic nervous system, respiratory system and fine motor skills (1,2). The addition of stress challenges the control of these systems and has been shown to reduce marksmanship performance (3).

Previous research examining the effects of stress on fine motor skills and marksmanship has been focused primarily on two areas:

1. Marksmanship during stressful situations like military combat or high-risk policing. This stress response is often referred to as Survival Stress Reaction (SSR) (3).
2. Marksmanship during physically demanding events like the sport of biathlon (6).

Early studies into SSR (1960s and 1970s) revealed a direct relationship between the heart rate increases experienced during stressful events and declines in fine motor skills and visual acuity (3).

According to this research, heart rates of approximately 115 beats per minute (BPM) caused individuals to lose fine motor skills such as finger dexterity and eye/hand coordination. Furthermore, at heart rates above 145 BPM SSD research reported that most people begin to lose coordination in their complex motor skills (3). Additional research into SSR reported that heart rates above 175 BPM caused measurable decreases in visual tracking and focus (3).

In further research examining the physiological responses to stress, Dr. Alexis Atwood, found that stress can also result in tunnel vision (peripheral narrowing), feelings of dislocation, diminished auditory exclusion and memory impairment (4).

Research conducted at the University of Arizona examining the stress-injury relationship found further support that stress can significantly impact motor skills. This research found that stressful conditions resulted in a significant decrease in peripheral vision and hand steadiness (5).

The sport of biathlon has provided loads of useful insight into the effect of physical stress on marksmanship. The sport of biathlon requires athletes to ski long distances, often near 90% of their maximum heart rate. In-between these physical events athletes stop briefly to shoot in the prone or standing position.

One study, using elite biathletes, found that exercise intensity had only a minimal effect on shooting accuracy in supported positions. However, although not statistically significant, the study also found that exercise intensity had a more measured effect during standing trials (6).

Another study using elite biathletes found that on average biathletes maintain an exercise intensity of approximately 90% of their maximum heart rate. Slowing slightly, these athletes often arrive at their firing lines with heart rates around 166 BPM (85-87% of maximum). While firing, these athletes were able to lower their heart rates to around 119 BPM in the prone position and around 140 BPM in the standing position. This difference in heart rate was attributed to athletes spending longer times in the prone position and to a more rapid decline in heart rate in a prone position. Although not statistically significant the athletes were slightly more accurate from the prone position (with lower heart rates) (7).

Lastly, a study conducted by the U.S. Army Research Institute of Environmental Medicine examining the effects of altitude and exercise found that exercise conducted prior to marksmanship tests reduced marksmanship accuracy but did not effect sighting time. On-the-other-hand altitude exposure reduced marksmanship accuracy and decreased sighting time.

### 1.2 Mission Direct Approach

For this study stress was applied through a single drill which manipulated four variables: (1) Physical Activity, (2) Time, (3) Limited Resources (ammunition) and (4) Competition. These four 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.

## 2. METHODS

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### 2.1 Subjects

Fifteen healthy male subjects (29-43 years) who were all members of a full-time state law enforcement (LE) tactical unit participated in the study. Participants were all experienced marksman with at least 7 years of LE experience and a minimum of 1 year of full-time tactical experience.

**TABLE 1: Subject Data**

	Average
<b>Age</b> (years)	36.3
<b>Height</b> (inches)	71.3
<b>Weight</b> (pounds)	206.9
<b>Tactical Team Experience</b> (years)	7.5
<b>LE Experience</b> (years)	12.7
<b>Military Experience</b> (years)	1.5
<b>Total Marksmanship Experience</b> (years)	15.5

### 2.2 Marksmanship Trials

After the initial data was collected subjects completing a series of 24 marksmanship trials. Trials were divided into two categories: (1) Non-stressed and (2) Stressed. Each trial consisted of one magazine of 5 rounds (5.56mm). Subjects fired a total of 60 rounds during the non-stressed trials and 60 rounds during the stressed trials (120 total rounds).

Marksmanship category type:

1. Each Non-Stress drill required athletes to assume a kneeling position and fire 5 rounds at a MGM 10 inch Steel Challenge target. The target was located 80 yards from shooter. The drill was not timed. Two heart rate measures (HR average and HR max) were recorded during each trial. As was the total number of hits per 5 round magazine.  
Non-Stress Drill [Video Link](#)
2. Each Stress drill required athletes to complete two 15-yard shuttle runs, retrieve their weapon from a tabled location, assume a kneeling position and fire 5 rounds at a MGM 10 inch Steel Challenge target. The target was located 80 yards from shooter. The drill was completed with a 20 second time limit. Two heart rate measures (HR average and HR max) were recorded during each trial. As was the total number of hits per 5 round magazine  
Stress Drill [Video Link](#)

### 2.3 Range Fitness Theory of Stressed Marksmanship

Range Fitness is a system which trains accurate marksmanship under stress developed by Rob Shaul at Military Athlete in 2009. Range Fitness drills are not "PT at the Range" nor are they "stress shoots" in the traditional understanding. In a general comparison to high school football practice, a "Stress Shoot" would be a full-speed scrimmage. A Range Fitness drill would be similar to a tackling drill - short and focused on developing a specific fundamental skill. Range Fitness drills are short, focused, simple, repeatable and progressable. Range Fitness Drills apply four specific stressors on the Operator:

1. Physical Stress
2. Time Limit Stress
3. Ammo Limit
4. Competition

### *2.3 Weapons*

All subjects used their personal assault rifles during the study (5.56mm). There were no research controls applied to individual weapons. Athletes were allowed to use their preferred configurations and optics.

### *2.4 Data Collections*

HR data was collected using the iOS Polar Team Training App® and Polar H7® bluetooth heart rate monitors. Marksmanship accuracy was assessed by tactical team members not participating in the study. Accuracy was measured in hits per 5 round magazine.

### *2.5 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.

### 3. RESULTS

#### 3.1 Non-Stressed Marksmanship

Subject's average non-stressed trials varied from 2.9 to 4.6 hits per 5 rounds. The overall average for all 15 subjects was 3.7 hits per 5 rounds. Non-stressed marksmanship trials produced an averaged heart rate (HRavg) of 101.8 beats per minute (BPM). Subject's average maximum HR (HRmax) was 109.8 BPM.

#### 3.2 Stressed Marksmanship

Subject's average stressed trials varied from 2.0 to 3.4 hits per 5 rounds. The overall average for all 15 subjects was 2.8 hits per 5 rounds. Stressed marksmanship trials produced a HRavg of 148.5 BPM. Subject's average HRmax was 159.7 BPM.

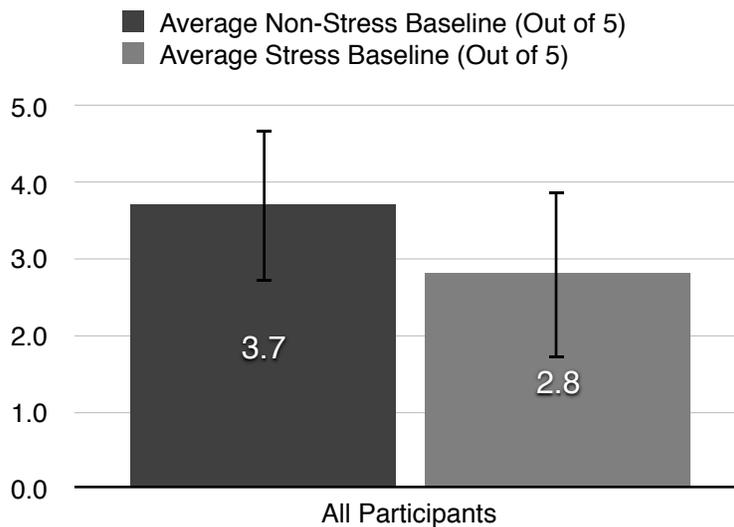
#### 3.3 Non-Stressed versus Stressed Marksmanship

Stressed marksmanship drills produced an average decline of 0.9 hits per 5 rounds. This represented a 24.1% decrease in performance over the non-stressed drills. Despite the relatively large standard deviations found during non-stressed and stressed trials (1.1 and 1.0 hits, respectively) the difference was statistically significant ( $p < .01$ )

**TABLE 2: Non-Stressed versus Stressed Marksmanship**

	Non-Stress (per 5 rounds)	Stressed (per 5 rounds)	Percent Difference	TTest (p)
<b>Average</b>	3.7	2.8	-24.1%	0.0000
<b>Standard Deviation (SD)</b>	1.1	1.0		

**GRAPH 1: Non-Stressed versus Stressed Marksmanship**



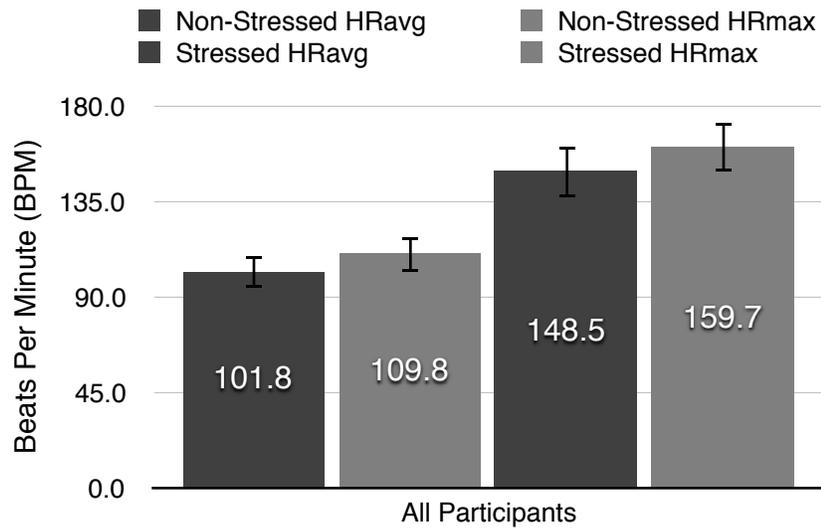
#### 3.4 Non-Stressed versus Stressed Heart Rates

Stressed marksmanship drills produced an average increase of 46.1 BPM across all subject's HRavg. This represented an HRavg increase of 45.9%. Stressed drills also produced an average increase of 50.0 BPM across all subject's HRmax. This represented an HRmax increase of 45.5%. Both increases (HRavg and HRmax) were statistically significant ( $p < .01$ ).

**TABLE 3: Non-Stressed versus Stressed Heart Rates**

		Non-Stress (BPM)	Stressed (BPM)	Percent Difference	TTest (p)
<b>HRaverage</b>	Average	101.8	148.5	+45.9%	0.0000
	SD	7.7	11.4		
<b>HRmax</b>	Average	109.8	159.7	+45.5%	0.0000
	SD	8.0	11.3		

**GRAPH 2: Non-Stressed versus Stressed Heart Rates**



#### 4. DISCUSSION

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The overall objective of this study was to determine the effects of stress on marksmanship. Stress was applied through a single drill which manipulated four variables: (1) Physical Activity, (2) Time, (3) Limited Ammunition and (4) Competition. Stress was measured using two heart rate measures, HRavg and HRmax. Marksmanship was measured through target hits per five rounds.

Based on previous research physical activity alone should negatively impact marksmanship (8). Since this study not only increased physical activity, but added a time constraint and increased competitive stress, it came as no surprise that a significant decrease in marksmanship performance was found during stressed trials. During this study, on average subject performance decreased from 3.7 hits per 5 rounds to 2.8 hits per five rounds.

This 24.1% decrease in performance during the stressed trials supported previous SSR research which showed the negative impact stress has on visual acuity and motor performance (3).

Previous SSR research found that heart rates above 115 BPM negatively impacted fine motor skills, like those need for marksmanship. Since the Non-stress trials in this study occurred at an average heart rate of 101.8 BPM, well below the 115 BPM it would seem that they were likely unaffected by these decreases. On-the-other-hand, the stressed trials produced an average heart rate of approximately 148.5 BPM, well above both the 115 BPM and 145 BPM standard which SSR research identified as producing negative effects (3,4).

Furthermore, although the stressed trials in this study were sufficient to illicit a negative performance response in our athletes they were not stressful enough to produce heart rates on levels equal to those experienced during the sport of biathlon. The average maximum heart rate experienced during the stressed portion of this study was 159.7 BPM, well below the 180-190 BPM attained by elite biathletes (7).

However, the mean stressed heart rates experienced during this study were similar to the lower heart rate levels experienced by biathletes during their marksmanship trials. Although elite biathlete often arrive at the firing line at heart rates around 166 BPM they will drop to around 119 BPM and 140 BPM during prone and standing marksmanship respectively. These heart rate ranges are very similar to the average heart rates experienced during this study's stressed trials, 148.5 BPM.

Unfortunately the researchers could find no research to compare the actual declines in performance between the non-stressed and stressed trials (decline from 3.7 to 2.8 hits per 5 rounds). Previous research has shown that stress negatively impacts visual skills, diminished auditory exclusion and impairs motor skills however no quantifiable marksmanship measures were provided (4). Biathlon research did reveal a slight increase in prone (supported) marksmanship over standing marksmanship. Although prone trials do occur at a lower heart rate the increase in performance is not necessarily a result of lower stress.

## 5. PRACTICAL APPLICATIONS

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The findings from this study clearly reveal a significant difference between non-stressed and stressed marksmanship. This difference establishes a distinct training requirement which must be addressed by the tactical professional.

Thus, this study can be used to help tactical athletes better prepare, train, and perform marksmanship exercises. Based on the results presented, drills similar to the one used in this study represent a simple and safe means of applying stress to marksmanship exercises. Since most real-world tactical marksmanship situations occur during times of stress, providing a simple means of training under similar circumstances should help tactical athletes more effectively prepare for real-life situations.

Furthermore, since the means of applying stress presented above (physical activity, time, resource constraints and competition) are safe, simple and scalable any drills built around similar principals can be progressed and used as regular training tools.

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