Stress Response and Performance Changes of Law Enforcement officers’ Marksmanship Under Varied Levels of Stress

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ABSTRACT

STRESS RESPONSE AND PERFORMANCE CHANGES OF LAW ENFORCEMENT OFFICERS’ MARKSMANSHIP UNDER VARIED LEVELS OF STRESS

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Northern Illinois University, 2019
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Objective: To investigate changes in physiological stress response and shooting performance of law enforcement officers under varying levels of stress. More specifically, the purpose of this study was to determine how increasing levels of stress from operating a firearm on static targets changes when law enforcement officers are subjected to a simulated life-threatening or dangerous situation.

Background: Performance changes associated with high levels of stress have been well documented in disciplines such as sports psychology, medicine, and military/law enforcement fields. However, little work has been done to draw comparisons between firearm training methods and qualification procedures which closely mimic armed conflict.

Method: A sample of 13 experienced law enforcement officers completed three trials of handgun shooting. Trial one included a modified course of fire adopted from the Illinois State Firearms Qualification Course of Fire, and two simulated conflicts using a TI Simulator (TI Training, Golden, Colorado). Heart rate, blood pressure, salivary alpha-amylase, and salivary cortisol as well as shooting performance data were collected before, during, and after courses of fire.

Results: Compared with the qualification course of fire, results showed a statistically significant reduction in percentage of shots hit during both simulated conflicts. No significant correlation
was found between any physiological variable measured in this study and marksmanship performance in either simulated conflict.

**Discussion:** Simulated dangerous encounters can be used to expose law enforcement officers to complex situations where marksmanship skills can be trained and evaluated. Further research may be necessary to determine if such training protocols can create enough stress response to cause any adaptation to stress during a real-life deadly encounter.

*Keywords:* Law Enforcement, Marksmanship, Stress, Cortisol, Blood Pressure, Heart Rate
STRESS RESPONSE AND PERFORMANCE CHANGES OF LAW ENFORCEMENT OFFICERS’ MARKSMANSHIP UNDER VARIED LEVELS OF STRESS

BY

BRANDON M. MALE
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A DISSERTATION SUBMITTED TO THE GRADUATE SCHOOL IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE DOCTOR OF PHILOSOPHY

COLLEGE OF HEALTH AND HUMAN SCIENCES

Doctoral Director:
Judith M. Lukaszuk
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DEDICATION

This project is completed in dedication to my amazing wife and children.

None of this work would be possible without your unwavering support,

    love, and enthusiasm for what I do.

    I hope to make you all as proud as you have made me.
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Several personal experiences have led to my interest in conducting this specific research project. As a hobby, I have enjoyed several types of marksmanship disciplines, including the use of pistols similar to those used by law enforcement officers. While receiving professional instruction at the Gunsight Academy (Paulden, Arizona), I was trained in defensive pistol techniques and tactics including weapon manipulations, operation in low light and no light conditions, engaging multiple targets simultaneously, and building clearing exercises against paper targets and force-on-force encounters against human role players. Witnessing the changes in performance of myself and my classmates as well as noticing the subtle changes in physiological variables including respiration, sweat rate, and perceived exertion, it became clear that the psychological stimulation of armed combat training may have influenced the performance of those participating in the class, including myself. Upon further investigation, I found anecdotal evidence of this occurring in real armed conflict through stories from law enforcement encounters as well as military operations. Research has begun to emerge about this occurrence, which is placing new interest on the training and preparation of law enforcement officers and military personnel. As a human performance specialist, I have a strong interest in better understanding how the human body can perform tasks of varying levels of complexity in a wide range of environments. To that end, it is my hope that greater understanding of the effects of fine motor skills performed under stress can be incorporated into the training and preparation of law enforcement officers and military personnel to enhance their
capabilities and increase the likelihood of survival if these individuals are called upon to defend themselves or others in armed conflict.
CHAPTER 1
INTRODUCTION

Human Performance and Stress

Fine motor skill performance under stress is commonly demonstrated by competitive athletes performing during game-time situations in challenging environments. Being able to maintain technical proficiency and execute a specific skill while under time and performance duress occurs with great regularity in athletic competition. However, for military personnel, law enforcement officers and occasionally a civilian who find themselves in a self-defense situation, physically performing under stress can mean the difference between life and death for themselves and for those around them. Groer et al. (2010) specifically state, with regard to law enforcement officers,

Police work is one of the most highly stressful and demanding occupations in the United States. It is characterized by high expectations for performance, unpredictable exposures to violence, shift work, uncertainty, death, and threat to life. Survival stress in police work is perception of a deadly force threat that can occur at any point in time. (p.595)

If a law enforcement officer is called upon to use deadly force in the defense of themselves or others, the precise movement patterns which they must undertake in the process of marksmanship skills leave little margin for error and may present a great danger to those near the conflict should the skills of marksmanship be executed inaccurately. In further support of this, Nieuwenhuys and Oudejans (2010) state that several professions involve the use of motor skills during high pressure situations. As an example, law enforcement officers can experience high
levels of physical stress while in a foot pursuit or during the use of control tactics in a hand-to-hand confrontation. Additionally from Nieuwenhuys and Oudejans (2010),

Given the criticality of a successful shooting performance in the line of duty, such a finding specifies a need to further our understanding of how anxiety affects performance, especially if decrements are to be prevented in the future (see also Oudejans, 2008). (p.225)

Similarly, Chung, O’Neil, Delacruz, and Bewley (2005) investigated marksmanship performance of military personnel and stated the following:

In a domain such as marksmanship, affect can have a large impact on performance, presumably due to the way negative affect manifests itself either cognitively, for example, with interfering thoughts, or physiologically, for instance, with nervousness increasing heart and breathing rates, which results in minute changes in the stability of the rifle. Such minute movements often get transferred to the rifle—a situation that can result in increasingly large deviations proportional to the distance to the target. (p.261)

Though military and law enforcement officers are required to qualify annually with their firearm performance, this may not necessarily equate to adequate precision in the field when confronted with the threat of harm or death (Taverniers & Boeck, 2014). In support of this, Charles and Copay (2003) present the following statistics in their report on law enforcement training techniques:

Between 1987 and 1996, 696 law enforcement officers were feloniously killed in the United States. Of these, 91.5% were killed by firearms; and a body armour did not prevent the death of 38.3% of the officers killed by firearms (Federal Bureau of Investigation, 1992, 1996). These statistics dramatically underline the fact that handgun proficiency is crucial for officer safety and survival. However, firearms proficiency appears to be lacking in US law enforcement.

Currently, law enforcement officers receive a varied duration of training on marksmanship skills, with the use of several different modes of training and professional qualification. Charles and Copay (2003) specifically mention the state of Illinois and the
availability of marksmanship training, with officers in Illinois receiving 480 hours of basic
training during police academy curriculum. Additionally, according to Charles and Copay
(2003) regarding specific marksmanship training, traditional line officers receive 48 hours of
training over a 480-hour police academy curriculum. Further training may take place at
individual police departments on top of the required firearms qualification, but as Charles and
Copay (2003) point out, “The typical police training and the qualification test, supposedly
sanctioning police firearms proficiency, are not sufficiently related to the skills required to
perform in real life shooting incidents.” Operating a firearm requires a complex set of actions to
bring about the desired goal of appropriate shot placement as well as maintaining safety for not
only the shooter, but the surrounding environment which may include innocent bystanders.
From incidents related to the use of firearms on the part of law enforcement officers, it has been
suggested that officers be exposed to different styles of training and qualification to gain
experience of realistic high-stress situations while operating a firearm in a controlled
environment. Taverniers and Boeck (2014) believe that current firearms training for law
enforcement officers (dominated by traditional cardboard-style targets) is not sufficient; they
argue there is a need for adoption of more stressful situations possibly involving physical activity
and dynamic environments whereby more effort and stress can be placed on the officers in
training. Thomasson, Gorman, Lirgg, and Adams (2014) state the following in discussing
current trends in marksmanship training and qualification:

In the qualification and training of law enforcement officers, firearm training is arguably
one of the most important aspects due to the public’s expectation of protection and the
potential liability involved with the improper use of a weapon. The perceived necessity
of realistic training is so great that multiple court rulings have decided that, for law
enforcement firearms training to be sufficient, officers must take part in realistic training
(McClelland v Facteau;1 Popow v City of Margate;2 Tuttle v Oklahoma3). (p.225)
Given the stressful situation of self-defense and the potential dangers associated with poor performance of marksmanship skills, a stronger understanding of how the human body reacts to dangerous situations—both mentally and physically—may be beneficial to the training and preparation of law enforcement officers involved in armed conflict. Taverniers and Boeck (2014) defined stress in the following manner in relation to marksmanship performance, “Stress has been referred to as an individual reaction to tangible or mentally evoked threats that destabilize the bodily equilibrium or homeostasis . . .” (p.404). Furthermore, Taverniers and Boeck (2014) highlight a quote from Lazarus and Folkman (1984) defining stress as a “particular relationship between the person and the environment that is appraised by the person as taxing or exceeding his or her resources and endangering his or her wellbeing” (p.404).

When an individual undergoes a stressful situation, the body is equipped to respond with several different actions. Specifically, if an individual were to encounter a situation of heightened activity such as exercise or if they are placed into a dangerous situation, many actions of the body are governed by the sympathetic branch of the autonomic nervous system (Martini, 1998). Depending on the severity of the situation, the sympathetic branch of the autonomic nervous system may take a varying degree of control and at its highest level of control, the individual would be considered to be experiencing a “fight-or-flight” response which, according to Martini (1998), “prepares the body for a crisis that may require sudden, intense physical activity” (p. 514).

Some of the results of the fight-or-flight response in humans have been summarized by Martini (1998) in the following set of outcomes: “(1) heightened mental alertness, (2) increased metabolic rate, (3) reduced digestive and urinary function, (4) activation of energy reserves, (5)
increased respiratory rate and dilation of respiratory passageways, (6) increased heart rate and blood pressure, (7) activation of sweat glands” (p. 514). Each of these actions is in place to assist the body with maintaining its survival through the rigorous activity of combat or fleeing a known threat. Many of these responses are also administered by a link between the sympathetic division of the autonomic nervous system and the body’s endocrine system.

The hypothalamus serves as a link between the nervous and endocrine systems of the body and works to collect information from several organs and govern responses to incoming messages (Shier, Butler, & Lewis, 2016). In response to stress, the hypothalamus aids in initiating the fight-or-flight response by causing a cascading release of chemical messengers leading to the secretion of hormones from the adrenal glands. The interaction between the hypothalamus and the adrenal glands, by way of the pituitary gland, is known as the hypothalamic–pituitary–adrenal (HPA) axis (Flier, Underhill, & Chrousos, 1995). Activation of the HPA axis results in a release of stress hormones released into the bloodstream, including cortisol, released from the adrenal cortex, and catecholamines epinephrine (E) and norepinephrine (NE), released from the adrenal medulla (Amerman, 2016).

Much like the effects of the sympathetic division of the ANS, the release of these hormones into the bloodstream causes alterations in several target tissues for surviving a stressful situation. According to Amerman (2016), the release of cortisol into the bloodstream causes an increase in gluconeogenesis by the liver, an increase in lipolysis from adipose tissue, and inhibition of the inflammatory response. These effects have a positive impact on energy levels for acute muscular activity related to the fight-or-flight activity. Working in conjunction with cortisol, epinephrine and norepinephrine target nearly every tissue type within the body and bring about several changes in response to stress as well. Amerman (2016) identifies the effects
of epinephrine and norepinephrine in response to stress as increasing both the heart rate and force of heart contraction resulting in improved blood flow, dilating the bronchioles to increase ventilation, constricting the blood vessels supplying the skin, digestive organs, and urinary system while simultaneously dilating the blood vessels supplying skeletal muscles and pupils of the eye to enhance muscle activity and visual acuity. Additionally, these effects are brought about by the ANS, with the intent of providing the individual with increased musculoskeletal contractile capacity and maintaining the ability to fight or flee a dangerous situation (Shier et al., 2016).

The purpose of these responses to stressful situations is to allow the individual experiencing them to either fight for survival or flee from danger to avoid being harmed. However, with the heightened potential for physical ability seen in a fight-or-flight response, researchers witnessed diminished capacities in other mental and physical variables. Thompson, Swain, Branch, Spina, and Grieco (2015) concluded:

Specific responses while under duress can affect an individual’s ability to perform mental and physical tasks. In the case of psychomotor tasks such as tactical shooting, autonomic response could potentially influence performance. For military operators, controlling this reflex could be the difference between life and death. (p.926)

Thompson et al. (2015) continue,

Neuroscience research has revealed that the sympathetic response can inhibit the prefrontal cortex (PFC), a structure responsible for higher-level executive functions. In combat, the PFC would not only help make strategic battlefield maneuver decisions but also assist with the fine motor coordination responsible for skillful marksmanship execution. Even mild, acute stress rapidly degrades cognitive performance, attention, and decision making. (p.926)

Inhibition of the prefrontal cortex during a high-stress situation limits the individual’s ability to perform fine motor skills while promoting gross motor ability more related to running or hand-to-hand fighting. Movements involved in marksmanship activities include several steps,
all of which must be completed accurately to insure safe, purposeful, and accurate use of a firearm. Campbell, Roelofs, Davey, and Straker (2012) list the biomechanical steps involved in handling a pistol when drawn from a holster, with the following actions taking place: Move the dominant hand to the pistol, gripping the pistol, unlocking the thumb lock, removing the pistol from the holster. With the pistol clear of the holster, bring the pistol to the firing position level with the intended target by holding the pistol with the dominant hand, supported by the nondominant hand, at shoulder height with both arms extended in front of the trunk. At this point, align the weapon’s sights with the target and press the trigger fully to send a single round from the weapon.

As a law enforcement officer follows these steps in drawing his or her weapon, several errors in movement mechanics can take place which may alter the officer’s ability to accurately place shots into a desired target. As Thompson et al. (2015) illustrate, fine motor skill is diminished while individuals experience a fight-or-flight response, which may lead to poorly executed movements and inappropriate decision making. Contributing to the poor mechanical execution of marksmanship skills, physical activity related to police work which may involve running or demands of physical altercation can influence fine motor skills as well. Brown, Tandy, Young, and Wolf (2013) provide the following in relation to this occurrence: “Shooting performance has been characterized by accuracy (i.e., deviation from target), precision (i.e., consistency), and stability of hold. Increases in postural sway and heart rate have been cited as factors contributing to diminished shooting performance” (p. 273). In explaining their stance on marksmanship skills and physical activity, Brown et al. (2013) add that there is some minor movement (i.e., tremor) of an outstretched arm expected, as this is likely the result of the body attempting to limit movement. This movement can be further exacerbated with additional weight
added to the arm, which in this case would be a loaded service pistol. Compounding this minor lack of stability, Brown et al. (2013) add, “Exercise-induced increases in heart rate and ventilation further contribute to the tremor. Thus, the physiological response to exercise is opposite to that needed in target shooting” (p. 274).

To combat the poor execution of movements related to marksmanship, law enforcement officers are required to demonstrate marksmanship ability at regular intervals through a process of qualification. This process though, is not without its flaws and many, including Thomasson et al. (2014), believe new approaches should be investigated, as they state with the following,

Despite the legal requirements for training to be more practical to constitute validity, it is common for law enforcement firearms qualifications courses and training to consist of static shooting exercises utilizing paper targets rather than realistic, dynamic training methods (Siddle, 1995). This method of training, as noted in the ruling in Tuttle v Oklahoma, offers little resemblance to scenarios that would likely be experienced during the course of day-to-day duties for a law enforcement officer and, thus, does not prepare law enforcement officers for the extreme levels of stress inherent in deadly combat.

The New York Police Department, one of the few agencies that has attempted to consistently keep shooting statistics, implemented a programme called ‘Standard Operating Procedure #9’ (SOP-9) which began in 1970 as a way to track police-involved shootings from incidents as wide ranging as confrontations to suicides. These statistics have shown a low hit percentage for officers shooting at suspects and, as would be expected, an even lower hit ratio for shots taken at increasingly longer distances, e.g. 4% at 25+ feet (Aveni, 2003). From the years 1990 to 2000, according to data collected from the New York Police Department SOP-9 (Aveni, 2003), the New York Police Department recorded only a 15% hit ratio when shooting at suspects. (p. 226)

The need for enhanced training is multiplied by the statistics mentioned above when consideration is given to the poor hit ratio demonstrated by a major municipal police department. Consider the other side of the statistic being an 85% first shot miss rate and the given danger created by the impact of the bullet somewhere other than within the intended target.

Additionally, actions that occur after the initial shot is fired by the police officer must be
considered. If it is deemed necessary to discharge their weapon, law enforcement officers must justify this action as being necessary for preserving the life of themselves or others. Until an assailant is stopped, their activity may continue, which places officers and bystanders at increased risk of harm or death. Further adding to the importance of control and precision movements of an office must undertake in a dangerous situation Biggs, Cain, and Mitroff (2015) make the following illustration:

Civilian casualties occur when shooters hit noncombatants with weapons fire (Kahl, 2007; Wright, 2003; cf. friendly-fire incidents, in which an ally is hit with weapons fire; Webb & Hewett, 2010), and this critical shooting error can have dramatic psychological, ethical, economic, and practical implications. Thus, every effort should be made to minimize these occurrences. (p.1)

Recently, efforts have been undertaken to quantify variables related to emotional stress and draw comparisons to physical activities and motor performance. Wegner, Koedijker, and Budde (2014) give several examples of physical activity and emotional stress that have a negative effect on fine motor skill performance. They mention further that there appears to be an inverted-U relationship between physical activity stress and fine motor performance. This finding amongst others, including Thomason et al. (2014), supports this relationship. Thomason et al(2014) specifically states,

Perhaps the most commonly adhered to theories on the effects of psychological stress on performance situations is the inverted-U hypothesis, which is based upon the work of Yerkes and Dodson (Graydon, 2002). According to the inverted-U hypothesis, if arousal is too low or too high, performance is negatively affected, which would lead to the conclusion that a person would perform optimally in a relatively moderate state of arousal. (p. 226)

Based on this statement it can be said that for physical activity to be performed at its greatest potential by an individual, that person must be under a moderate level of stress or stimulation. Greater or lesser levels of stimulation will result in a diminished level of performance. Given the stress involved in certain activities performed by law enforcement,
especially during a dangerous encounter where marksmanship is called upon, it is reasonable to understand that the individual officer may exceed the optimal level of stimulus and ultimately perform the activities of marksmanship with reduced technical proficiency. Nieuwenhuys and Oudejans (2010) explain this occurrence with two contributing factors related to stress response and physical activity:

First, anxiety is thought to draw attention away from task-relevant information toward more distracting stimuli such as threat-related information and internal worries, leaving less attention available to perform the task at hand. Secondly, anxiety may also serve a motivational function in that individuals can compensate for the debilitative effects of anxiety by increasing the amount of mental effort they invest in maintaining a task-relevant focus. (p.225)

Nieuwenhuys and Oudejans (2010) continue to explain how this relationship may be present in stressful situations where law enforcement officers are required to perform marksmanship skills as stress diminishes task relevant focus on several activities related to drawing and operating a firearm including aiming and trigger control of the weapon.

One challenge presented to researchers attempting to investigate fine motor skill performance under stress, is how to determine the level of stress placed upon the participant and if they are experiencing a fight-or-flight response to a given stimulus. As stated earlier in this paper, a fight-or-flight response creates several alterations of resting or homeostatic physiological mechanisms. Research into this topic must measure some of these physiological variables at an appropriate time before, during, and after a stressful situation to determine how an individual subject responds and if any fine motor skills were engaged while under a fight-or-flight response.

Several measurable variables related to stress response are available to researchers. In a paper written by Taverniers and Boeck (2014), borrowing from Karasek and Theorell (1990), the authors illustrated the multidimensional characteristics of stress exposure by stating, “Stress is a
systemic concept referring to a disequilibrium of the system as a whole, in particular of the
system’s control capabilities. Biological control systems include the brain, the heart muscle, and
psychoendocrine systems” (p.404). Other investigators including Thompson et al. (2015) and
Morgan, Aikins, Steffian, Coric, and Southwick (2007) also suggest the use of heart rate
variability as a possible less invasive means by which researchers can assess stress response
during performance of a wide range of activities. Morgan et al. (2007) define heart rate
variability as follows:

The term “heart rate variability” is used to describe all EKG derived variance data;
“heart period variability” is reserved for data derived specifically from inter heart beat
interval (IBI) values (Berntson et al., 1997). Thus, heart period variability (HPV) refers to
measures of variance that surround IBI values. Such measures are calculated primarily in
one of two ways. Time domain measures consist of standard descriptive measures of
variance. More sophisticated analyses treat IBI data as a time series from which
frequency components of heart period variability may be generated . . . . (p.120)

In measuring changes in heart rate during activity and examining inter beat interval, researchers
can assess stress levels through less invasive means.

Alternatively, research has pointed to a neuroendocrine variable of measure for stress
levels in individuals. Current technology provides researchers the opportunity to assess stress
response through the measurement of enzymes and hormones released into salivary gland
mention a link between the nervous and endocrine systems allowing for stress assessment with
the following:

Interestingly, it is generally assumed that endocrine and psychological stress responses
represent indicators of the same construct and thus a high psycho-endocrine covariance
should be expected. On a neuroanatomical level this hypothesis is corroborated by close
links between the HPAA and cortical and limbic structures, which are important
mediators of subjective-psychological stress responses. (p.164)
Application of this approach has been used in studies like those completed by Nater and Rohleder (2009), who state the following in their use of the salivary secretion of alpha-amylase as a measurement for stress response:

One parameter that has been suggested to reflect stress-related changes in the body is the salivary enzyme alpha-amylase . . . . Salivary alpha-amylase (sAA) release is known to be elicited by activation of the autonomic nervous system (ANS) which controls the salivary glands. It is a calcium-containing metalloenzyme that hydrolyzes the α-1,4 linkages of starch to glucose and maltose. It is known to be mainly involved in the initiation of the digestion of starch in the oral cavity. (p. 487)

Salivary alpha-amylase has also been recognized as a valid biomarker for stress research according to Granger, Kivlighan, El-Sheikh, Gordis, and Stroud (2007), who illustrate the valid use of salivary alpha-amylase as a measurement of sympathetic nervous system activity in situations including stressful social activities, heat and cold stress, written examinations, and collegiate-level individual sport competition.

Similarly, literature suggests that other factors can be used to measure sympathetic nervous system activity for the assessment of stress levels in social situations and physical activities. Hellhammer et al. (2009) suggest the use of salivary cortisol measurement as an assessment of stress response due to its simplicity in collection and its link to HPA axis activity. However, they caution researchers, saying, “Several additional variables, such as adrenal sensitivity, capacity, cortisol binding, etc. affect total and free cortisol levels in blood, and, finally, salivary cortisol levels. Thus, perceived stress can only be expected to be moderately associated with salivary cortisol” (Hellhammer et al., 2009, p.168).

Groer et al. (2010) found that cortisol measurement from saliva samples of individuals experiencing different stressful situations correlated closely with other variables related to stress
response and providing a validation for its use as well. From their research, Groer et al. (2010) state the following:

The salivary cortisol response observed in the workplace group suggests activation of the HPA. Although the complexity of the HPA response suggests that there are not universal linear relations between various stressors and corticotrophin releasing hormone, adrenocorticotropic hormone, and cortisol, our observation of a rise in salivary cortisol concentration over time suggests that the brain did perceive the scenario as significantly stressful and activated the HPA. (p.597)

Their findings suggest that salivary cortisol is a useful measure of stress response during the observation of high-stress situations. Strahler and Ziegert (2015) measured several physiological variables related to stress response and found a strong correlation between cortisol and others, including salivary alpha-amylase, heart rate, and heart rate variability, given different stressful situations and timing of involvement in dangerous situations.

Biggs et al. (2015) state that operating a firearm involves a complex set of actions, each linked to its own ability. More specifically, Biggs et al. (2019) say,

For example, finding appropriate targets involves visual search, determining whether someone is a friend or foe involves decision-making processes, taking aim involves perceptual estimations of distance and motion, and squeezing the trigger (or withholding the shot) involves response execution (or inhibition). (p.1)

Resulting from the inherent dangers of a situation where a law enforcement officer must draw their weapon, it is very likely that the officer will be experiencing a strong psychological and physiological stress response and as a result, performance decrements may be expected. Therefore, investigation is needed to build upon existing knowledge of how performance of fine motor skills, in particular those related to pistol marksmanship, can be altered by increasing levels of stress or anxiety. The purpose of this examination was to determine how increased levels of stress affect the performance of fine motor skills related to pistol marksmanship in law enforcement officers.
Hypotheses

The following hypotheses were tested during this investigation.

1. Conditions under which a firearm is used will alter the performance of trained law enforcement officers.

   *Independent Variables:* Firearms qualification and training procedure
   
   *Attributes:* TI Simulation Use of Force Encounter with Dangerous Subject
   
   *Control:* State of Illinois Law Enforcement Firearms Course-of-Fire
   
   *Dependent Variable:* Marksmanship Skill
   
   *Attribute:* Shots fired scored as Hit or No-Hit
   
   Paired samples $t$-test comparing hit percentage of modified IFQC to Simulated Conflicts 1 and 2.

2. There will be an inverse relationship between stress biomarker cortisol levels found in saliva samples and marksmanship skills observed in law enforcement officers undergoing a simulated deadly encounter.

   *Independent Variables:* Firearms qualification and training procedure
   
   *Attributes:* TI Simulation Use of Force Encounter with Dangerous Subject
   
   *Control:* Resting State
   
   *Dependent Variable:* Salivary Cortisol Concentration
   
   *Attribute:* Stress level in response to operating a firearm in two scenarios
   
   Pearson Correlation between change in cortisol levels from resting and hit percentage after two simulated conflicts

3. There will be an inverse relationship between stress biomarker alpha-amylase levels found in saliva samples and marksmanship skills observed in law enforcement officers undergoing a simulated deadly encounter.
Independent Variables: Firearms qualification and training procedure

Attributes: TI Simulation Use of Force Encounter with Dangerous Subject

Control: Resting State

Dependent Variable: Salivary alpha-amylase Concentration

Attribute: Stress level in response to operating a firearm in two scenarios

Pearson Correlation between change in Salivary alpha-amylase levels from resting and hit percentage after two simulated conflicts

4. There will be an inverse relationship between heart rate and marksmanship skills observed in law enforcement officers undergoing a simulated deadly encounter.

Independent Variables: Firearms qualification and training procedure

Attributes: TI Simulation Use of Force Encounter with Dangerous Subject

Control: Resting State

Dependent Variable: Heart Rate

Attribute: Stress level in response to operating a firearm in two scenarios

Pearson Correlation between change in heart rate levels from resting and hit percentage after two simulated conflicts

5. There will be an inverse relationship between blood pressure and marksmanship observed in law enforcement officers undergoing a simulated deadly encounter.

Independent Variables: Firearms qualification and training procedure

Attributes: TI Simulation Use of Force Encounter with Dangerous Subject

Control: Resting State

Dependent Variable: Blood Pressure

Attribute: Stress level in response to operating a firearm in two scenarios

Pearson Correlation between change in blood pressure levels from resting and hit percentage after two simulated conflicts
Statement of the Problem

The problem in this study was to investigate changes in physiological stress response and shooting performance of law enforcement officers under varying levels of stress. More specifically, this study aimed to determine how increasing levels of stress from operating a firearm on static targets change when law enforcement officers are subjected to a simulated life-threatening or dangerous situation. The researcher recorded heart rate, blood pressure, and salivary biomarker concentrations while participants engaged in various marksmanship scenarios as well as shooting-specific performance scored by hits on targets in a simulated encounter.

Performance changes associated with high levels of stress have been well documented in disciplines such as sports psychology, medicine, and military/law enforcement fields. However, little work has been done to draw comparisons between training methods and qualification procedures which closely mimic armed conflict. To date, there is no known investigation pointing to differences in stress levels of law enforcement personnel during various training methods in comparison to armed conflict situations. Gaining insight into these variables may shape the way law enforcement officers are trained to handle armed conflict and potentially alter the methods of qualification for officers to assess their preparedness to act in defense of themselves or others with the use of deadly force. The outcomes from improved styles of training and qualification may result in fewer incidents of injury and death of officers and innocent bystanders. Protecting members of the community from harm is a primary goal of law enforcement agencies, and providing officers with the most effective training and preparation for conflict is one way to enhance the effectiveness of officers’ actions in saving lives.
CHAPTER 2

METHODOLOGY

Subjects

Thirteen police officers between the ages of 25-55 were recruited using a flyer (Appendix A) to participate in this simulation-based study. Subjects included police and/or officers from Special Weapons and Tactics (SWAT) teams from municipal police departments and county sheriff’s departments with varying lengths of service. Identifying officers with SWAT experience may be particularly relevant, as in most cases SWAT officers have received additional training in skills related to this investigation. According to Pryor, Colburn, Crill, Hostler, and Suyama (2012), “Special Weapons and Tactics (SWAT) operators resolve unique situations beyond the duties of regular LEOs such as hostage rescue, clearing dangerous scenes, and diffusing riotous situations and events involving snipers or terrorists” (p. 752). As such, these officers will have additional training in marksmanship skills and related equipment use. Exclusion criteria for this investigation included uncontrolled hypertension and/or cardiac arrhythmias. Only male subjects were eligible to participate in this investigation due to hormonal differences between male and female subjects as well as possible risks to unborn children due to loud noises and any risk of falling during experimental activities. Participants provided a health history through self-reported means via the health history questionnaire (Appendix B). All participants in this experiment were full-time, active duty law enforcement officers with at least one prior firearms qualification experience within their respective departments.
All subjects were informed of the risks and benefits associated with this investigation and provided written consent (Appendix C) prior to participating, in accordance with Northern Illinois University’s Institution Review Board and the Institution Biosafety Committee. Permission to conduct this study was approved by the departmental review boards of the testing location.

Experimental Design

This study used a counterbalanced quasi-experimental design. Each subject participated in two different conditions separated by at least 48 hours with different levels of complexity and stress. After initial baseline data was collected at rest using the form found in Appendix D, subjects were randomized between two different assessments: (1) basic pistol qualification procedures (operating their standard duty firearm against static simulation targets within the time limit adopted from the Illinois Law Enforcement Training and Standards Board), and (2) a simulated conflict (involving complex problem-solving and challenging marksmanship activities including encounters with simulated aggressive assailants). The basic pistol qualification course adopted from the Illinois Law Enforcement Training and Standards Board included stages of fire similar to those outlined in Appendix E. Short distance shooting required the participants to draw the pistol from a holster and fire 2 rounds in 6 seconds repeated 6 times for a total of 12 possible shots. Middle distance shots continued the pattern of 2 shots fired in 6 seconds repeated 6 times, for 12 total shots. The longest distance stages included drawing from the holster and firing 1 shot in 6 seconds for 6 total rounds during this portion of the course. This format allowed for 30 shots to be taken across 3 distances.

Subjects began the virtual reality condition after receiving a situational report on how to approach their scenario as a real-life call in the line of duty. A state-certified range master was
on site at all times during the experience and was able to provide feedback to the participants in relation to law enforcement procedures, as would be the case in a live training exercise.

Preliminary Screening and Study Protocol

During the preliminary screening, subjects completed a health history questionnaire (Appendix B) and consent form (Appendix C). Each subject wore a heart rate monitor for the duration of the investigation, with data collected between each course of fire adopted by the Illinois Law Enforcement Training and Standards Board. Initial measurements included resting heart rate, blood pressure, and saliva samples with each subject seated quietly. Once paperwork was completed, subjects rested for 10 minutes and then had their baseline saliva samples taken for cortisol and salivary alpha-amylase.

Assessment of Heart Rate and Blood Pressure

Each subject was given a Polar FT60 heart rate monitor (Polar Electro, Lake Success, NY) to wear over the entire course of data collection. Heart rate monitor display watches were worn by each participant on their wrists to be read by investigators between courses of fire. Heart rate data was collected immediately prior to beginning and between each section of the course of fire. Final heart rate data was collected immediately at the conclusion of the courses of fire.

Blood pressure data was collected by the same master’s-level exercise physiologist prior to beginning any conditions, with the subjects resting in a seated position for baseline. Immediately at the completion of each condition, once the subjects had made safe and holstered their firearm, blood pressure was measured and recorded again in a seated position.
All data was collected using the data collection sheets included in Appendix D, including heart rate, blood pressure, shots fired, and shots hit by each participant.

**Assessment of Salivary Biomarkers**

To best assure that proper collection took place, subjects were asked not to eat, drink beverages other than water, or smoke within 1 hour of testing time. Baseline salivary samples were collected 5 minutes following completion of their paperwork.

At the termination of each marksmanship scenario, saliva samples were collected at the 10-minute post-termination point to insure samples were taken at the greatest possible concentration level for both cortisol and salivary alpha-amylase. Samples were kept frozen and sent to Salimetrics (State College, PA) for analysis. Analysis included enzyme-linked immunosorbent assays for cortisol and enzymatic reaction performed with reagents for alpha-amylase. Samples were thawed to room temperature, vortexed, and then centrifuged for 15 minutes at approximately 3,000 RPM (1,500 x g) immediately before performing the assay. Samples were tested for salivary cortisol using a high sensitivity enzyme immunoassay (Cat. No. 1-3002). Sample test volume was 25 μl of saliva per determination. The assay has a lower limit of sensitivity of 0.007 μg/dL, a standard curve range from 0.012-3.0 μg/dL, an average intra-assay coefficient of variation of 4.60%, and an average inter-assay coefficient of variation 6.00%, which meets the manufacturer’s criteria for accuracy and repeatability in salivary bioscience, and exceeds the applicable NIH guidelines for enhancing reproducibility through rigor and transparency.
Assessment of Marksmanship Scoring

Initial marksmanship scores were determined on a flat simulated shooting range within a TI Training Simulator (TI Training, Golden, Colorado) against static overlay/center mass of targets, with each subject using a battery-operated pistol with marking laser. Prior to each round of data collection, the TI Training Simulator was calibrated using the same laser marking pistol to ensure accuracy of shots placed by each subject. Each participant was asked to follow a course of fire adopted from the Illinois Law Enforcement Training and Standards Board, which can be found in Appendix E. Scoring data included number of shots taken and counted as either “Hit” or “No-Hit” in accordance with the standard qualification procedure.

The second condition required each participant to engage in two simulated dangerous encounters with virtual suspects using a TI Training Simulator (TI Training, Golden, Colorado). This activity required the participant to perform duties as they would in a real-life situation, including discharging of their firearm at various intervals against an unknown number of assailants. Hit percentage scores were collected for each subject, including those against multiple targets in succession and simultaneously. Scoring data included the number of shots taken and counted as either “Hit” or “No-Hit” in accordance with the standard training procedure.

Statistical Analysis

Data were analyzed using the computer software program IBM SPSS (version 22.0, Chicago, IL). Changes in heart rate, blood pressure, and cortisol levels from resting values were analyzed using a Pearson correlation to determine if changes in heart rate, blood pressure, and salivary cortisol correlate to changes in accuracy of marksmanship. To determine if the different shooting scenarios resulted in different levels of accuracy, a paired-samples t-test was performed.
comparing hit percentages of the modified Illinois Firearms Qualification Course-of-Fire to the
two simulated conflicts. Cohen’s $d$ analysis was used to illustrate the mean standardized
difference of hit percentage between qualification course-of-fire (mIFQC) and the simulated
conflicts (SimCon1 and SimCon2).
CHAPTER 3

REVIEW OF CURRENT LITERATURE

The effects of acute stress response are well documented in literature across multiple disciplines including physiology and psychology. New research is emerging in the field of psychoneuroendocrinology to better understand how the psychological response to stressful situations effects the human body during both acute and chronic exposures. Currently research is being done to examine the effects of acute stress response on fine motor skill performance, but little is fully understood on what variables of human stress response directly contribute in altering the performance of such activities. Specific research in this area is being conducted on military and law enforcement officers who can be exposed to the highest levels of stress during life-threatening situations involving armed combat.

Groer et al. (2010) utilized 141 participants from law enforcement departments to examine the effects of a critical incident lethal force scenario on the levels of stress biomarkers found in saliva at baseline and 10 and 30 minutes post exposure. According to Groer et al. (2010), salivary biomarkers can provide a view of endocrine and immune system activity brought about by a stressful situation. During this study, participants were randomly assigned to two groups who each participated in a different simulated scenario involving dangerous police work on a large screen. Scenario 1 involved the participants (n=49) watching a law enforcement officer pursue a suspect riding a motorcycle. As the pursuit ends, the officer confronts the suspect, who draws a gun and shoots the police officer. The total time for this scenario is 2
minutes. The second scenario involved participants (n=92) simulating a law enforcement officer responding to an active shooter call at an office building. During the 6-minute scenario, the officer is involved in tracking the active shooter through several areas of the office building, with the expected chaotic events unfolding with innocent bystanders and a violent suspect.

Baseline data was collected on all participants after they performed several movements related to marksmanship including standing, walking, and kneeling. According to the author, this was done to “control measures of physiologic responses while controlling for movement” (Groer et al., 2010, p.596). After baseline activities, saliva samples were collected for analysis. After each scenario, participants provided a similar saliva sample at 10 minutes and again at 30 minutes after the conclusion of the simulation.

Salivary samples collected by Groer et al. (2010) were analyzed for alpha-amylase, cortisol, immunoglobulin A and interleukin-6. Salivary cortisol increased from baseline to 10 minutes post scenario and maintained at elevated levels through the 30-minute mark for participants who viewed the workplace violence scenario. Scenario 1 involving the motorcycle chase showed no significant increase in salivary cortisol. Alpha-amylase levels increased for both groups from baseline values. The workplace scenario provided a significant increase, whereas the motorcycle scenario showed an increase with marginal significance.

Charles and Copay (2003) evaluated the level of skill acquisition of marksmanship skills learned though the training of a current law enforcement department. Several skills including stance variation, trigger control, gun handling, malfunction clearing, and marksmanship performance were evaluated. These skills were evaluated via a test re-test method using recruits (n=216) who had no prior formalized training with firearms. Each subject was evaluated in the variables listed above, with performance scores determined by the standard evaluation
procedures set forth by the standard law enforcement academy protocols. After the initial testing period, each student participated in a formalized police firearms training course. At the completion of the firearms training course, the subjects were reassessed using the same testing procedures as the pre-test. Results from the investigation showed a significant improvement in marksmanship scores between the pre- and post-tests. Male subjects improved to a greater extent than the female subjects. Other variables including gun handling, loading and unloading the weapon, and clearing of malfunctions increased significantly in speed and proficiency when comparing the pre-test to the post-test. These results suggest a significant improvement in several firearms-related skills when individuals participate in firearms training courses; however, further investigation is needed, as the author notes that trained police officers’ first-round hit rates are still significantly lacking in appropriate performance levels when comparing training scenarios to real-world experiences.

As noted by Charles and Copay (2003), police training programs can have a strong effect on the physical performance of marksmanship skills on both male and female officer recruits. However, the controlled environment of this teaching method and its intent to deliver marksmanship-specific skills, including variables such as stance variation, trigger control, gun handling, malfunction clearing, and marksmanship performance, only include the basics of marksmanship and do not allow for the physical or mental stress of operating a firearm in a real-world dangerous encounter.

Given some of the physical activities related to police work including running pursuit, control tactics, and suspect apprehension techniques, it is possible the officers may be forced to operate their firearm while under the stress of physical activity. As physical activity increases, the body’s natural responses and fatigue may influence physical performance of skills such as
Lakie (2010) mentions that the involuntary movements of a marksman can have a great effect on the performance of shooting. In previous studies, physiological tremors have been found to have a demonstrable inverse correlation with shooting performance. The purpose of this paper was to provide evidence for the sources of physiological tremor and to determine how it may influence shooting performance. The definition of physiological tremor as well as several contributing factors were listed within the paper. The role of physiological tremor is well documented across disciplines, including military and law enforcement sharp shooters, as well as competitors in the winter event of the Biathlon.

In support of the article by Lakie, Brown et al. (2013) examined how physical activity inducing fatigue affects shooting performance. Brown et al. (2013) suggest that previous literature shows rifle shooting performance is diminished when the ability to stand is hampered by bodily fatigue. Accordingly, Brown et al. (2013) note that several law enforcement jobs require long hours spent with officers on their feet and occasionally involved in foot chases. If the need arises that a fatigued officer must use his or her weapon, it is reasonable to assume that their performance will be reduced. The purpose of this study was to investigate the pistol-shooting performance in police officers under conditions of physical fatigue. Eight police officers volunteered for this investigation. Shooting performance was assessed before and after exercise bouts on the same day. Exercise protocols included several bouts on a cycle ergometer for a predetermined duration at 85% of estimated VO2 max. During this investigation it was found that shooting accuracy was identical before and after exercise. Shooting precision was also assessed and was determined to be unchanged from pre-exercise to post-exercise. In this case, heart rate was not a predictor of shooting accuracy or precision. Charles and Copay (2013) noted that in this case, subjects were assessed in rifle marksmanship abilities, which differ in
several mechanical variables from pistol marksmanship skills, including weapon stability and support.

Taverniers and Boeck (2014) explored several human factors in response to reality-based “force–on-force” training with 20 military personnel under two conditions. The two conditions used in this exploration included simunition based force-on-force practice and standard cardboard target practice. Variables examined during the study included subject-reported anticipated distress, salivary alpha-amylase, shooting accuracy, and subject-perceived training seriousness. Results showed that subjects reported significantly more anticipated distress with force-on-force practice compared to cardboard target practice. Additionally, the stress-related biomarker of salivary alpha-amylase was significantly higher in the force-on-force practice when compared to the standard cardboard target practice. Shooting performance by the subjects also became significantly degraded in the force-on-force practice when compared to the cardboard target practice, illustrating the possibility that fine motor skill performance may be altered when individuals are placed under increased levels of psychological stress through perceived danger. These results showed that simunition based force-on-force practice is an effective tool for training of officers within a stressful environment, as it appears to closely mimic the real-life situations faced by officers in armed conflict as evidenced by the increased stress response biomarker levels and poor shooting performance.

Thomasson et al. (2014) investigated the effects of differing stressors commonly found during exercises of handgun training on law enforcement officers. Two variables measured included shooting performance and heart rate. Eight police officers (7 male, 1 female) participated in four differing exercises, including shooting static targets from multiple body positions, run and shoot exercises requiring the participants to run a distance of 50 meters to
elevate their level of physical stress before shooting at static cardboard targets, simulated shoot house exercises using shoot and no-shoot paper targets, and simunition based force-on-force practice which, according to Thomasson et al. (2014), proceeded in the following manner:

Before beginning, officers were briefed on the situation with which they would be presented, as if being sent by an emergency dispatcher. Upon entering the combat scenarios, officers followed protocol for the scenarios to which they were assigned. Varying scenarios, such as hostage active shooter situations, were presented to each group. In the different scenarios, officers were presented with armed “suspects”, also carrying modified guns shooting marking cartridges that presented a threat to the officer and/or others. Officers were required to wield their weapons and stop the “threat”. (p. 229)

Results from the Thomasson et al. (2014) investigation showed that, as the physical and psychological stress increased for the participants, shooting hit percentages decreased across all participants. The results of this investigation indicated that physical and psychological stress can greatly diminish marksmanship performance. Additionally, based on the results of this study, traditional police firearms qualification procedures may be invalid as adequate preparation for deadly conflict.

Acknowledging the physical and technical training that goes into law enforcement as well as the continued training and preparation seen through regular qualification with firearms, Oudejans (2008) set out to determine if more realistic training exercises would allow a law enforcement officer to perform at a higher level when placed under the psychological stress of armed conflict. Utilizing 17 participants, Oudejans (2008) created two groups for study and compared training methods involving either low-pressure or high-pressure training methods. This examination involved a pre-test, followed by three training sessions and a post-test. Testing involved both high-pressure and low-pressure tests and were performed as follows: “In the low-pressure test, participants shot at cardboard targets. In the high-pressure test participants shot at
an opponent, one of the certified firearms instructors, who also fire[d] back with marking cartridges” (Oudejans, 2008, p. 264).

Training protocols followed a similar design to the tests created for this investigation. The low-pressure training group participated in firearms training utilizing only cardboard targets simulating shooting at an individual’s legs and chest in a prearranged pattern. The high-pressure training group was exposed to similar shooting patterns and targets but in their training sessions, the targets were worn by training officers who would periodically shoot back at the participant with marking cartridges which would have a noticeably painful impact on the participant, thereby increasing the pressure to perform quickly and accurately. Data from this investigation included hit percentages measured by shots on target and heart rate taken during the testing procedures, as well as anxiety scores taken from surveys conducted during pre-test and post-test events.

Results from the Oudejans (2008) investigation showed a moderate correlation in high-pressure testing protocols manifesting a heightened level of anxiety amongst participants. More specifically, during the post-test high-pressure scenario, the pressure condition of an opponent firing back did create heightened anxiety. Heart rate data collected during testing showed a marginal correlation between groups, with the control group showing higher heart rates during high-pressure testing when compared to the experimental group. Of greatest note was shooting percentages. Comparisons between experimental and control group showed both groups’ performance degraded in high-pressure tests in the pre-testing event and, after training sessions, the drop in performance remained for the low-pressure training group while the high-pressure group showed no change in performance with high-pressure testing during the post-test events. Oudejans (2008) reported,
an opponent led to a measurable increase in pressure as revealed by higher anxiety scores as well as higher heart rates for both groups. In line with the expectations, shooting performance of the experimental group, who had practiced with pressure, no longer deteriorated in front of a real opponent during the post-test while that of the control group, who had practiced without additional pressure, still did. (p. 270)

The author adds that reality-based training clearly demonstrates a greater effect for the performance of law enforcement officers involved in armed conflict.

Lewinski, Avery, Dysterheft, Dicks, and Bushey (2015) investigated the level of shooting accuracy demonstrated by law enforcement recruits upon completion of their law enforcement firearms training in comparison with novice shooters. Participants included 247 law enforcement recruits divided into groups by level of firearms experience (expert, intermediate, novice). Each subject was evaluated on shooting abilities from ranges between 3 feet and 75 feet. At all ranges there were no significant differences between the groups considered to be expert and the group classified as intermediate. Novice shooters were the least proficient at all ranges for the test and results were significant when compared to the other groups. Experts did, however, only perform 10% more accurately with a firearm at distances between 3 and 15 feet when compared to novices. The results of this study indicate that expert law enforcement officers had no advantage over intermediate shooters and a small advantage over novices at various ranges of shooting.

Shooting involves a series of several steps, all performed with a high level of precision and often in a very short period of time. Cognitive abilities and other decision-making skills combine with several physical parameters when an individual executes the accurate and timely discharge of a firearm. Biggs et al. (2015) investigated the relationship between shooting and cognition in a simulated environment, specifically examining civilian casualties and response inhibition. Eighty-eight participants performed a baseline pre-training session involving
electronic simulation of shooting exercises as well as multiple surveys related to their tasks, including assessment of the participants’ impulsivity, symptoms of ADHD, and an individual’s desire to maximize outcomes. The participants were then asked to perform similar tasks after receiving two types of cognitive training over the course of 4 days before retesting with similar computer simulations. One group (n=28) performed Response Inhibition Training involving a 30-minute Stop Signal Reaction Time (SSRT) task and an IPAD based Go/No-Go task. Meanwhile, the other group (n=29) performed Visual Search Training (VST) with the purpose of enhancing an individual’s visual search consistency. After the 5-day training and examination period, results showed improved shooting performance, including fewer civilian casualties seen when training of marksmen involves cognitive training including Response Inhibition Training. Visual Search Training did not the occurrence of civilian casualties. Biggs et al. (2015) observed four links to cognitive training and shooting skills, as illustrated in the following:

First, individuals with lower inhibitory control and higher attentional impulsivity were more likely to shoot civilians in the simulated scenarios. Second, significant relationships between simulated civilian casualties and attentional measures, but not between civilian casualties and motor-impulsivity measures, suggest a cognitive underpinning of the relationship—an itchy brain more so than an itchy trigger finger. Third, response-inhibition training offers exciting potential to inform future training procedures, which might ultimately reduce unintended casualties. Finally, individuals who self-reported high levels of ADHD symptoms benefited most from the response-inhibition training—which suggests not only that some people benefit more from training than others, but also that such individuals could be identified prior to training. (p.9)
CHAPTER 4
RESULTS

The purpose of this investigation was to determine how varying levels of stress created by different marksmanship drills paralleled the accuracy of participant shot placement. Fifteen police officers who met participation criteria were selected to participate in this study; two subjects were removed because they did not complete all phases of the study. A total of thirteen subjects completed all phases of this study.

Marksmanship Performance

After data collection had been completed, a paired-samples \( t \)-test was done to determine if a significant difference existed in the accuracy of shooting between the modified Illinois Firearms Qualification Course-of-Fire (IFQC) and two simulated conflicts (SimCon1, SimCon2).

Hit Rate: Simulated Conflict 1

During the modified IFQC, participants fired 390 total rounds at targets, with 387 falling within the target area, resulting in a 99.23% hit rate. During the first simulated conflict (SimCon1), participants fired 56 total shots, with 27 of them recorded as hits to the intended targets. This yielded a 47.48% average hit rate with an individual range of 100% hit rate to 0% hit rate across participants. Median hit percentage for Simulated Conflict 1 was 37.50%. A box plot generated using SPSS (version 22.0, Chicago, IL) depicting the distribution of hit percentage between the modified IFQC and SimCon1 is shown in Figure 4.1.
Figure 4.1: Shot hit Percentage of mIFQC and Simulated Conflict 1.

**Hit Rate: Simulated Conflict 2**

During the second simulated conflict (SimCon2), participants fired 41 total shots, with 23 hitting their intended target. This yielded a 50.13% hit rate with an individual range of 100% hit rate to 0% hit rate across participants. Median hit percentage for Simulated Conflict 2 was 50.00%. A box plot generated using SPSS (version 22.0, Chicago, IL) depicting the distribution of hit percentage between the modified IFQC and SimCon2 is shown in Figure 4.2.
Figure 4.2: Shot Hit Percentage of mIFQC and Simulated Conflict 2.

A paired samples $t$-test comparing hit percentage of the modified IFQC to SimCon1 showed a mean difference between the two tests as 51.75% with a standard deviation of 28.19%. The $t$ statistic between the modified IFQC and SimCon1 was 6.62 with a significance level of $p = .000025$. A paired samples $t$-test comparing hit percentage of the modified IFQC to SimCon2 showed a mean difference between the two tests as 49.10% with a standard deviation of 34.74%. The $t$ statistic between the modified IFQC and SimCon2 was 5.01 with a significance level of $p = 0.000263$. With both tests showing statistical significance with $p<0.05$ the null hypothesis was rejected. To further illustrate the effect size, a Cohen’s $d$ test was performed between means of the modified IFQC and SimCon1 which resulted in a score of 2.5598; the same test for the modified IFQC and SimCon2 resulted in a score of 1.9415. According to Rice and Harris
(2005), Cohen’s D scores of .2, .5, and .8 represent small, medium, and large effects, respectively. With the results from this study yielding much larger scores of over 2.5 and 1.94, we conclude that there is a very large effect size between the modified IFQC tests and both simulated conflicts.

Salivary Cortisol and Alpha-Amylase

Saliva samples analyzed for the biomarker alpha-amylase yielded insufficient results and were not included in the analysis portion of this experiment. Due to one sample providing insufficient saliva for both cortisol and alpha-amylase, one sample of cortisol was missing from the data set and labeled as QNS (quantity not sufficient). In this instance, we were able to impute the mean from the remaining data to provide a data point for the single missing cortisol level. Salivary cortisol was measured at resting and again after the completion of the modified IFQC and the 2 simulated conflicts (SimCon1 and SimCon2). With the known decrease in accuracy as shown above, a Pearson’s r correlation was used to assess any relationship between the change in salivary cortisol with performance in the two simulated conflicts. By including the hit percentages of both simulated conflicts together, as they were completed collectively before the salivary cortisol was measured, the Pearson statistics showed no relationship between the two variables. The Pearson correlation between salivary cortisol and hit percentages recorded during the simulated conflicts yielded .010 and a significance of \( p = .975 \). A scatter plot of both simulated conflicts total hit percentage and salivary cortisol change from resting is shown in Figure 4.3.
Heart Rate

Heart rate data was collected several times throughout the experiment and for both the modified IFQC and the simulated conflicts. To find the greatest possible effect of the shooting experience on heart rate, statistical analysis took place on the data representing the change from resting heart rate to the data collected immediately after the shooting activities. In recognition of the significantly decreased accuracy taking place during the simulated conflict in comparison to the modified IFQC, analysis focused on the simulated conflict to find any correlation between change in heart rate from resting and decreased shooting accuracy. The Pearson correlation between heart rate and hit percentages recorded during the first simulated conflict (SimCon1)
yielded .022 and a significance level of $p = .943$. With the test repeated after the second simulated conflict (SimCon2), the Pearson correlation yielded $- .35$ and a significance level of $p = .909$.

**Blood Pressure**

Blood pressure data was collected at rest, immediately prior to beginning any course of fire and once each simulation was completed. To find the greatest possible effect of the shooting experience on blood pressure, statistical analysis was conducted on the data representing the change from resting heart rate to the data collected immediately after the shooting activities. Once again, with the significantly decreased accuracy taking place during the simulated conflicts in comparison to the modified IFQC, analysis focused on the simulated conflicts to determine any correlation between change in blood pressure and decreased shooting accuracy. During Simulated Conflicts 1 and 2 the average change in participants’ systolic blood pressure was 18.77 mmHg and 23.08 mmHg, respectively. Diastolic blood pressure had an average change for the same tests of 4.15 mmHg and 5.54 mmHg. When comparing the change in systolic blood pressure to shooting performance, a Pearson correlation for SimCon1 showed a correlation of $- .104$ and a significance level of $p = .735$. A scatterplot representing the relationship between systolic blood pressure and shot hit percentage during SimCon1 is shown in Figure 4.4.

For SimCon2, the same statistical approach showed a correlation of $- .429$ and a significance level of $p = .144$. A scatterplot representing the relationship between systolic blood pressure and shot hit percentage during SimCon2 is shown in Figure 4.5.

In summary, a profound difference in shooting performance between the modified IFQC and the two simulated conflicts (SimCon1 and SimCon2) was observed in the significant change
in total hit percentage between the two tests. No significant correlations between the diminished performance of the subjects were found with any physiological data collected for this study. Post hoc analysis confirmed the poor correlation between the physiological variables of salivary cortisol, heart rate, and blood pressure with the participants’ performance in the simulated conflicts. Post hoc analysis showed 2.7% power between salivary cortisol and shooting performance at the lowest end and 30.5% power between systolic blood pressure and shooting performance at best during Simulated Conflict 2.

Figure 4.4: Relationship Between Change in Systolic Blood Pressure and Hit Percentage During Simulated Conflict 1
Figure 4.5: Relationship Between Change in Systolic Blood Pressure and Hit Percentage During Simulated Conflict 2
CHAPTER 5
DISCUSSION

Discussion of Results

This study investigated how shooting performance of trained active duty law enforcement officers changed when they experienced conditions of varying levels of stress. This investigation used a simulated conflict created using a TI Training Simulator (TI Training, Golden, Colorado) housed within a law enforcement departmental training facility. Subjects underwent three different courses of fire, including the modified State of Illinois Firearms Qualification Course (IFQC) and two simulated conflicts (SimCon1 and SimCon2) involving scenarios where each subject was required to draw their weapon and fire against an armed assailant.

SimCon1 involved an officer in pursuit of an armed female subject through a gated backyard of a residential neighborhood. After the female subject is stopped near a locked gate, she appears to comply with actions likely given to a subject where she drops her weapon and walks backward toward the arresting officer. At this point, another armed individual suddenly appears from around the corner of the residence, armed with a shotgun. Very quickly, that subject raises the shotgun and proceeds to open fire in the direction of the officer. This action would necessitate the officer fire their weapon at the second individual after rapidly assessing the situation to be threatening.

SimCon2 placed the officer outside of a residence in response to a noise complaint from a neighbor. After approaching the house, several individuals can be heard screaming at one
another through the open front door. The officer enters the home, where a visibly upset female subject can be seen at the end of a narrow hallway. The simulation continues with the officer approaching the female subject down the hallway where they enter a large living room area with a male subject seated in front of a fireplace. In the hands of the male subject is a shotgun which lays across his lap; however, once the male subject notices the officer, he quickly raises the shotgun and opens fire on the officer. This action would necessitate the officer fire their weapon at the male subject after assessing the situation to be threatening.

Similarities exist between the two scenarios in that the officer’s initial attention was directed toward another individual before recognizing the presence of the second subject. Furthermore, in both instances, the officer was required to act in a confined space against only a single known threat. One significant difference between the two simulated conflicts included the need for rapid target acquisition after transitioning from the female subject who complies with commands and the second subject appearing from around the corner in SimCon1. During SimCon2, the second subject is very clearly armed with a weapon but acts quickly to attempt to harm the officer.

During these simulation exercises, there were no repercussions to the officers as seen with other simulation equipment, including marker ammunition fired back at the officers or the use of electric shock to establish the threat of harm to the officer. However, if the participating officer did not draw their weapon and accurately fire against the threat, the screen would change to black, indicating the officer would have been struck by the assailant’s fire. Additionally, all shooting exercises took place under the eye of a departmental rangemaster who would provide useful feedback once the scenario concluded, which may have added to some level of stress or anxiety on the part of the participants. All data collection took place during regular hours of
work for the participants and each participant was on duty and beginning a shift during the time of data collection.

According to Taverniers and Boeck (2014), the purpose of this style of training, and other force-on-force simulations, is to “familiarize armed officers with working under pressure, anxiety and stress” (p.410). Working under the condition of stressful situations can be useful in high-pressure jobs such as law enforcement and the use of simulation training and other force-on-force training modalities can have a positive effect on an individual’s ability to function under stress. Thompson et al. (2015) add, “The effect of an excessive sympathetic response is detrimental to cognitive and psychomotor tasks, such as shooting performance. Repetitive exposure to this constant strain can develop a stress inoculation effect, rendering less of a sympathetic response to similar stimuli” (p.932). Though it is highly unlikely that real-life data on the physiological effects of armed combat by police could accurately or appropriately be measured, the use of technology like this can begin to show officers what they may experience in a deadly encounter and can provide researchers with a controlled environment in which to examine several aspects of human performance under stress.

Based on the results of this investigation, it should be noted that the type of simulation used in this study did elicit a physiological response by the participants, including a mean heart rate increase of 16.46 beats per minute after SimCon1 and 19.70 beats per minute after SimCon2, and increased mean systolic blood pressure of 18.77 mmHg and 23.08 mmHg across the two simulated conflict trials. As Thompson et al. (2015) noted, several studies have shown that an increased arousal during stressful situations can influence psychomotor tasks, including the skills related to marksmanship. Authors Oudejans (2008) and Nieuwenhuys and Oudejans (2010) found results from similar studies where shooting performance during stressful situations was
significantly diminished in both military personnel and law enforcement officers. However, although a physiological response was noted during this investigation, it did not statistically correlate with the change in shooting performance of the group.

A couple of other factors must be considered when physiological response does not appear to have a relationship to diminished fine motor skills, as was the case in this investigation. The first consideration includes whether the simulation was creating enough of a physiological response to drive the participants to a state of arousal where diminished performance would consistently occur over a greater number of participants. As Wegner et al. (2014) point out, regarding the effects of psychological stress on motor skills most publications found a negative effect of high levels of anxiety on gross motor performance. For fine motor skills, it has been reported in surgery that stress impairs surgical performance while being exposed to theatre background noise at 80 to 85 dB or due to the speed of performance (as quickly as possible). However, it was also found that motor performance increases under moderate stress conditions. So, similar to the effects of exercise, motor performance can be assumed to follow an inverted-U as a function of the intensity of psychological stress. (p. 1)

It is possible that the simulation used during this investigation may have driven certain participants to perform at a higher level of function while simultaneously causing others to perform at a lower level of function, depending on individual responses to stress and how the participants respond to varying levels of perceived stress.

A second consideration is in the difference between the skills necessary to operate a firearm during the Illinois Firearms Qualification Course-of-Fire and the simulated conflicts. Although the same equipment was used, including the pistol and simulation screen, the actions of shooting were different in some ways. For instance, during the modified Illinois Firearms Qualification Course-of-Fire, participants were required to draw the pistol from a holster and accurately place two shots into a standard bullseye-style target in six seconds. This skill was repeated six times each at two distances and again at a larger distance from the target, with only
one shot being taken at the longest distance in six seconds, again repeated for six rounds. In this instance, the participants encountered a known, non-threatening target, with no movement and constant clear vision of the target with a relatively long duration to complete the task of placing one or two shots per cycle of the course of fire.

As outlined earlier in this paper, drawing a weapon and accurately placing shots on target require several skills to be executed in a specific order. These skills include identifying the target, grasping and removing the weapon from its holster, properly acquiring a sight picture and pressing the trigger. With a known target established, no other movement required and a relatively long period of time in which to work, accurately placing two shots may be performed with a high degree of success, and the results (99.23% hit rate) of this study would tend to support that idea.

However, during the simulated conflicts (SimCon1 and SimCon2), other elements were presented to the subjects of this study while operating a firearm. In both instances, the subjects’ attention was directed to a known threat represented by the armed and fleeing female subject in SimCon1 and the amok situation of an argument taking place in a private residence in SimCon2. Strahler and Ziegert (2015) illustrate the value of training of this type for high-risk occupations including military and police officers. This type of training can closely reflect the type of situations they may encounter, including both psychological stressors and specific skills related to dangerous situations.

Furthermore, during SimCon1, the fleeing female subject begins to comply with the subject’s directions, potentially leading the subject to believe the simulation was over. At that point the second armed suspect quickly appears and fires a shot at the subject in a manner suggestive of a planned ambush. This event requires the subject to quickly acquire a new target,
establish a level of threat, create a new sight picture with the newly established threat and press the trigger with control for accuracy but fast enough to stop the threat in a relatively short period of time. As stated in the results section, subjects for this study recorded a 47.48% hit rate during this portion of the investigation. The added element of a second target and shortened time period in which to act likely played a role in increasing psychological stress but increased the complexity of the actions of marksmanship taking place, which represented a skill not assessed in the Illinois State Firearms Qualification Course-of-Fire, modified for this experiment or otherwise.

During SimCon2, the subjects of the study were immersed into a more complex environment as there were two individuals in close proximity to the subject, a loud and aggressive argument taking place, and an armed individual in sight but initially not threatening to the subject or the other parties present in the simulation. At a point during the simulation the armed suspect raises his weapon in a threatening manner toward the subject and fires. With many factors to consider, and two suspects in close proximity, subjects had to divide their attention between multiple parties and maintain watch over the weapon across the lap of the armed suspect. This increased complexity may have added to the psychological stress placed upon the subjects and increased the difficulty in placing accurate shots once called for. As stated in the results section, subjects for this study recorded a 50.13% hit rate during this portion of the investigation. However, with attention drawn towards several variables present in the amok situation, certain skills not well represented in the Illinois State Firearms Qualification Course-of-Fire, or in the version used for this study, may have been necessary to accurately place shots on target.
Comparing the two different treatments of this study, including the modified IFQC and the simulated conflicts, we see a stark contrast between possible marksmanship scenarios and the performance of law enforcement officers. Brown et al. (2013) looked at different training techniques employed by law enforcement officers and including physical and psychological stress and commented,

Most firearm training and qualification for police officers takes place on a shooting range under standardized conditions. However, qualification on the shooting range is not well correlated with shooting performance under pressure in the field (Oudejans, 2008). Effective shooting under pressure, as in pursuit of a suspect, requires situational awareness, quick decision making, and judgment. Consistency in form, movement, and shot location are characteristics of highly skilled and trained rapid-fire marksmen (Walmsley & Williams, 1994). While exercise-induced fatigue and physiological arousal can be distractions which negatively affect performance, expert performers in pistol shooting are able to narrow their attentional focus to the target, so as not to be distracted (Rose & Christina 1990; Vickers & Williams, 2007). (p. 280)

The lack of correlation between the diminished shooting performance and physiological variables in this study highlights the need to evaluate higher performance skills related to quick reaction marksmanship. With subjects of this study performing at a high level with known targets and a lower stress time constraint, the skills are in place to successfully complete a standard qualification course of fire. However, the diminished performance during scenarios including amok situations, where we cannot correlate a physiological relationship, may show a need for additional skill refinement on the part of participating subjects as a group.

Limitations and Future Research

This investigation has limitations which must be acknowledged. Though each subject served as their own control, certainly the number of participants who provided complete data for this study should be increased to better represent the population. However, with research of this type, it was necessary to recruit subjects who were current law enforcement officers and, due to
departmental needs, they must be on duty to participate. This creates challenges for participants, as their occupation requires their attention and total time commitment while on duty.

As Hellhammer et al. (2009) reported, cortisol can only moderately be linked directly with acute stress response. To standardize data collection methods, each subject provided saliva samples at the same time post shooting activity. In future studies, more attention should be given to assessing the inter-individual rates of cortisol release into saliva to take samples at their highest levels post shooting activity.

This study was intended to use saliva samples to examine levels of alpha-amylase as an additional biomarker representing acute stress levels; however, with insufficient saliva provided into the cotton swabs for detection by a number of participants, alpha-amylase data was excluded from the study. Similarly, a single measurement of cortisol was missing from formal laboratory results; therefore it was created by a process of imputing the mean to complete the data set. Future studies should collect repeated samples of saliva for additional processing when looking for biomarker concentrations.

For the purposes of this study, only male subjects were used, as it was important to maintain consistent protocols for all subjects, and female subjects would necessitate the use of differing protocols to account for hormonal differences between males and females. However, future researchers should work to include female participants in order to examine any gender differences in stress response and marksmanship skill.

Future researchers should also examine the extent to which participants are stressed versus normal resting values. The addition of physical and psychological stress in combination could be beneficial to elevating the stress response to levels where we see a correlation between markers and decreased performance. As with this study, individuals may have experienced
stress but not to the point of diminished performance, as seen with certain subjects performing much better than others.

Additional research opportunities may be taken to determine the effect of previous experience on tolerance to stress in these simulation encounters. It may be possible that previous experience with the simulator may diminish the stress response, especially without the threat of consequences such as marker ammunition or electric shock. Additionally, previous experience with dangerous encounters involving use of force or involvement in combat situations with prior military service may alter the stress response in one way or another.

Finally, with the widespread use of simulation training and other real-life analogs such as simunition drills, future investigation should compare the effects of detrimental feedback to the participants such as pain from marker ammunition as a further enhancement to understanding how officers respond to stressful situations, which may necessitate the more consistent use of these tools in officer training protocols.
REFERENCES


APPENDIX A

RECRUITMENT FLYER
Volunteers needed for scientific investigation into performance marksmanship

Who: We are looking for male active duty law enforcement officers between the ages of 25-55 years old who are physically capable of completing mild physical activity, including walking, while operating their primary duty sidearm.

Why: The purpose for this examination is to determine how increased levels of stress effect the performance of fine motor skills related to pistol marksmanship in law enforcement officers.

What: 2 sessions 45 minutes (approx. 90 minutes in total) involving the use of a simulated firearm at a professional training facility. Participants will be asked to perform basic marksmanship skills against static targets on a simulated flat shooting range and while performing a building clearing exercise. Data collected will include hit percentage, heart rate, blood pressure, and salivary biomarker sampling for stress assessment.

Where: Sycamore Illinois Public Safety building
150 North Main Street,
Sycamore, IL 60178

When: OCTOBER NOVEMBER 2018

Benefit: Helping to advance the knowledge about stress response and related alterations to marksmanship performance of law enforcement officers. Simulator range time and experience for participants

If you wish to participate please contact: Brandon M. Male PhD Student Northern Illinois University 563-940-9694 or bmale2@niu.edu
APPENDIX B

HEALTH HISTORY QUESTIONNAIRE
Medical History Questionnaire

This is your medical history form, to be completed prior to participation in this study. All information will be kept confidential. This information will be used for the evaluation of your health and readiness to participate in this scientific study. The form is extensive, but please try to make it as accurate and complete as possible. Please take your time and complete it carefully and thoroughly, and then review it to be certain you have not left anything out. Your answers will help us determine if you can safely participate in this scientific study.

If you have questions or concerns, we will help you with those after this form is completed. We realize that some parts of the form will be unclear to you. Do your best to complete the form. Your questions will be thoroughly addressed afterwards. It might be helpful for you to keep a written list of questions or concerns as you complete the medical history form.

Name: ________________________________
Date: ________________________________
MEDICAL HISTORY AND SCREENING FORM

General Information

Participant:
Name _______________________________________________________________
Address _______________________________________________________________
Contact phone number ___________________________________________________
Birth date _______________________________________________________________

In case of emergency please contact
Name  ____________________________ Phone  ___________________________
Name  ____________________________ Phone  ___________________________

Sex:
□ Male          □ Female

Current Occupation:
Position ___________________________ Employer ___________________________

Years of Law Enforcement Service
□ 1-5           □ 6-10           □ 11-15
□ 15-20         □ 21+

Date of Last Firearm Qualification _________________________________
Present Medical History

Check those questions to which you answer yes (leave the others blank).

- Has a doctor ever said your blood pressure was too high?
- Do you ever have pain in your chest or heart?
- Are you often bothered by a thumping of the heart?
- Does your heart often race?
- Do you ever notice extra heartbeats or skipped beats?
- Are your ankles often badly swollen?
- Do cold hands or feet trouble you even in hot weather?
- Has a doctor ever said that you have or have had heart trouble, an abnormal electrocardiogram (ECG or EKG), or heart attack?
- Do you have orthopedic injuries which limit physical activity?
- Do you often have difficulty breathing?
- Do you get out of breath long before anyone else?
- Do you sometimes get out of breath when sitting still or sleeping?
- Has a doctor ever told you your cholesterol level was high?
- Has a doctor ever told you that you have an abdominal aortic aneurysm?
- Has a doctor ever told you that you have critical aortic stenosis?

Comments: ____________________________________________
_____________________________________________________________________________
_____________________________________________________________________________
_____________________________________________________________________________

Do you now have or have you recently experienced:

- Chronic, recurrent or morning cough?
- Episode of coughing up blood?
- Swollen or painful knees or ankles?
- Swollen, stiff or painful joints?
- Pain in your legs after walking short distances?
- Foot problems?
- Back problems?
- Significant vision or hearing problems?
- An infection such as pneumonia accompanied by a fever?
- Significant unexplained weight loss?
- A fever, which can cause dehydration and rapid heart beat?
- A deep vein thrombosis (blood clot)?
- Persistent pain or problems walking after you have fallen?
Comments: __________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

Please answer each of the following:

Date of last complete physical examination: ________________________________
☐ Normal   ☐ Abnormal   ☐ Never   ☐ Can’t remember

Date of last electrocardiogram (EKG or ECG): ______________
☐ Normal   ☐ Abnormal   ☐ Never   ☐ Can’t remember

List any other medical or diagnostic test you have had in the past two years: __________________
________________________________________________________________________
________________________________________________________________________

List hospitalizations, including dates of and reasons for hospitalization: ______________
________________________________________________________________________
________________________________________________________________________

I verify that all of the completed information is correct to the best of my knowledge. I declare that I am participating voluntarily in a scientific study. The physical exertion during the study is at my discretion and I understand that I can stop participation at any time. I declare that I have no medical problems that prevent me from undertaking the scientific study and that I am not currently taking any medication that could present a danger with the performance associated with this study.

Printed Name __________________________________________________________
Signature _____________________________________________________________
Date ___________________________
If you feel that you would benefit from working with a therapist, please consider consulting these resources to find help in your area:

Find a cognitive behavioral therapist: http://www.findcbt.org/xFAT/

*Psychology Today’s “Find a Therapist”*  
website: https://therapists.psychologytoday.com/rms/

Crisis Text Line (free, 24/7, confidential): Text “GO” to 741-741

National Suicide Prevention Lifeline (English and Spanish): 1-800-273-8255

For Counseling Centers in the Northern Illinois Area

Living Rite: 1-779-777-7335  http://www.livingrite.org/

KishHealth System Behavioral Health Services at Ben Gordon Center: 815.756.4875  
http://www.kishhealth.org/locations/profile/?id=233
APPENDIX C

INFORMED CONSENT FOR PARTICIPATION
TITLE OF STUDY
Physiological Stress Indicators and Performance Changes of Law Enforcement Officers’ Marksmanship Under Increased Levels of Stress

PRINCIPAL INVESTIGATOR
Brandon M. Male, PhD Student
College of Health and Human Sciences
Wirtz Hall 227, DeKalb, IL 60115
563-940-9694
Bmale2@niu.edu

PURPOSE OF STUDY
You are being asked to take part in a research study. Before you decide to participate in this study, it is important that you understand why the research is being done and what it will involve. Please read the following information carefully. Please ask the researcher if there is anything that is not clear or if you need more information.

The purpose of this study is to investigate changes in heart rate, blood pressure, salivary biomarker concentration and shooting performance of law enforcement officers under varying levels of stress. More specifically, the purpose of this study is to determine how increasing levels of stress from operating a firearm on static targets changes when law enforcement officers are subjected to a simulated dangerous encounter.

STUDY PROCEDURES
Thirty subjects invited to participate in this study will include law enforcement officers from multiple departments located in and around the northern Illinois area. Subjects may include officers from municipal police departments and county sheriff’s departments with varying lengths of service. Participation in local Special Response Teams (SWAT) will also be noted, as subjects who participate in this branch of law enforcement will have had additional training in scenarios similar to this investigation.

This investigation will require participation over 2 non-consecutive days involving less than 60 minutes per day. Resting values of heart rate and blood pressure will be taken on day one of the investigation. Additionally, a resting sample of saliva will be collected for analysis of stress-related biomarker concentration for baseline comparison.

Initial marksmanship scores will be determined on a simulated flat shooting range against static circular targets measuring 8 inches (20.32 cm) in diameter. You will be asked to fire 30 total rounds from various distances ranging from 5 meters to 15 meters in 2 shot groups over durations from 6 to 10 seconds per shot group. This course of fire is in line with the Illinois Law Enforcement Training and Standards Board firearms qualification procedures.

The final condition will require you to maneuver through a simulated dangerous situation requiring the clearing of a multi-room building of multiple armed assailants represented in a virtual reality environment. Your hit percentage scores will be collected for both...
scenarios. At even increments during the simulation, heart rate will be recorded and blood pressure data will be collected and recorded immediately at the completion of the drill. Saliva samples will be taken at the onset of the investigation and ten minutes after each marksmanship drill is completed. Total time for data collection will not exceed 120 minutes.

RISKS

You will be required to operate a CO2-powered simulated firearm in a virtual reality environment at a law enforcement headquarters training facility. Risks associated with this investigation include possible injury to hearing or eyesight, as well as injury related to the use of a CO2-operated simulation firearm. All activities performed in this study, including the use of CO2-operated simulation firearms against static and virtual targets, fall within the scope of training and potential daily activities of current law enforcement officers.

You may terminate your involvement in this study at any time if you choose.

BENEFITS

You will benefit from the investigation by having your technique of marksmanship evaluated by active certified Firearms Instructors present for the study. Additionally, the opportunity to practice their marksmanship skills under stress in a controlled environment outside of standard departmental facilities will provide a learning experience for each subject.

CONFIDENTIALITY

Your responses and data recorded for this study will be confidential. Every effort will be made by the researcher to preserve your confidentiality, including the following:

- Assigning code names/numbers for participants that will be used on all research notes and documents
- Keeping notes, interview transcriptions, and any other identifying participant information in a locked file cabinet in the personal possession of the researcher.
- Data collected during this pilot study will not be used for publication or presentation of any kind.
- No data will be provided to the individual’s employers or supervisors

Participant data will be kept confidential except in cases where the researcher is legally obligated to report specific incidents. These incidents include, but may not be limited to, incidents of abuse and suicide risk. Additionally, the lead investigator is not nor has ever been a law enforcement officer; therefore, no professional relationship has ever existed between the lead investigator and any subject in the study.

CONTACT INFORMATION

If you have questions at any time about this study, or you experience adverse effects as the result
of participating in this study, you may contact the researcher, Brandon M. Male PhD Student Northern Illinois University 563-940-9694 or bmale2@niu.edu, or Dr. Judith Lukaszuk: Dissertation Chair Northern Illinois University 815-753-6352 or jmlukaszuk@niu.edu. If you have questions regarding your rights as a research participant, or if problems arise which you do not feel you can discuss with the Primary Investigator, please contact the Northern Illinois University Office of Research Compliance at (815) 753-8588.

VOLUNTARY PARTICIPATION

Your participation in this study is voluntary. You will be asked to complete a medical history questionnaire prior to participation to verify your eligibility to participate. It is up to you to decide whether or not to take part in this study. If you decide to take part in this study, you will be asked to sign a consent form. After you sign the consent form, you are still free to withdraw at any time and without giving a reason. Withdrawing from this study will not affect the relationship you have, if any, with the researcher. If you withdraw from the study before data collection is completed, your data will be returned to you or destroyed.

CONSENT

I have read and I understand the provided information and have had the opportunity to ask questions. I understand that my participation is voluntary and that I am free to withdraw at any time, without giving a reason and without cost. I understand that I will be given a copy of this consent form. I voluntarily agree to take part in this study.

Participant's signature _____________________________ Date __________

Investigator's signature _____________________________ Date __________
APPENDIX D

DATA COLLECTION FORM
Resting Data: After 5 minutes of quiet rest in the lounge after heart rate monitor is fitted to participant.

Heart Rate:__________ Blood Pressure:_____________

Saliva Sample Collected □

**Trial 1: Illinois Firearms Qualification Course-of-Fire**

Immediately prior to beginning the course of fire

Heart Rate: __________ Blood Pressure: __________

**After 5-Yard line – Total of 12 rounds**  Targets Hit: _____ Targets Missed: _____

Heart Rate: __________

**After 7-Yard line – Total of 12 rounds**  Targets Hit: _____ Targets Missed: _____

Heart Rate: __________

**After 15-Yard line – Total of 6 rounds**  Targets Hit: _____ Targets Missed: _____

Heart Rate: __________ Blood Pressure: _______________

Saliva Sample Collected □

(This Concludes Trial 1)

**Trial 2: Simulated Conflict**

Immediately prior to beginning the course of fire

Heart Rate: __________ Blood Pressure: __________

**After Simulated Encounter Number 1**  Shots Fired: _____ Shots Hit: _____

Heart Rate: __________ Blood Pressure: __________

**After Simulated Encounter Number 2**  Shots Fired: _____ Shots Hit: _____

Heart Rate: __________ Blood Pressure: __________

**TEN MINUTES DEBRIEFING**

COLLECT SALIVA 10 MINUTES AFTER Sim Encounter 2

Saliva Sample Collected □

(This Concludes Trial 2)
APPENDIX E

ILLINOIS FIREARM QUALIFICATION COURSE-OF-FIRE
1) Target Scoring Area: 8½ x 14 inch overlay/center mass of target. The defined firearm types are: Semi-auto/Revolver handgun; minimum capacity 5 rounds

2) For Duty Handgun Qualification, all stages of fire will commence from a secured holster. For Off Duty/Retired Officer Qualification, all stages of fire will commence with the handgun in hand from the "low ready" position. A passing score is 70% = 21 hits on center mass.

3) Where indicated below, the word "DRAW" requires the shooter to withdraw the handgun from a secured holster on the command to fire. The word "PRESENT" means that the shooter has the handgun in the shooting hand in low ready (depressed muzzle) position and stands ready for the command to fire under the following conditions:

   5 Yard line – Total of 12 rounds
   Stage 1 Draw/Present and fire 2 rounds in 6 seconds
   Stage 2 Draw/Present and fire 2 rounds in 6 seconds
   Stage 3 Draw/Present and fire 2 rounds in 6 seconds
   Stage 4 Draw/Present and fire 2 rounds in 6 seconds
   Stage 5 Draw/Present and fire 2 rounds in 6 seconds
   Stage 6 Draw/Present and fire 2 rounds in 6 seconds

   Shooters will reload without command as needed between stages of fire.

   7 Yard line – Total of 12 rounds
   Stage 7 Draw/Present and fire 3 rounds in 7 seconds
   Stage 8 Draw/Present and fire 3 rounds in 7 seconds
   Stage 9 Draw/Present and fire 3 rounds in 7 seconds
   Stage 10 Draw/Present and fire 3 rounds in 7 seconds

   15 Yard line – Total of 6 rounds
   Stage 11 Draw/Present and fire 3 rounds in 10 seconds
   Stage 12 Draw/Present and fire 3 rounds in 10 seconds
   Stage 12 <OPTIONAL> 25 Yard line-: Draw/Present and fire 3 rounds in 15 seconds (in lieu of the second 10 second /three round string at 15 yards)

4) The above course of fire is the minimum standard required. Any agency may include any modification that increases the level of difficulty such as reloading, alternate hands, movement, time restriction, or other job-related skills. (Source: Added at 30 Ill. Reg. 7925, effective April 11, 2006)