MARKSMANSHIP ACCURACY AND PRECISION AFTER TACTICAL EXERCISES AMONG SPECIAL WEAPONS AND TACTICS (SWAT) TEAM OPERATORS

A Thesis

by

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Texas A&M University-Corpus Christi and is hereby approved.

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ABSTRACT

Law enforcement is one of the most stressful occupations and investigations have demonstrated law enforcement officers (LEOs) have greater CVD-related morbidity and mortality than the general population. LEOs are chronically exposed to events including physical dangers and psychological stress. Every day, LEOs utilize their training to save lives and keep themselves and their communities safe, however, Special Weapons and Tactics (SWAT) teams have duties that are beyond the scope of normal law enforcement personnel. Part of this training includes the use of firearms to prepare officers to protect themselves and others in highly dangerous situations. Engaging in these dangerous situations can often cause high levels of stress and decrease shooting accuracy and precision. PURPOSE: To evaluate the effects of consecutive tactical task exercises on accuracy and precision of pistol shooting in SWAT team operators. METHODS: Thirty-two active SWAT team members (age = 38.04 ± 1.29 y.; experience on SWAT = 7.33 ± 1.04 y.), were recruited from a local police department. SWAT members performed 3 tactical exercises using their service weapon. Participants completed a 73.31-m sprint entry into the range, performed a 13.71 m dummy drag (79.73 kg), and a 13.71 m battering-ram carry (17.5 kg). After each tactical exercise, participants discharged 5-rounds of ammunition into separate paper targets located 13.71 meter from the firing line while wearing full tactical vest and situated behind a tactical barrier. Participants completed psychometric questions and provided saliva samples prior to and after completing the testing protocol. RESULTS: SWAT team members completed the tactical exercise protocol in 77.31 ± 3.22 sec. RMANOVAs demonstrated significant differences in marksmanship accuracy between shooting conditions for: distance from the target center-of-mass (DCM_{SG}; $F_{3,93} = 4.78$, $p < .01$), distance from center of mass shot average (DCM_S; $F_{3,93} = 4.29$, $p < 0.001$). RMANOVAs demonstrated significant differences in marksmanship precision between shooting conditions for: radius of the shot grouping (MR_S; $F_{3,93} = 4.29$, $p < 0.001$), horizontal range (H_R; $F_{3,93} = 4.16$, $p < 0.05$), vertical range (V_R; $F_{3,93} = 3.15$, $p < 0.05$), area of the dispersion of shots (AD; $F_{3,93} = 6.35$, $p < 0.01$), and the diagonal of dispersion (DD; $F_{3,93} = 6.18$, $p < 0.01$). CONCLUSIONS: Accuracy and precision decreased from static baseline shooting as a result of physical exertion. Fatigue and stress may contribute to the differences seen between static baseline marksmanship and post-tactical exercise marksmanship with greater differences seen in tactical tasks that require upper body involvement.

DEDICATION

This thesis is dedicated to all those that have supported and inspired me to pursue education to the highest degree. Especially, Corpus Christi Police Department SWAT team that allowed me to enjoy and experience the thrill of training.

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CHAPTER I

Introduction

Tactical athletes such as police officers, also known as law enforcement officers (LEOs), face challenges while protecting their community and enforcing laws. Law enforcement is an occupation inherent with physical dangers, psychological stress, and physiological exertion (Beaton, Murphy, Johnson, Pike, & Corneil, 1998). When there is danger in the field and officers must resort to pulling their service weapon, decision-making skills are crucial in allowing the officer to remain calm and collected (Alpert, Dunham, Stroshine, Bennett, & MacDonald, 2004). Studies have shown that when an officer-involved shooting occurs, officers may become less accurate when using their service weapon (Donner & Popovich, 2018). In 2017, the third leading cause of death in emergency responders, which includes LEOs, was gunfire (International Public Safety Association, 2018). While protecting their community, police officers are responsible for reducing the risk of injury to themselves and those around them.

When situations arise that are deemed extreme in nature and/or are a threat to public safety, specialist tactical police operators (STPOs) such as those serving in Special Weapons and Tactics (SWAT) units are activated and deployed to handle the situation (Cartner, Dugan, Eells, et al., 2008). SWAT teams are responsible for higher-risk duties that require the use of additional body armor, weapons, and equipment to enhance bodily protection from high-risk encounters and to expand the scope of tactical operations. These high-risk encounters can include but are not limited to hostage rescue, clearing dangerous scenes, diffusing riotous situations and/or events involving snipers or terrorists (Clark, Jackson, Schaefer and Sharpe, 2000). SWAT operators, due to being utilized during high-risk and sometimes extreme situations, can be and typically are exposed to stressful situations every time they are deployed.

It can be assumed that SWAT team members must perform at higher workloads than those typically endured during routine law enforcement operations. SWAT officers' demands rely heavily on training of their physical abilities, knowledge of tactics strategies and equipment, to ensure the safety of individuals involved (Compton, Demir, Oliva, & Boyce, 2009).

Officers face a multitude of different stressors while on the job (Violanti, et. al., 2017), which can be elevated for SWAT officers. Stressors can be divided into two categories. The first category of stressors concerns the operational aspects of work (e.g. physical threats, responding to a bloody crime scene, public verbal aggression, chasing a suspect, etc.). While the second category concerns organizational aspects (e.g. managerial style, lack of social support, employment shortages, high turnover, etc; McCreary & Thompson, 2006).

Stress and anxiety have both beneficial and detrimental effects physiologically and psychologically (Schneiderman, Ironson, & Siegel, 2005). When an individual becomes stressed acutely, a chain reaction occurs within the body to adapt to the added stimuli. The chain reaction of response from the acute stress occurs in the sympathoadrenal (SA) axis and hypothalamic pituitary adrenal (HPA) axis. From the SA axis, acute stress has been shown to evoke increased secretion of epinephrine and norepinephrine (Frankenhaeuser, 1991; Gerra, Zaimovic, Mascetti, Gardini, Zambelli, Timpano, Raggi, & Brambilla, 2001; Schöder, Silverman, Campisi, Sayre, Phelps, Schelbert, & Czernin, 2000) while cortisol is secreted from the HPA axis (Frankenhaeuser, 1991; Gerra, et al., 2001). During acute stress, the secretion of epinephrine and norepinephrine causes increases in heart rate, in blood pressure, and peripheral blood flow to skeletal muscles.

When placed in a stressful situation the body responds in different ways. A suddenly emerging threat or assault in close proximity may overwhelm the LEO due to limited time available to perceive the scenario contexts and select the appropriate action (Mather & Lighthall, 2012). Statistics published annually by the FBI's Law Enforcement Officers Killed and Assaulted (LEOKA) Program have been used to better understand incidents involving LEOs. A study conducted in 2015 looked at the information gathered from 1996 to 2010, to determine the incidents involving firearms, their prevalence, and homicide of LEOs. There were 782 homicides of LEOs over the study period, 716 (92%) of which were committed with firearms. Handguns were used in 515 homicides, or 72% of firearm-related homicides, and overall, 66% of all homicides (Swedler, Simmons, Dominici, & Hemenway, 2015).

Statistical information, involving shootings, suggests that suspect encounters, when there is little distance between the officer and the suspect, feature more officers killed by an offender compared with situations involving greater distances. Over a 10-year period between 2005 and 2014, approximately 60 percent of officers murdered with firearms in the line of duty were shot within 0 to 10 feet of the perpetrator. Of those incidents, approximately 45 percent included events where offenders within 0 to 5 feet killed officers with firearms (Swedler, Simmons, Dominici, & Hemenway, 2015).

During stressful situations, responses under duress can affect an individual's ability to perform mental and physical tasks (Anderson, Di Nota, Metz, & Andersen, 2019). During psychomotor tasks, such as tactical shooting, autonomic responses could potentially influence performance, and controlling this reflex could be the difference in bodily injury or not (Thompson, Swain, Branch, Spina, & Grieco, 2015). Susceptibility to stress depends on previous experiences and research shows that those with more experience in high-pressure incidents respond more accurately than those with little to no experience during high-pressure incidences (Landman, Nieuwenhuys, & Oudejans, 2016). However, with greater experience there also tends to be a decrease in physical fitness for LEOs (Dawes et al., 2017).

Physical fitness plays a large part in the occupational requirements of LEOs. However, while on duty, LEOs often spend a large amount of time involved in sedentary activities, such as completing organizational duties such as paperwork and writing reports (Arial, Gonik, Wild, & Danuser, 2010). These types of organizational objectives can be interrupted by occupational objectives, including a call-out. Law enforcement officers can often be required to switch from passive observer to active responder when interacting with suspects (Shell, 2002). During these situations LEOs might be required to move quickly and efficiently utilizing their cardiovascular system and muscular fitness.

Specific occupational duties, such as suspect pursuits and physical altercations with suspects or detainees, may require sudden high levels of physical exertion (Gershon, Lin, & Li, 2002; Anderson, Litzenberger, Plecas, 2002; Violanti & Aron, 1994). Sudden cardiac deaths (SCD) account for up to 10% of all on-duty deaths during police activities and SCD events are much more likely to occur during stressful duties, such as physical altercations and pursuit of suspects (Varvarigou, Farioli, Korre, Sato, Dahabreh, Kales, 2014). Therefore, there are many reasons that police officers and candidate recruits joining law enforcement should be physically fit.

Prior to entering a Police Academy, cadets are required to take a Physical Qualification Test (PQT), which in the state of Texas, not consistent across jurisdictions. As an example, some academies only utilize a timed 1.5-mile running trial, whereas others use a combination of sit-ups, push-ups, pull-ups, and running. After entering the Police Academy, cadets are then required to pass a Physical Ability Test (PAT), however, research suggests that there is no consistency in the PATs used by police agencies across the country and that evidence regarding their validity is almost completely lacking (Lonsway, 2003).

After graduation and induction into a law enforcement department, most LEOs are no longer required to complete or met minimum physical fitness guidelines. A longitudinal study observed 139 LEOs who had graduated from a police academy, found that within 3 years of working as a LEO, that overall physical activity and the priority of training decreased (Lagestad & van den Tillaar, 2014). However, the desire of an officer to advance or move into other roles within the department may require the LEO to maintain or enhance their physical fitness. For example, to become a SWAT operator, training and entry requirements vary by jurisdiction, but almost all require higher level of physical fitness than that of a typical LEO.

There are four tiers of SWAT teams, ranging from Tier 1 teams to perimeter control teams, with the work, responsibilities, and capabilities being reduced each step down from Tier 1 (See Table 1). SWAT teams can also be distinguished by the level of training as well as personnel numbers.

SWAT Tier 1 teams are distinguished by the number of personnel and their abilities to perform hostage rescue, engaging with barricaded gunmen, sniper operations, high-risk warrant service and high-risk apprehension, high-risk security operations, terrorism response, as well as special assignments and other incidents which exceed the capability and/or capacity of an agency's first responders and/or investigative units (Clark, Jackson, Schaefer and Sharpe, 2000). Tier 1 teams typically have 26 members, including 1 team commander, 3 team leaders, 4 snipers, and 18 operators, whereas, Tier 2 SWAT teams have fewer personnel, with only 12 operators.

Type	Capabilities	Personnel
SWAT Tier 1 – a single agency team, multi-jurisdictional team, regional team or through a military operation area (MOA).	Capable of serving as a primary SWAT mutual aid team to another Tier 1 or 2 team. • Hostage rescue operations - Planned and emergency related • Ballistic, thermal, mechanics, and explosive breaching • Barricaded subject operations • Sniper operations • High-risk warrant service • High-risk apprehension operations • high-risk security operations • Terrorism response operations • Tactical operations integrating SWAT and Bomb Squad • Tactical operations in a contaminated environment	26 members: • 1 Team Commander • 3 Team Leaders • 4 Snipers • 18 Operators
SWAT Tier 2 – a single agency team, multi-jurisdictional team, regional team or through an MOA.	All mission capabilities except planned deliberate hostage rescues. • Emergency Hostage rescue operations • Ballistic, thermal, and mechanics breaching • Barricaded subject operations • Sniper operations • High-risk warrant service • High-risk apprehension operations • high-risk security operations • terrorism response operations • Tactical operations integrating SWAT and Bomb Squad • Tactical operations in a contaminated environment	19 members • 1 Team Commander • 2 Team Leaders • 4 Snipers • 12 Operators
Tactical Response Teams	Can conduct any single or combination of: • Barricaded subject operations • Sniper operations • High-risk warrant service • High-risk apprehension operations • high-risk security operations • terrorism response operations	15 members • 1 Team Commander • 2 Team Leaders • 12 Operators
Perimeter Control and Containment Team	Establish an effective perimeter and/or establish a tactical command area	Any number of appropriately trained personnel.

Table 1: Represent recommended minimums operational Tiers of SWAT and tactical response teams (TRT) based upon typical residential applications. They were promulgated as a guideline from NTOA with input and the concurrence of local, federal, and international partners. Jurisdictional conditions including, but not limited to, topography, operational tempo and anticipated mission requirements may necessitate modifications to these configurations (Cartner, et al., 2008).

A meta-analysis of physical characteristics in elite tactical units, such as SWAT operators, has shown inconclusive data on the physical fitness profile of SWAT personnel (Maupin, Wills, Orr, & Schram, 2018), but physical characteristics are higher compared to general-duties LEOs. Differences in physical characteristics could be due to the demands and training requirements needed for SWAT teams.

Depending on the department's needs, SWAT teams can be either full-time or part-time SWAT operators, also known as collateral-duty operators. Operators of the collateral-duty type are called upon when the need arises but are still required to conduct training as a team. The National Tactical Officers Association (NTOA) recommends that all incoming operators complete and attend a basic SWAT course, which is typically 40 hours in length. Once completed, a formal competencies-based field training program that is supervised by a senior SWAT operator training officer is implemented. All SWAT teams are also recommended to complete 16-40 hours of training per month, as a group, with a total of 192-480 hours recommended annually (Cartner, et al., 2008). Training protocols during these times are used to maintain operational readiness which may include firearms, tactical emergency medical support, explosive breaching, and other operational training.

Often, part of this training incorporates firearm usage of both rifle and pistol. Firearms training often includes situations and scenarios where active shooter dialogue is used and stationary targets are fired upon. Typically, the stationary targets used are either metal or paper and the realism of the situation is not especially great. When the use of deadly force is necessary for a situation, accuracy and precision of firearm usage are critical to reducing the risk to themselves as well as innocent bystanders. However, accuracy and precision are important in different ways.

Accuracy allows an individual to shoot the intended target or near a specific location on the body, while precision encompasses the repeatability of shooting accuracy and the capabilities of control through a duration of multiple shots.

Precision as defined in this study as the closeness/nearness of shots to each other. Measurement will be determined based upon the circumference of the closest five bullet holes, also known as a shot grouping. Accuracy is defined as a measurement of how close to the center of the target the center each of the shot groupings is (see Figure 1).

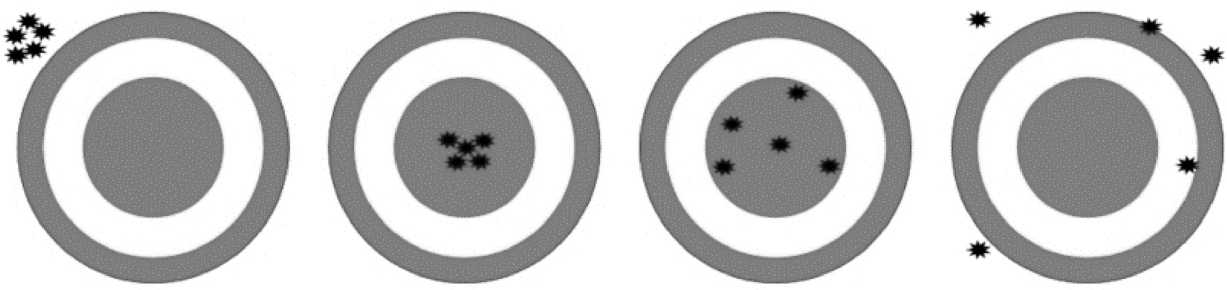

Figure 1: Differences between marksmanship precision and accuracy. The precision of shots is based of the distance from shot to shot, where the closer the shots are to each other, the more precise the shooter is. Accuracy is determined by how close the shot grouping is to the center of the target. The closer the shot grouping to the center of the target, the more accurate one is.

Though military and LEOs are required to qualify annually with their firearm performance, this may not necessarily transfer to precision and accuracy when confronted with a threat (Taverniers & Boeck, 2014). While training and annual qualifications are necessary, these competencies are not always sufficiently related to the skills and performance needed during actual shooting incidents (Charles & Copay, 2003). Taverniers and Boeck (2014) state that traditional firearms training for LEOs, dominated by traditional carboard-style targets in a static stance, is not sufficient. Dynamic shooting, the practice of shooting while moving, has started to be implemented in the training of tactical operators, such as military personnel (Kelley, Britt, Lawson, & Hayes, 2020), and SWAT teams. These populations utilize this form of training due to having more incidences within their occupational duties involving the need to move and shot (James & Dyer, 2011). SWAT operators are required to qualify annually on pistol shooting and rifle shooting accuracy, and have extensive training on tactical approaches and usage of deadly force (37 Tex. Admin. Code §218.9, 2020). However, very little research has been conducted on SWAT teams where marksmanship and stress are the main variables. Although it is known that SWAT operators face high levels of stress when activated as a unit to a situation (Pryor, Colburn, Crill, Hostler, Suyama, 2012), researchers have not investigated how SWAT operators will respond when placed in a situation that is both tactically and physically demanding. Studies involving shooting accuracy and precision have been conducted post-distance running and tactical drills; however, to our knowledge, repeated bouts of acute, exertional exercise and shooting accuracy and precision have not been examined in this population.

Purpose of Study:

The purpose of the study is to determine the effects of three tactical task exercises on measures of accuracy and precision of shooting in SWAT team members and their perceived levels of stress and effort needed to complete a tactical exercise.

Statement of Hypotheses:

For this study, the hypotheses being tested will include:

1. There will be a decrease in shooting accuracy compared to baseline static shooting, as task requirements increase in response to physical demands needed to complete all exercises.
2. There will be a decrease in shooting precision compared to baseline static shooting, as tactical tasks increase in response to physical demands needed throughout all exercises.

3. Psychometric measures of perceived arousal and affect will increase after the tactical exercises.
4. Contributing factors to perceived workload of the tactical task protocol will not be different between subscale measures within the NASA Task Load Index (NTLX).
5. There will be an increase in salivary cortisol levels from the pre-tactical exercise sample to the post-tactical exercise protocol sample.

Significance of the Study:

Even though numerous studies have reinforced the importance of moderate physical activity in providing cardiovascular protective effects (Baumen, 2004), fitness initiatives have not been adopted by a majority of departments (Myers, et al., 2019). With the ever-changing environment in both urban and rural settings, LEOs must adapt to maintain safety for themselves and others. Multiple studies have indicated a correlation between the result of the pistol shooting and selected physical fitness variables are significant (Anderson and Plecas, 2000; Vuckovic and Dopsaj, 2007). A study examining the effects of prior exercise intensity on rifle shooting performance in biathletes found that prior exercise intensity affected central aspects of shooting accuracy, shooting precision, and stability of rifle hold (Hoffman, Gilson, Westenburg, & Spencer, 1992). However, very little research has shown changes in dynamic marksmanship during consecutive bouts of tactical exercise. Understanding these changes will allow for better understanding of the psychological stress and physical stress placed on SWAT operators in the active line of duty when tactical exercises are implemented in the field.

Assumptions:

For this study, assumptions include:

1. Participants will answer all questionnaires in an honest and accurate manner.

2. All participants are proficient shooters due to their training and experience as SWAT operators.
3. The participants are representative of the general SWAT officer population.
4. All participants will give maximal exercise effort during the entire protocol.

Limitations:

1. Testing will be conducted in an outdoor shooting range, and the tactical exercise will be performed once.
2. The tactical exercises performed were chosen by SWAT team leaders in conjunction with the researchers.

Delimitations:

1. Participants are active members of the SWAT team.
2. Participants all passed their SWAT shooting qualifications for pistol shooting on their service weapon within the previous 45 days.

CHAPTER II

Review of Literature

This chapter will discuss different topics pertaining to careers in law enforcement. LEOs face different types of stress which could lead to health issues and possibly death. LEOs must maintain fitness to not only perform during dangerous encounters but also combat possible health concerns. Further, this chapter will discuss the requirements and differences needed to become a SWAT operator as well as the training of this populations. Specifically, training regarding marksmanship and research conducted to help reduce liability for this population.

Stress in Law Enforcement

A career within the field of law enforcement encompasses two conflicting occupational objective requirements: 1) sedentary responsibilities including desk-bound administrative work, and 2) physically demanding, field-based manual tasks (Violanti et al., 2017). Due to job demands, law enforcement has been recognized as one of the most stressful professions, as the occupation entails both physically and emotionally demanding situations which may lead to dangerous encounters (Mostert & Rothman, 2006; Martinussen, Richardsen, & Burke, 2007; Bishopp, Piquero, Worrall & Piquero, 2018). Due to the complexity of stress involved in law enforcement, previous research has divided sources of law enforcement stress into categories of organizational stress and occupational stress (Burke, 2016; Newman & Rucker-Reed, 2004).

Research on organizational stress within law enforcement research has suggested that this form of stress is related to inactivity, boredom, bureaucratic administration, relationships with colleagues and superiors, the public's perception of police work, and inadequate relationships with supervisors (Shane, 2013; Burke, 2016). Conversely, occupational stressors are defined as any persistent psychological difficulty resulting from operational duties performed as part of the job, which include making decisions in critical situations, risk of harm to oneself or others, the use of force, accidents, injuries, and exposure to violence (Kop, Euwema & Schaufeli, 1999; Newman & Rucker-Reed, 2004). When these stressors become chronic in nature, this may have a negative effect on health and performance can be observed (Ramey, Downing, & Knoblauch, 2008).

Chronic stress in LEOs can lead to burnout, psychological/mental disorders, and even suicide (Garbarino, Cuomo, Chiorri, & Magnavita, 2013; Violanti, Owens, McCanlies, Fekedulegn, & Andrew, 2019; Baka, 2015). Psychological stress has also been linked to an increased risk of cardiovascular disease (CVD), diabetes, hypertension, and hypercholesterolemia in LEOs (Franke, Ramey, Shelley, 2002), and Franke, Collins & Hinz (1998), reported that 81% of retired LEOs perceived that their occupation contributed to their increased risk in CVD. Nyberg et al. (2013) found in a meta-analytic survey that work-related stress was linked to an increased risk for CVDs, mainly due to an elevated risk for type II diabetes, smoking, and physical inactivity. Sorensen et al. (2000) suggested that high levels of stress and a lack of physical fitness in LEOs may lead to a decline in health and fitness over the course of their career.

Occupational stressors are often felt in an acute and uncontrolled manner and can cause an increase and activation of the sympathetic nervous system (Kemeny, 2003), leading to increases in HR, BP, and the activation of a stress hormone cascade (Brondolo, et. al, 2009). Cortisol, a primary stress hormone, is released due to the activation of the hypothalamic pituitary adrenal (HPA) axis. Cortisol activation is most likely to occur when stressors are uncontrollable, ambiguous, unique, or contain an element of psychosocial stress (Kemeny, 2003) or when physical exertion levels are greater than 70% VO_2 or last greater than an hour (Kanaley, Weltman, Pieper, & Weltman, 2001). Salivary cortisol has been used as a biomarker for psychological stress due to its indirect connection to the complex system of the HPA axis (Hellhammer, Wüst & Kudielka, 2009).

Previous research has suggested an increase in salivary cortisol occurs when LEOs respond to simulated law enforcement activities. Groer et al. (2010) observed increases in salivary cortisol during two simulated critical incident scenarios involving firearms in LEOs. Force-on-Force handgun training (Taverniers & De Boeck, 2014) and a simulated school shooting scenario (Strahler & Ziegert, 2015) were also shown to significantly increase salivary cortisol levels in LEOs. Webb et al. (2010), as well as Woodford and Webb (2020), determined that anxiety and perceived workload during dual stress protocols increased in first responders as well as salivary cortisol levels. These studies suggest that with an increase in stimuli and added physical stress, first responders respond with higher levels of anxiety and perceived workload.

The lack of knowledge about the situation to which a LEO is being dispatched or approaching can increase stress responses (Petersson, Bertilsson, Fredriksson, Magnusson, & Fransson, 2017). Anshel et al. (1997) reported that LEOs facing unpredictable situations as the most severe acute stressor experienced by this population, a situation which is characteristic of most police deployments. Anderson et al. (2002) found increased cardiovascular stress responses during periods of heightened physical demand (e.g., escalation of force), potential threat situations (e.g., hand on gun situations) and during periods of anticipation (e.g., pre-deployment to an event with patrol car lights and sirens).

More recently, Baldwin et al. (2019) measured officers' cardiovascular activity (peak heart rate above resting average) and physical movement (speed) to reveal unique and dynamic influences of physical and psychological stressors during various phases of general duty calls (i.e., dispatch, arriving on scene, apprehending a subject). Increases in stress responses were observed relevant to the priority of a call (i.e., very urgent > urgent > routine) and with reports of a weapon present. Calls involving the use of force produced elevated stress responses during all phases of the call, including dispatch, en-route, and arrival (Baldwin et al., 2019).

Law Enforcement Physical Fitness

One factor that could influence an LEO's ability to perform their occupational objectives effectively and safely during stressful situations is their level of physical fitness (Franke, et al., 2002; Ramsey, et al. 2008). LEOs must pass a physical qualification test before gaining admission into the academy. Once admitted, to prepare LEO recruits for the physical demands of law enforcement, cadets are required to undergo preliminary physical fitness training (Orr, Dawes, Pope & Terry, 2018). An emphasis is placed on developing LEOs who can perform the physically demanding tasks required of them in the workforce with high success rate (Shusko et al., 2017; Orr, Ford & Stierli, 2016). These physical tasks can include running, jumping, crawling, vaulting, climbing, lifting, carrying, fighting, dragging, and restraining a suspect (Bonneau & Brown, 1995; Orr, Pope, Stierli, & Hinton, 2017; Quigley, 2008). Academy attendance ranges from six to eight months, based on state and department standards. During this time, the academy cadets go through training consisting of intense physical fitness, educational classes on law and procedure, and weapons training. Physical training during academy has been shown to improve performance on agility, upper- and lower-body peak power, sit-ups, and push-ups in the first eight weeks (Crawley, Sherman, Crawley, & Cosio-Lima, 2016).

However, current research has shown a significant decline in physical fitness of LEOs often occurs while actively employed, post academy, which could negatively impact occupational objective performance over time. Sorensen et al. (2000) found that LEOs performance significantly decreased in push-up ability over a 15-year period as well as reduction in VO_{2max}, pull-up and sit-up performances. There is a large variation in fitness levels of police officers, which can be influenced by stage of training, duration of career, age, and sex (Lentz, Randall, Guptill, Gross, Senthilselvan, & Voaklander, 2019). It is recognized that declines in physical fitness may be attributed to an increase in age (Lockie, et al., 2018), as well as more sedentary responsibilities (Orr, Ford & Stierli, 2016). Lack of fitness in officers has also been shown to lead to on-duty injuries and illnesses, increases in their exposure to liability, and engenders a loss of respect from the community based on their appearance (Quigley, 2008). However, there are groups of LEOs who tend to take their training and fitness more seriously after graduation from the police academies. Often, these LEOs are seeking to move to specialized departments or attempt to become part of the SWAT team.

SWAT Teams & Training

SWAT operators, depending on the type of team, are constructed of officers from other divisions within the department, such as the criminal investigation division, patrol, the auto theft division, etc. Tactical officers typically have specialized training that exceeds the requirements of most law enforcement officers (Klinger & Rojek, 2008; Cartner, et al., 2008; Williams & Westall, 2003). SWAT officers undergo in-depth examinations that include interviews, physical fitness abilities, and psychological evaluation, before selection to become a SWAT operator.

Once selected, SWAT operators are trained in close quarters combat, marksmanship, special weapons, and tactical strategies during basic SWAT school (Young, Hennington, & Eggleston, 2018). However, depending on the agency that is hosting the SWAT school and the State, new SWAT operators will be placed on probation until schooling is complete. Probational

SWAT operators can train with their SWAT teams during their monthly meetings but might not be able to perform certain tasks when the whole team is called upon until they have completed their training. After SWAT operators have completed their training, they are removed from probation, and will join their specific teams in a full capacity, including engaging in monthly training sessions.

Training during their monthly meetings is regulated by National Tactical Officers Association (Cartner, et al., 2008) as well as the specific state in which the teams are located. The National Assessment of Critical Trends and Issues (2009 to 2013) conducted a comprehensive study of United States SWAT teams', specifically their training and construct. The report stated that between 84 and 90 percent of all responding agencies included training in high-risk operations, negotiations, specialty munitions, SWAT management, tactical firearms, and operational tactics within their curriculum. These training programs and classes are both used during SWAT school and during the monthly training and regulated by the NTOA as well as the state, such as the Texas Tactical Police Officers Association (TTPOA).

Although no objective measures of work exist specifically for SWAT operations, it can be assumed that SWAT team operators perform at higher workloads than those typically experienced during routine law enforcement operations and that they are further considered highly trained and physically superior compared to patrol officers (Pryor, Colburn, Crill, Hostler, Suyama, 2012). Measures of strength & conditioning have shown SWAT operators have higher general strength and VO_{2max} values, as well as greater flexibility, muscular endurance, and power (Robinson, Roberts, Irving, Orr, 2018; MacDonald, Pope, Orr, 2016). However, studies have shown that these tactical professionals might not rank significantly higher in the areas of agility, sprint speed, or absolute strength (Pryor, Colburn, Crill, Hostler, Suyama, 2012).

During training, SWAT operators utilize full body movements for tactical operations. These tasks include trunk rotation, overhead upper extremity use, isometric upper extremity actions for firearm and shield use, explosive movements in formation, kneeling, and long waiting periods while wearing equipment (Pryor, et al., 2012). To perform these job-related tasks, SWAT operators require a blend of aerobic fitness, extremity strength, core strength, flexibility, and muscular power. An ideal fitness profile has not been determined due to the limited data associated with SWAT personnel (Maupin, et. al., 2018). No single element of this physical fitness profile seems to be paramount for ideal performance of the job-related tasks due to the complexity of the tasks needed in order to perform occupational objective demands (Maupin, et al., 2018). Certain tasks, however, did emphasize that certain muscular fitness elements of the profile and high aerobic capacity appeared to support ideal performance for all the job-related tasks studied (Robinson, et al., 2018).

While on duty, officers are required to wear personal protective equipment and duty belts. These external load for LEOs consist of, but is not limited to, a ballistic vest, duty belt, handcuffs, taser, communication radio, flashlight, tactical boots, extra loaded magazines, and a department-issued sidearm. The weight of this equipment for general LEOs can be up to 12kg with SWAT carrying loads ranging 20kg to 40kg, depending on the operator’s position on the team (Dulla, Baran, Pope, & Orr, 2017; Thomas, Pohl, Shapiro, Keeler, & Abel, 2018). The weight of this equipment is believed to negatively impact the ability to pursue and apprehend a suspect (Thomas, Schram, Irving, Robinson, & Orr, 2019; Beards, Woods, Stubbs, & David, 2008) significantly reduce the performance of break contact, fire and movement, combat-rush simulations (Hunt, Tofari, Billing, & Silk, 2016; Drain, Billing, Neesham-Smith, & Aisbett, 2016), vertical jump ability (Dempsey, Handcock, & Rehrner, 2014; Drain, & et. al, 2016), as well as increase times of both short-distance sprints (Lewinski, Dysterheft, Dicks, & Pettitt, 2015; Drain, & et. al, 2016), and the agility run (Martin & Nelson, 1985).

LEOs may also have to deal with traumatic events while on duty; consequently, they are frequently required to draw on their physical and mental resources. During the pursuit of a suspect, an officer may be required to perform a multitude of physical tasks depending upon the suspect's movement. Additionally, officers may be required to attend to situations of high risk that threaten the wellbeing of themselves, their colleagues, or the general public (Anderson, Litzenberger & Plecas, 2002). Characteristics of physical fitness, technical and tactical training, and the experience of the LEO contribute to their ability to efficiently master complex situations requiring the use of a service weapon for defense.

Marksmanship Training

Firearms training is one of the most important aspects of LEO training due to the high risk of liability and public expectations (Thomasson, Gorman, Lirgg, & Adams, 2014). The greatest amount of firearms training LEOs engage in is typically during their time at the law enforcement academy. Typical training consists of static shooting with static paper targets (Charles & Copay, 2003) and can average about 71 hours in total time (Reaves, 2016), depending on the department and academy standards. Between 2006 and 2013, the average amount of instruction in firearms skills required per recruit increased, from 63 hours in 2006 to 71 hours in 2013 (Reaves, 2009; 2016). LEOs are required annually to complete firearm qualifications that range in degree of difficulty depending on departments and jurisdiction, but typically, the qualification test consists of static shooting (37 Tex. Admin. Code §218.9, 2020).

In Texas, the minimum to pass handgun proficiency is 50 rounds, fired at ranges from point-blank to at least 15 yards with at least 20 rounds shot/fired at or beyond seven yards, including at least one timed reload, with a score of at least 70 percent (37 Tex. Admin. Code §218.9, 2020). Handgun proficiency assessments typically use a B-27 target (see figure X) with passing value established (using combat scoring) at a threshold of at least 175 points out of 250 using 50 rounds of ammunition (Commission Rule §218.9 (c)(1)). However, there are multiple qualifications proficiency tests depending on the jurisdictions of the law enforcement agencies as well as the States.

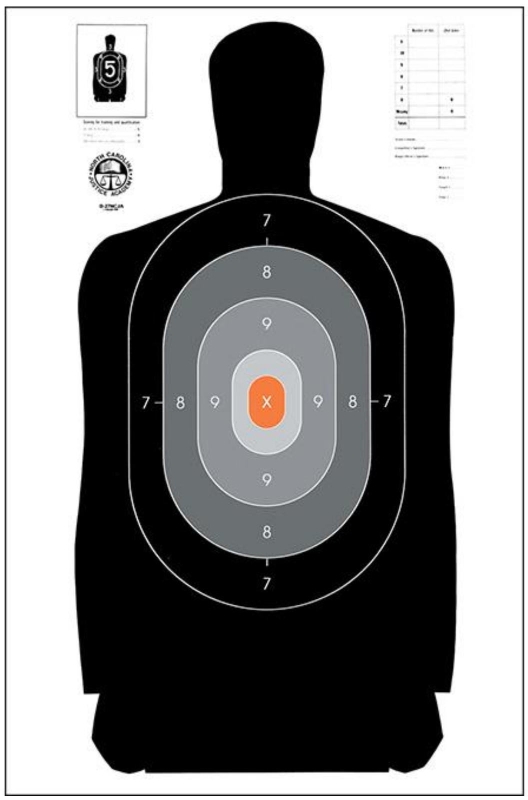

Figure 2: B27 targets used for annual qualifications of firearm proficiency. Combat scoring is used to determine overall qualification percentage. For the B-27 target scoring is calculated by shot penetrations placement in designated rings. Calculations are scored by 8, 9,10, X rings = 5 points, 7 ring = 4 points, hits on silhouette = 3 points multiply by .4 to obtain percent. In the state of Texas, passing percentage is designated at 70%.

Short-distance encounters with suspects rely on decision-making skills, expertise, and training. Currently, most firearms training programs teach officers to focus their gaze on two locations, first on the sights of their gun, and secondly on the target before pulling the trigger

(Hancock, Hendrick, Hornick & Paradis, 2006). In a study researching differences between rookies and experienced LEOs, it was found that during simulated deadly encounters, experienced officers had better accuracy, decision-making skills, and faster motor movement responses in key muscles for shooting (Vickers & Lewinski, 2012).

Past research has focused on one-dimensional assessments of marksmanship during a static movement or post aerobic fatigue. Some studies indicate that the relationship between pistol shooting and selected physical fitness variables were significant (Anderson and Plecas, 2000; Vuckovic and Dopsaj, 2007). A study examining the effects of prior exercise intensity on rifle shooting performance in biathletes found that prior exercise intensity affected central aspects of shooting accuracy, shooting precision, and stability of rifle hold (Hoffman, Gilson, Westenburg, & Spencer, 1992). When shooting under pressure, LEO's shooting performance are lower than what might be expected, based upon standard shooting tests conducted within a shooting range (Murray, 2004). Muirhead, et al., (2019), suggested that static shooting training is not significantly transferable to dynamic shooting, where LEOs are required to move and shoot to complete occupational objectives. However, most of these studies have been conducted with patrol officers, and very little research has been conducted on SWAT operators (Thomasson, et al., 2014).

The specific amount of training on firearms within SWAT operators is inconclusive due to jurisdiction differences. There are no mandatory SWAT training standards, only suggestions by the California Peace Officers Standards and Training (POST) (Attorney General of California Commission on Special Weapons and Tactics, pp. 5-9, 2002; King, 2007), the NTOA, and the Texas Tactical Police Officer Association (TTPOA). It is suggested that part-time teams should train a minimum of 16 hours per month, while full-time teams should train 25 percent of their on-duty time. Typical training can range from tactical breaches using all team members, marksmanship, and combat tactical exercises. It is suggested SWAT teams train on the "big four" tactical operations law enforcement tactical teams are generally assigned, which are hostage rescue, high-risk warrant service, active shooters, and barricaded person[s] (Howe, 2006, p.136).

Howe (2006) also suggests these four tasks should be performed at dynamic and slow deliberate tempos. During these training days, marksmanship training integrated into the exercises can be both dynamic and static. It has been emphasized that LEO firearms training inadequately reflects the demands of real-life encounters (Brown 1984; Nielsen 1990; Marion 1998; Charles & Copay 2003). SWAT teams prepare for real-life encounters by conducting dynamic training to better prepare for situations that require force.

In conclusion, past research focusing on the LEO population has focused more on overall health and fitness (Crawley, et al., 2016; Sörensen, et al., 2000) with references to differences in age (Lockie, et al., 2018). Fitness testing has focused mostly on aerobic and strength measurements without the additions of marksmanship assessments, with very little research being conducted on SWAT personnel and marksmanship. Understanding the effects of exercise, specifically the different forms of possible occupational objectives, on marksmanship of LEOs will better help improve training and responses to overall threats LEOs are possibly faced with while on duty. Understanding differences in SWAT personnel, who face inherently more stressful situations and have significantly more training and are typically more experienced, compared to general LEOs may also establish a better understanding for specialized training and adaptation to stress and physical exercise required of new recruits on tactical units.

CHAPTER III

Methodology

This chapter discusses the methodology used to conduct this study design. Parameters regarding the inclusion of subjects, testing procedures, and instrumentation utilized are elucidated and illustrated when necessary. Additionally, methods for the sample and statistical analysis are clarified.

Participants

A sample of 32 active SWAT team operators were recruited from local law enforcement agencies (age = 38.04 ± 1.29 years; experience on SWAT = 7.33 ± 1.04 years) to participate in this study. SWAT team operators in this study reported being: (a) classified as active duty, (b) free of cardiometabolic disorders, (c) free of any known blood disorders (e.g., anemia, hemophilia), (d) non-tobacco users (including e-cigarettes, dip, and vape usage), (e) free of uncorrected vision impairments, (f) not on any prescription medication at the time of the study, (g) without any significant life events within 30 days of participation (e.g. death in family, divorce, wedding), and (h) free of any musculoskeletal injuries that removed them from full active duty. All procedures were approved by the Institutional Review Board at Texas A & M University – Corpus Christi (Appendix A).

Testing Location & Instrumentation

All testing procedures were conducted at an outdoor fully covered shooting range, with the full range used for each participant during individual testing. The exercise portion of the study consisted of three different variations of exercises used during academy training as well as conditioning. Exercise portions included: a 73.31-meter sprint entry into the range, a 13.71-meter weighted (79.73 kg) dummy drag and carrying a 17.5 kg battering-ram 13.71-meters.

During testing, subjects wore a Garmin FR60 watch, heart rate monitor, and foot pod (Olathe, Kansas, USA). These devices were used to determine heart rate (HR) during testing as well as determine the overall movement and activity of participants during the study protocol.

Environmental Analysis

Temperature, humidity, heat index, and wind speed were assessed using a Kestrel Model 5400 environmental meter (Kestrel Meters, Boothwyn, PA), which was mounted on a tripod and set at a height of 1.37 meters from the ground. Environmental data was continually collected starting at 20 minutes prior to each data collection session, and data sampling averaged for every 20-minute segment during the sessions for each day.

Psychometric Instruments

Four self-report measures were utilized to assess psychological measures related to the exercise and shooting assessments. The measures used for this study include: (1) the Rating of Perceived Exertion (RPE) scale (Borg, 1975), (2) the Feelings Scale (FS; Hardy & Rejeski, 1989), the Felt Arousal Scale (FAS; Svebak & Murgatroyd, 1985), and (4) the NASA Task Load Index (NTLX, Hart & Staveland, 1988).

The 6 – 20 Rating of Perceived Exertion scale (RPE; Borg, 1975) was used to assess perceived workload during the exercise session. Subjects were instructed during the initial session that perceived exertion is a measure of their perception of effort, stress, work, and/or discomfort felt during exercise. The participants were also informed of anchors for the RPE scale, defined for them by a member of the research team, in an attempt to utilize the participant's previous pertinent experiences to facilitate the likelihood of accurate perceptions. The Borg scale has been validated using test-retest comparisons of perceptual responses to changes in power output in accordance with HR and energy expenditure. Alpha reliability coefficients have been shown to range from 0.71 to 0.91, thus establishing the Borg 15-point graded scale of RPE as a reliable instrument for measuring perceived exertion (Borg, 1998).

The Feelings Scale (FS) and Felt Arousal Scale (FAS) are measures of basic affect (Ekkekakis & Petruzzello, 2000), specifically, the FS measures the valence (pleasure-displeasure) component, whereas the FAS measures the perceived activation (or arousal) component of basic affect, regardless of pleasure-displeasure.

The FS (Hardy & Rejeski, 1989) is an 11-point bipolar measure of pleasure-displeasure. The FS scale ranges from -5 to +5, with anchors provided at zero (neutral), maximal, and odd integers on the scale, from ‘very good’ (+5) to ‘very bad’ (-5). Participants were asked to rate how they felt at the moment and were informed that changes in feeling are natural. The FS was utilized as a single-item measure of affect and is commonly used to measure affective responses during exercise (Acevedo, Rinehardt, & Kraemer, 1994; Ekkekakis & Petruzello, 1999).

The FAS is a subscale of the Telic State Measure (Svebak & Murgatroyd, 1985). The FAS was used as a single-item measure of perceived activation and is a 6-item scale with anchors at 1 (Low Arousal) and 6 (High Arousal). Participants were informed that high arousal could be indicative of anger, excitement, or anxiety while low arousal might be related to boredom, relaxation, or calmness.

To assess the perceived overall workload after the conclusion of the task, participants were instructed to complete the NASA Task Load Index (NTLX; Hart & Staveland, 1988). The NTLX is a multi-dimensional subjective rating procedure that provides an overall workload score based on a weighted average of ratings on six subscales: mental demands, physical demands, temporal demands, performance, effort, and frustration. Three of the NTLX dimensions are related to the demands imposed upon the subject (mental, physical, and temporal demands), while the remaining three dimensions are related to the interaction of a subject with the task (effort, frustration, and performance).

Saliva Sample & Analysis

To collect saliva samples, the researcher handed the participant a 1” cotton roll, which the participant placed in their mouth, between their cheek and gum, for a 30-second duration. When the cotton swab was saturated with saliva, the research team member handed the participant a Salivette collection tube, in which the participant placed the cotton roll. The researcher handed the participant the cap to the Salivette and asked the participant to recap the tube and seal the cotton roll in the Salivette. The cotton roll absorbed the saliva and presents a low risk of cross-contamination even when saturated (Sarstedt, Ltd.). The researcher then had the participant place the Salivette in a Zip-Loc type bag and the bag was sealed by the researcher. This procedure was utilized for all collection procedures.

After collection of samples (2 samples per participant data collection), the collection bags were transported to Texas A&M University-Corpus Christi Exercise Physiology and Biochemistry Lab (Island Hall 146) by the researcher. Analysis of salivary cortisol levels was determined using an enzyme-linked immunoassay (ELISA; Salimetrics, State College, PA) technique. The intra-assay coefficient of variation was 2.79%. The value curve for the range of 0-3 ug/dL^{-1} had a correlation coefficient of 0.998.

Marksmanship Measures:

The participants utilized their duty weapon for use during the testing protocol. In this study, 9mm pistols, specifically Smith & Wesson M&P®9 M2.0™ (see figure 3a) were utilized. The ammunition used for the testing protocol was Remington UMC 9 mm Luger 115-Grain Centerfire Handgun Ammunition (See figure 3b). Targets used during the study were TQ-15 paper targets, which featured a gray silhouette and white background (see figure 4).

(A) (B)

Figure 3: SWAT operator's duty pistol and ammunition used during the protocol. (A) Smith & Wesson M&P®9 M2.0™ used during tactical exercises task marksmanship. (B) Remington UMC 9mm Luger 115-Grain ammunition used during tactical task exercises marksmanship a total of 20 rounds were used per individual during the total protocol.

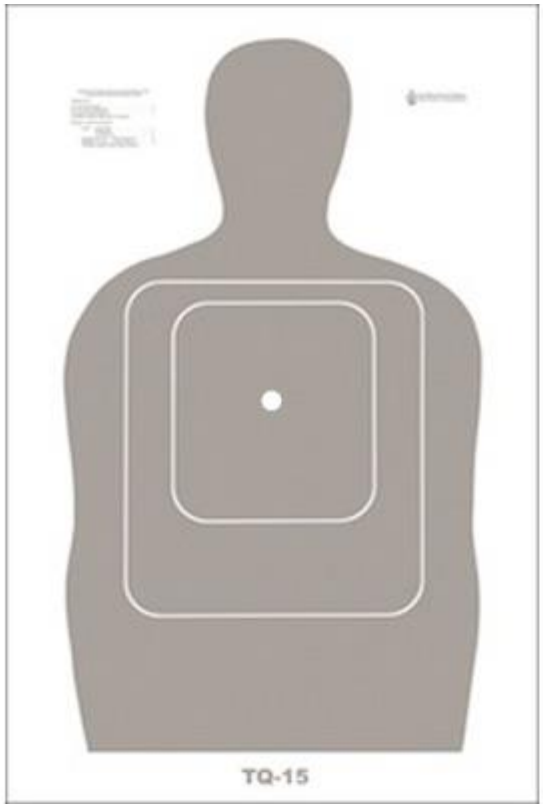

Figure 4: TQ-15 target used during marksmanship task. Dimensions of the target measure 24" x 40 in with a light gray silhouette. The center of mass (CM) is marked by the white dot in the middle of the target.

All marksmanship measures were adapted from Johnson (2001) and calculated for each target utilized in the protocol (4 target X 32 participants = 128 targets). Center of mass (CM) of the TQ-15 targets were standardized and marked by a single white dot on each individual target. The shooters aiming point is assumed to be the center of mass of the target, where (0,0) are the horizontal (X) and the vertical (Y) components, designated as the CM.

$$CM = (x, y) = (0,0)$$

A transparent plastic axis grid (5mm boxes) was placed over each individual target and included the entire silhouette body shape of the target from the neck down. The center of the grid was orientated to the CM of the target. Researchers recorded the coordinates of each individual shot to 5mm of position. Five shots were recorded per target, with a total of 20 shots per individual.

The shots recorded were measured based upon individual shots as well as the group of all five shots, called a shot grouping. The center of shot grouping (CSG) consisted of the array of the 5 shots. The CSG is the average point about which the individual's shots cluster. CSG is determined by first averaging the X components and then, separately, averaging the Y components of the bullet holes on the target that comprise the shot grouping (see Figure 5).

$$CSG = \left(\frac{\sum x_i}{n}\right), \left(\frac{\sum y_i}{n}\right) = (\bar{x}, \bar{y})$$

Two measures were used to determine marksmanship accuracy. The first measurement of shooting accuracy is the shot group distance from the center of mass (DCM_{SG}), which is a straight-line distance between the CSG and the CM on the target (see figure 5). DCM_{SG} represents the constant error component of marksmanship accuracy. The larger the DCM_{SG}, the less accurate the shooter.

$$DCM_{SG} = \sqrt{(\bar{x})^2 + (\bar{y})^2}$$

The second measurement, shot-distance from CM (DCM_S), is used to determine shooting error of each shot to the CM. DCM_S refers to the average of separate straight lines distances between each individual shot to the CM of the target (see Figure 5).

$$DCM_S = \frac{\sum\sqrt{(x_i)^2 + (y_i)^2}}{n}$$

Shot grouping tightness is a common term used to describe marksmanship precision. Marksmanship precision is used to determine the distance of CM from the CSG. There are six measures of marksmanship precision with two primary measures being mean radius (MR_S) and X and Y coordinates of CSG (CSG_X, CSG_Y). Mean Radius (MR_S) refers to the average distance of the straight line between the CSG and each shot that has penetrated the target. MR_S is used to determine the overall shot group tightness (see Figure 5).

$$MR_S = \frac{\sum\sqrt{(x_i - \bar{x})^2 + (y_i - \bar{y})^2}}{n}$$

Secondary measures of marksmanship precision are horizontal range (H_R), vertical range (V_R), area of dispersion (AD), diagonal of dispersion (DD). H_R is used to determine the shot grouping tightness in the horizontal plane (X component; see Figure 6).

$$H_R = (x_{max}) - (x_{min})$$

Whereas V_R is used to determine the vertical shot grouping tightness (Y component; see Figure 6).

$$V_r = (y_{max}) - (y_{min})$$

Further, AD describes the smallest rectangular area that contains all shots that penetrate the target (see Figure 6).

$$AD = (H_R)(V_R)$$

While DD represents the smallest diagonal of the rectangular area of the shot grouping (see Figure 6).

$$DD = \sqrt{(H_R)^2 + (V_R)^2}$$

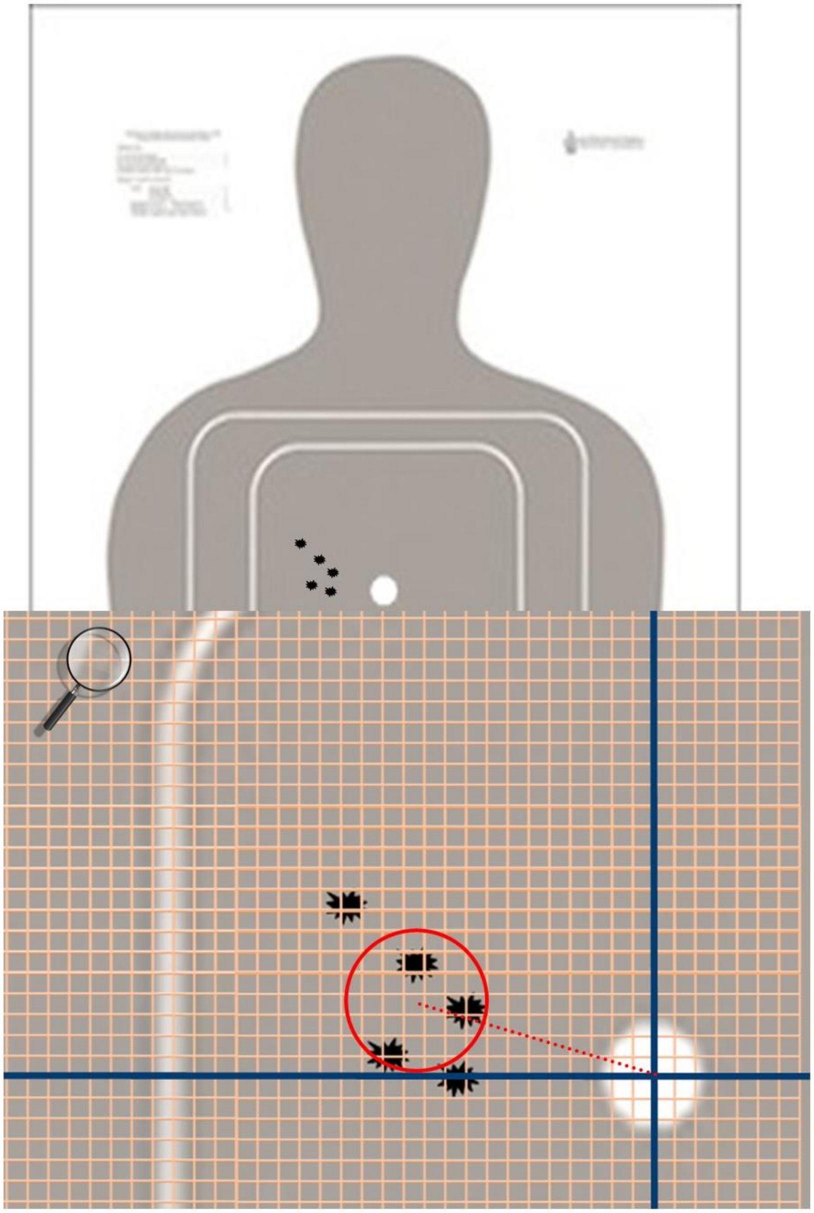

Figure 5: TQ-15 target with an example of DMC_{SG} and DMC_{S}. Coordinates of shots were recorded as: shot 1 (-9.5, 0), shot 2 (-13, 1), shot 3 (-9, 3), shot 4 (-11.5, 5.5) and shot 5 (-14.5, 8.5). DCM_{SG} was calculated as 12.05 cm represented as the dotted line, while DMC_{S} was calculated as 5.64 cm. Mean radius (MR_{S}) was calculated as 1.67 cm, which is represented as the circle encompassing the majority of shots. Not to scale.

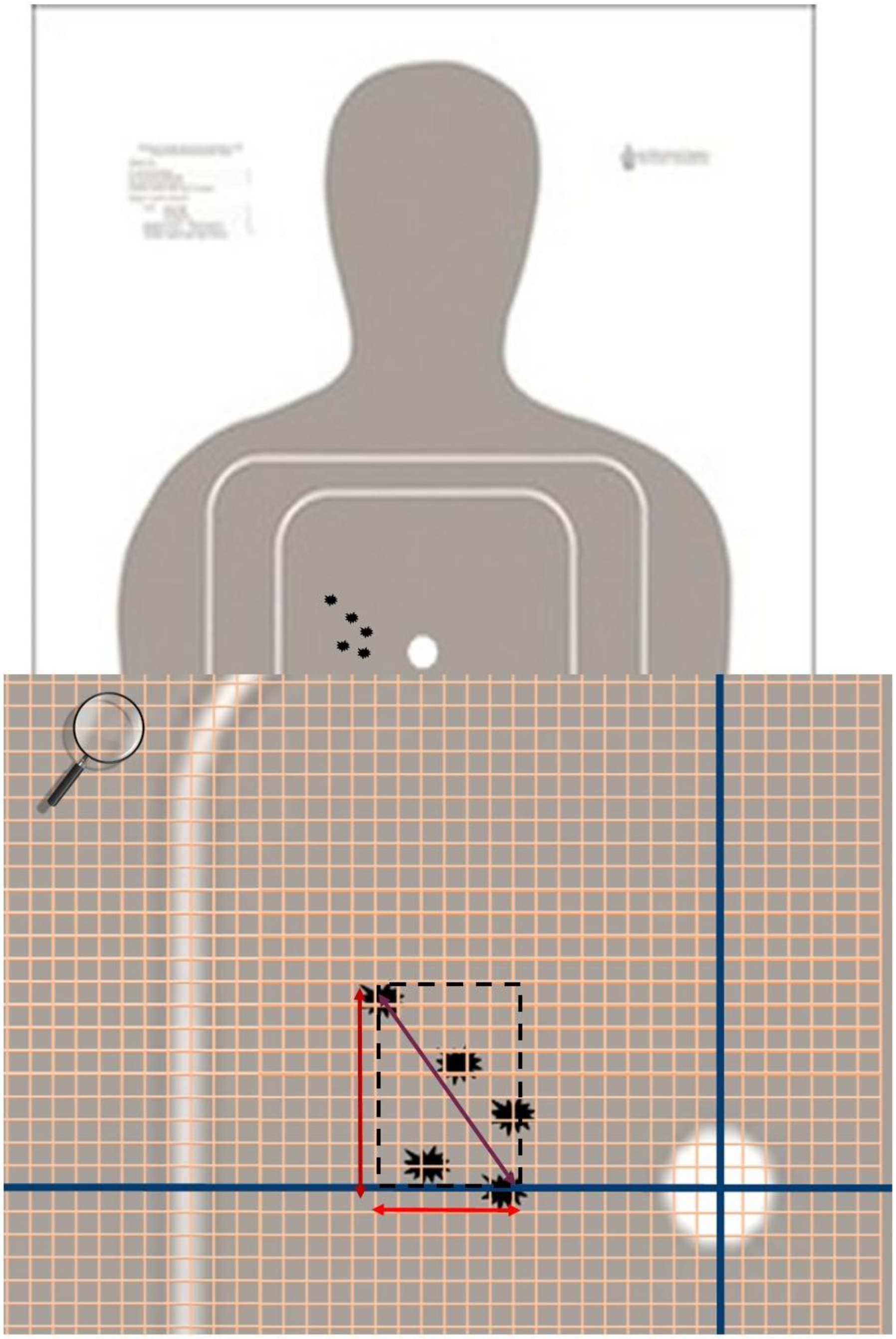

Figure 6: TQ-15 target with an example of V_R, H_R, AD, and DD. Coordinates of shots were recorded as: shot 1 (-9.5, 0), shot 2 (-13, 1), shot 3 (-9, 3), shot 4 (-11.5, 5.5) and shot 5 (-14.5, 8.5). V_R is represented by the arrow, which was calculated at 5.5 cm. H_R which is represented as the arrow was calculated at 8.5 cm. AD, which is represented by the dashed line was calculated as 46.75 cm^2, while DD is represented by the arrow was calculated as 10.13 cm. Not to scale.

Study Design

Participants completed a total of 2 testing sessions with session 1 occurring online via a Qualtrics survey. For session 1, participants were provided a link to the survey, which they could then access at their own convenience. The participant was informed of the purpose of this portion of the study and then acknowledged and provided consent (Appendix B). After consenting to participate in the online survey, participants were asked to complete a health history questionnaire, physical activity questionnaire, and the PSS regarding their feelings and thoughts during the previous month and a questionnaire about their law enforcement experience (see Appendices C & D).

Session 2 occurred during a monthly SWAT team training session over the course of three days. This session involved the participants performing four bouts of target shooting (baseline, post-sprint, post-drag, and post-carry) in conjunction with three tactical exercises (73.31-meter sprint, 79.73 kg weighted adult dummy drag, and a 17.5 kg battering ram carry). The research procedures for the session were briefly explained to the group, and participants were once again allowed to ask any questions they may have. Participants were then asked to sign an informed consent for Session 2 of the data collection (Appendix B).

The SWAT operators were then individually sent to the data collection area and had their height and weight measured without their patrol uniform on. Next, they were asked to place the Garmin HR monitor, under the shirt, touching their skin. Once properly placed and secured, SWAT operators were instructed to fully dress in their patrol uniform, which consisted of tactical pants, ballistic vest, work boots, thigh holster, and duty belts that contained two ammunition magazines, radio, handcuffs, tactical flashlight, pepper spray, gloves, and tourniquet with holder, batteries, gloves, pens, pencils, keys, and multi-tool. Garmin foot-pod was then placed on their right foot and Garmin watch was fastened to each participant. Once fully dressed and in their tactical gear, the SWAT operator's height and weight were remeasured.

Once this data was collected, the SWAT operators were asked to provide a saliva sample for measurement of cortisol level and complete the FS and FAS psychometrics. Once baseline data was collected, participants were then sent to the covered shooting range and instructed to pre-load one magazine for their sidearm pistol with 5 rounds of ammunition and a second magazine with 15 rounds of ammunition. Once loaded, the SWAT operators were asked to perform a 13.71 meter static shooting drill utilizing the magazine containing 5 rounds at a paper TQ-15 target, labeled as target A (see Figure 7). SWAT operators were instructed to aim at the center of mass of the target marked by a white dot.

Once static baseline shooting was completed, the SWAT Operator was then instructed to reload their pistol with the magazine containing the 15 rounds of ammunition for the remaining section of the protocol. Once their weapon was loaded and holstered, the SWAT Operator was moved to the patrol vehicle, positioned 73.31 meter from the range and instructed to take a seat in the vehicle, as if on duty, with the door closed. The SWAT Operator was again instructed on the task they needed to perform and allowed to ask any further questions. Once relaxed, time started when the SWAT Operator exited the patrol vehicle. The participant ran 73.31 meters to position X, turned 90° and entered the range swiftly and tactically. The SWAT Operators were instructed to find cover once inside the range at Position O and quickly fire 5 rounds of ammunition at target B. Cover was provided during tactical shooting by two plywood structure placed at position O. Each cover structure was recorded at 2.29 meters tall by 0.91 meters wide and were placed at position O at an angle of 50° from the centerline of the range.

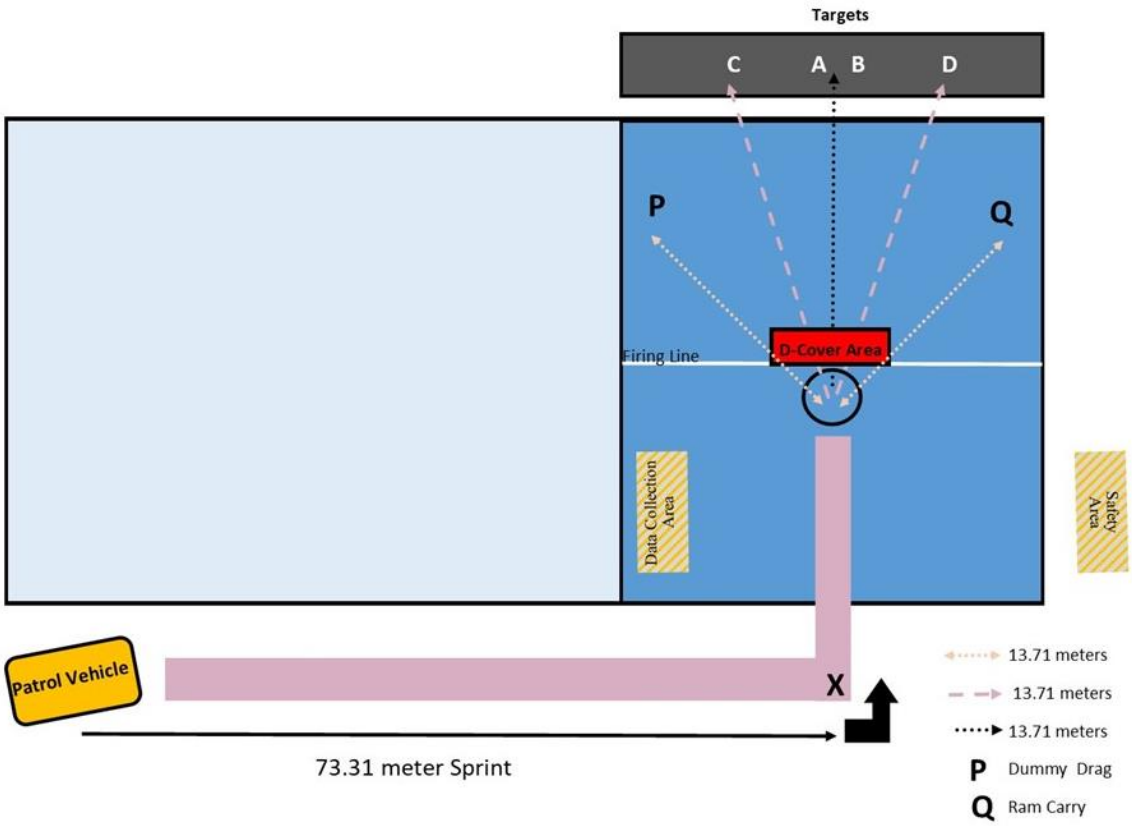

Figure 7: Training procedure with the movement of SWAT personnel and exercise during research protocol. Not draw to scale.

After shooting on Target B was completed, the SWAT Operator would then go and retrieve the 79.73 kg weighted dummy or the 17.5 kg battering ram from position P or Q, located 13.71 meters diagonal at a 60° angle from position O, and return to cover at position O. Upon returning to position O and behind cover, the SWAT Operator would then shoot 5 rounds into target C, or shoot the target in the direction from which they had retrieved the dummy or ram, located 15 meters from position O at a 45° angle. The SWAT Operator was instructed to remain behind the cover while shooting. The SWAT Operator then retrieved/dragged either the remaining weighted dummy or the weighted battering-ram and return to position O. Once covered and returned to position O, the SWAT Operator shot the final 5 remaining rounds into target C/D. The SWAT Operator then holstered their service weapon, their overall time was stopped, and an “all clear” called for range safety.

The SWAT Operator was then sent to the data collection area to provide the final saliva sample while also completing and reporting their RPE, FS and FAS for the exercise bout. Once completed, the SWAT Operator was also asked to complete the NTLX survey. While psychometrics and saliva samples were being collected, research assistants were resetting the range with targets, weighted dummy, battering ram and obstacles as well as clearing the range of discharged shells.

Researchers recorded on the targets the order in which the targets were shot. Targets were marked and designated according to their placement on the range and shooting order, as well as with the subject’s identification number. Once targets were used, researchers removed targets and placed them in a secure area to reduce environmental stress on the paper and prevent disclosure of results to others. Targets were then removed and flattened prior to collecting accuracy and precision measurements.

Statistical Analysis

Variables measured for this study included participants’ LEO experience, SWAT team experience, time to complete the protocol, FS, FAS, RPE, NTLX, salivary cortisol values, and the eight measures of marksmanship accuracy and precision (DCM_{SG}, DCM_S, MR_S, CSG_X, CSG_Y, RH, VH, AD, DD).

Shooting accuracy and precision were analyzed using one-way ANOVAs to compare the static baseline condition to the three dynamic tactical exercises (sprint; drag; and carry) on the eight dependent variables (DCM_{SG}, DCM_S, MR_S, CSG_X, CSG_Y, RH, VH, AD, DD). Tukey Post-hoc analyses were used, when appropriate, to determine specific differences in conditions compared to baseline static shooting. One-way ANOVAs were also utilized to determine the which NTLX subscales contributed the most to the participants' perceptions of the task workload.

Additionally, paired t-tests were utilized to examine differences between pre-protocol measures of FS, FAS, and salivary cortisol. Finally, relationships among the target dependent variables and between the participants' LEO experience, SWAT team experience, time to complete the protocol, reported RPE, and NTLX subscale and overall scores, post-FAS, post-FS, and post-salivary cortisol were examined with Pearson-Product Moment correlations.

CHAPTER IV

Results

Participants

Thirty-two active SWAT operators were recruited to participate in this study. The SWAT operators had served an average of 7.33 ± 1.04 years (mean ± SD) years as a SWAT operator and had a mean age of 38.67 ± 1.19 years. A summary of the group demographics for the SWAT team can be found in Table 2.

Table 2.
Participant demographic characteristics.

Variables	Mean ± SD
Age (years)	38.67 ± 6.23
Height (cm)	179.39 ± 6.81
Weight w/o gear (kg)	93.20 ± 11.54
Weight with Gear (kg)	110.68 ± 14.34
Years as LEO	13.32 ± 6.31
Years as SWAT	7.09 ± 5.28

Environment

Three days were used for data collection. Data collection on day one was collected between the hours of 1000 and 1200. Data collection of day two was collected between the hours of 0900 and 1230. Data collection on day three was collected between the hours of 0930 and 1130. Temperature (°C), relative humidity (%), and heat index (°C), and wind speed were recorded during the testing protocol. A summary of the environmental data for each day of testing can be found in Table 3.

Table 3.
Environmental data for the three consecutive days of data collection. Values equal mean ± SD; n = number of participants who completed the protocol per day.

Variable	**Day 1** ***(n = 9)***	**Day 2** ***(n = 19)***	**Day 3** ***(n = 4)***
Temperature (ºC) *(Min – Max)*	19.80 ± 0.62 (17.2 -23.2)	20.72 ± 0.40 (19 - 22.2)	16.87 ± 0.30 (15.8 - 22.3)
Relative Humidity (%) *(Min – Max)*	91.92 ± 1.93 (80.8 – 100)	83.36 ± 1.39 (77.4 - 88.9)	38.62 ± 0.23 (37.6 - 41.65)
Heat Index (ºC) *(Min – Max)*	20.57 ± 0.67 (17.3 – 24.5)	21.20 ± 0.44 (19.1 - 22.7)	14.63 ± 0.24 (13.7 - 15.6)
Wind Speed (m/min^{-1}) *(Min – Max)*	5.88 ± 0.10 (0.00 – 6.00)	175.20 ± 16.94 (2.00 - 4.90)	208.0 ± 19.90 (102.00 – 282.00)

It should be noted that on day 2, a weather front was coming in and that on day 3, the front had passed through the area. The majority of participants completed testing on day 1 and day 2, and analysis demonstrated that the weather differences did not seem to impact measures.

Tactical Exercise Effort

Descriptive statistics of the law enforcement tactical exercise effort includes participant's peak heart rate (HR_P), average heart rate (HR_A) during the tactical exercises, and cadence, the pace of movement, rating of perceived exertion (RPE), and total time to complete the protocol (see Table 4).

Table 4:
Physical demands from tactical exercises.

Variables	**Mean ± SD**	**Min – Max**	**n =**
Average HR (bpm)	147.95 ± 21.07	76 – 179	19
Peak HR (bpm)	166.53 ± 11.75	149 – 192	19
Cadence (step/min)	208.11 ± 16.06	186 – 252	18
Pace (minute/mile)	5:23 ± 0:43	4:16 – 6:46	18
RPE	13.84 ± 2.14	10 – 19	32
Total Time (seconds)	77.33 ± 18.22	50.08 – 143.5	32

There was a loss of some data points for HR, cadence, and pace due to technical errors experienced with the devices used to collect this data, and these losses are noted in the results where appropriate.

Marksmanship

Accuracy

Shooting accuracy was analyzed using repeated measures ANOVAs (RMANOVA) to compare the static baseline condition to the three dynamic tactical exercises (sprint; drag; and carry) on the variables of DCM_{SG} and DCM_{S}.

RMANOVA for DCM_{SG} demonstrated significant main effect between baseline shooting and the three shooting conditions ($F_{3,93} = 4.78$, $p < .01$). Post-hoc analyses demonstrated that only the post weighted adult dummy drag shooting situations was significantly different for DCM_{SG} ($t_{31} = 2.14$, $p < 0.05$) compared to baseline shooting. Shot grouping distance from the CM of the target was greater after the dummy drag compared to the distance during baseline shooting, resulting in an increase in constant error of accuracy after the drag condition (see Figure 8).

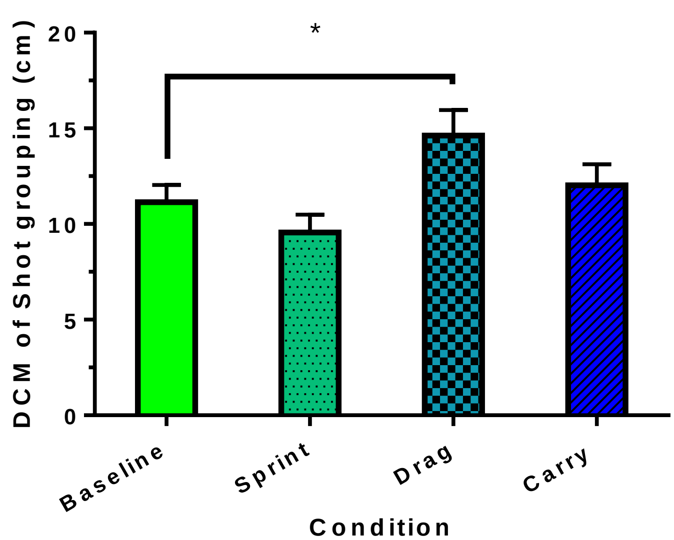

Figure 8: DCM_{SG} marksmanship accuracy values between baseline, post-sprint, post-drag, and post-ram carry conditions. Significant differences were found between baseline and post-drag conditions (*$p < .05$), but not post-sprint or post-battering ram carry conditions.

RMANOVA for DCM_S revealed a significant main effect between baseline shooting and each of the three tactical shooting conditions ($F_{3,93} = 4.29$, $p < 0.001$). Post-hoc analyses revealed that a significant difference was found comparing baseline DCM_S to both the post-weighted adult dummy drag DCM_S ($t_{31} = 3.21$, $p < 0.01$) and post-battering ram carry DCM_S ($t_{31} = 2.27$, $p < 0.05$) but not post-sprint. Average shot distance from center of mass of the target increased as a result of the adult dummy drag and battering ram carry compared to the baseline shooting condition, demonstrating an increase in shot error and decrease in accuracy for individual shots after the drag and carry exercises (see Figure 9).

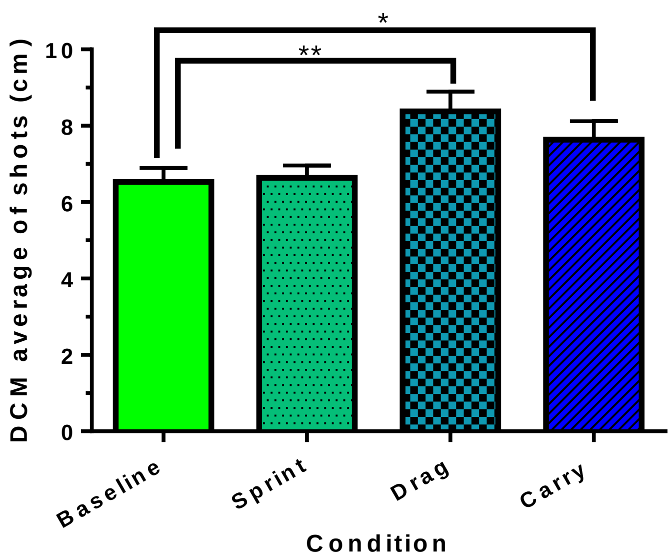

Figure 9: DCM_S marksmanship accuracy values between baseline, post-sprint, post-drag, and post-ram carry conditions. Significant differences were found between baseline and post-drag conditions (**p < .01), and post-ram carry (*p < .05) conditions, but not post-sprint conditions.

Precision

Shooting precision was analyzed using RMANOVA to compare the static baseline condition to the three dynamic tactical exercises (sprint; drag; and carry) on two primary variables and four secondary variables of precision. The two primary variables are MR_S and CSG, while the four secondary measurements of precision include H_R, V_R, AD and DD.

RMANOVA for MR_S demonstrated a significant main effect between baseline shooting and the three tactical exercise shooting conditions ($F_{3,93} = 4.29$, $p < 0.001$). Post-hoc analyses showed significant difference between baseline and all three conditions: post-sprint ($t_{31} = 2.46$, $p < 0.05$), post-drag ($t_{31} = 3.48$, $p < 0.01$) and post-battering ram carry ($t_{31} = 4.43$, $p < 0.001$). MR_S increased during the three tactical exercises compared to baseline resulting a larger distance between each individual shot and the CSG during each condition (see Figure 10).

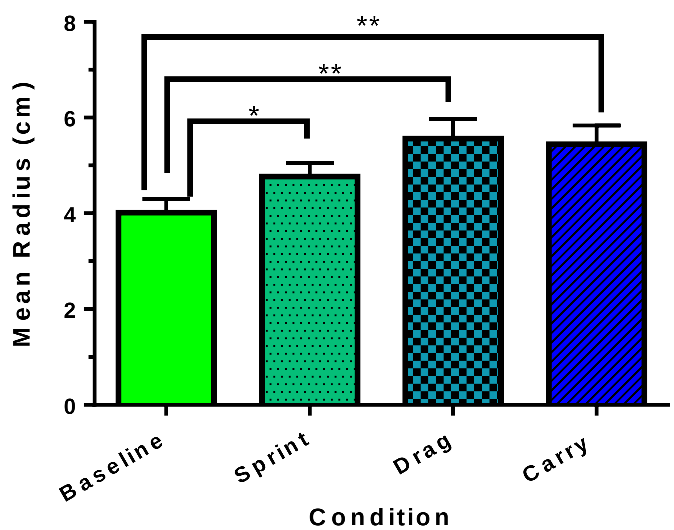

Figure 10: MR_S marksmanship primary precision values between baseline, post-sprint, post-drag, and post-ram carry conditions. Significant differences were found between baseline and post-drag conditions (**p < .01), and post-ram carry (**p < .01) conditions, and post-sprint (*p < .05) conditions.

Measurements of both CSG_X and CSG_Y RMANOVA analysis did not demonstrate any significant main effects between baseline shooting and the three post- tactical exercise shooting precision. CSG did not show a significant change in location, either horizontally or vertically, between the four shooting conditions (see Figure 11ab).

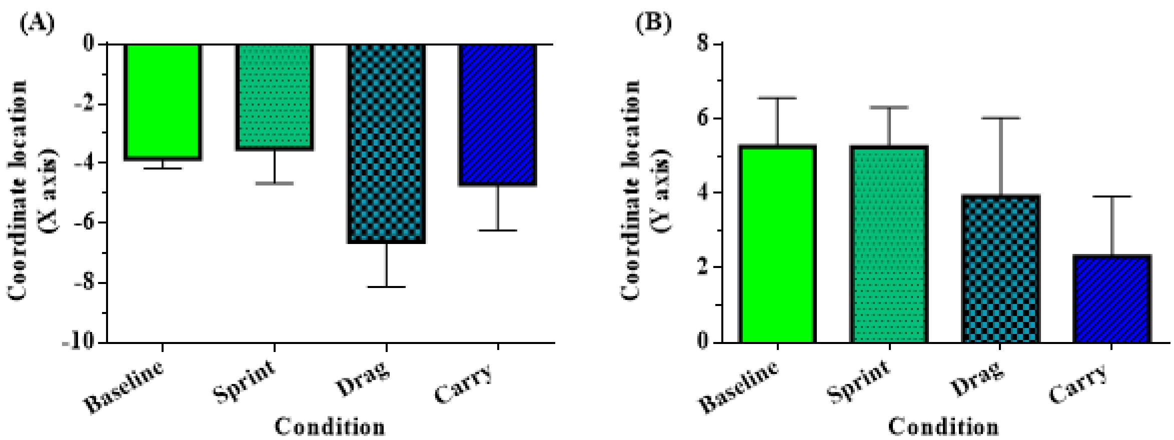

Figure 11: The center of shot grouping coordinate locations between baseline, post-sprint, post-drag, and post-ram carry conditions. (A) CSG_X marksmanship primary precision values showed no significant differences between baseline and after the three tactical exercises. (B) CSG_Y demonstrated no significant differences between baseline and after the three tactical exercises.

RMANOVA for the secondary precision measurement of H_R demonstrated a significant main effect between baseline shooting and the three shooting situations ($F_{3,93} = 4.16$, $p < 0.05$). Post-hoc analyses did not demonstrate a significant difference between baseline shooting and post-sprint shooting but did reveal a significant main effect between baseline shooting and the three shooting situations ($F_{3,93} = 4.16$, $p < 0.05$). H_R increased during the post-drag and post-ram carry condition compared to baseline; however, the post-sprint H_R was not significantly different (see Figure 12).

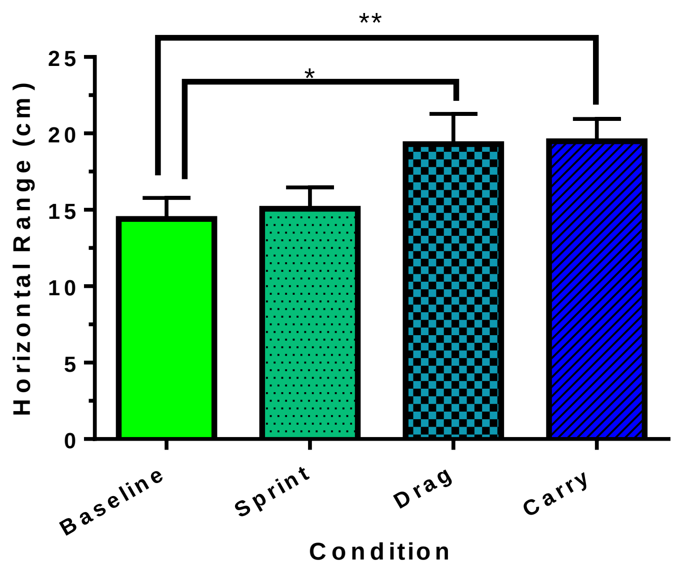

Figure 12: H_R marksmanship secondary precision values between baseline, post-sprint, post-drag, and post-ram carry conditions. Significant differences were found between baseline and post-drag conditions (*p < .05), and post-ram carry (**p < .01) conditions, but not post-sprint conditions.

RMANOVA for the secondary precision measurement of V_R showed a significant main effect between baseline shooting and the three tactical exercise shooting conditions ($F_{3,93} = 3.15$, $p < 0.05$). Post-hoc analyses demonstrate a significant difference between baseline shooting compared to post-drag V_R ($t_{31} = 2.08$, $p < 0.05$) and post-battering ram carry V_R ($t_{31} = 3.86$, $p < 0.001$), but not post-sprint. VR increased during the post-drag and post-battering ram carry condition compared to baseline, however post-sprint V_R was not significantly different (see Figure 13).

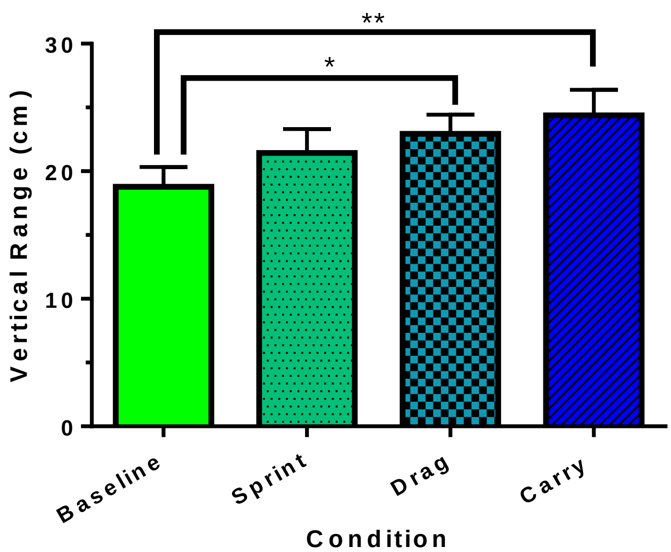

Figure 13: V_R marksmanship secondary precision values between baseline, post-sprint, post-drag, and post-ram carry conditions. Significant differences were found between baseline and post-drag conditions (*p < .05), and post-ram carry (**p < .01) conditions, but not post-sprint conditions.

RMANOVA for the secondary precision measurement of AD revealed a significant main effect between baseline shooting and the three tactical exercise shooting conditions ($F_{3,93} = 6.35$, $p < 0.01$). Post-hoc analyses comparing baseline shooting to the three tactical exercise shooting demonstrated significant difference between post-drag AD ($t_{31} = 2.99$, $p < 0.01$) and post-ram carry AD ($t_{31} = 4.12$, $p < 0.001$), but not post-sprint AD. The rectangular area that contains each individual shot during the post-drag and post-ram carry conditions increased in size compared to that of the baseline (see Figure 14).

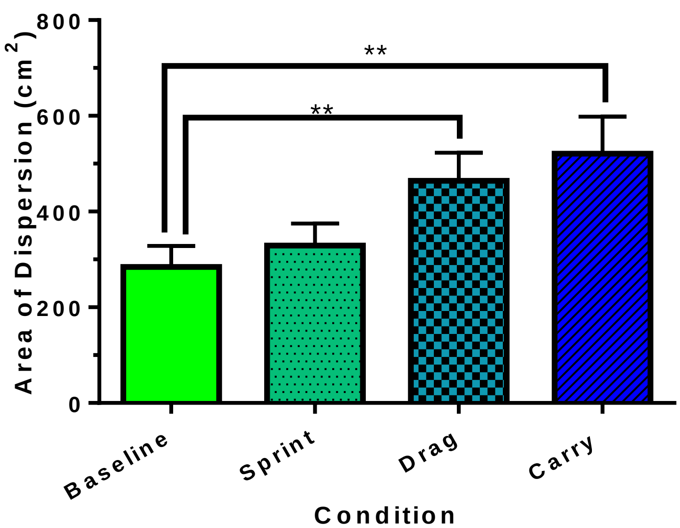

Figure 14: AD marksmanship secondary precision values between baseline, post-sprint, post-drag, and post-ram carry conditions. Significant differences were found between baseline and post-drag conditions (**p < .01), and post-ram carry (**p < .01) conditions, but not post-sprint conditions.

For the secondary measure of precision of DD, RMANOVA resulted in a significant main effect between baseline and the three tactical exercises ($F_{3,93} = 6.18$, $p < 0.01$). Post-hoc analyses revealed that a significant difference was found comparing baseline DD to both post-drag ($t_{31} = 2.95$, $p < 0.01$) and post-ram carry ($t_{31} = 4.48$, $p < 0.001$), but not post-sprint. The results suggest that DD during the conditions increased during post-drag and post-ram carry (see Figure 15).

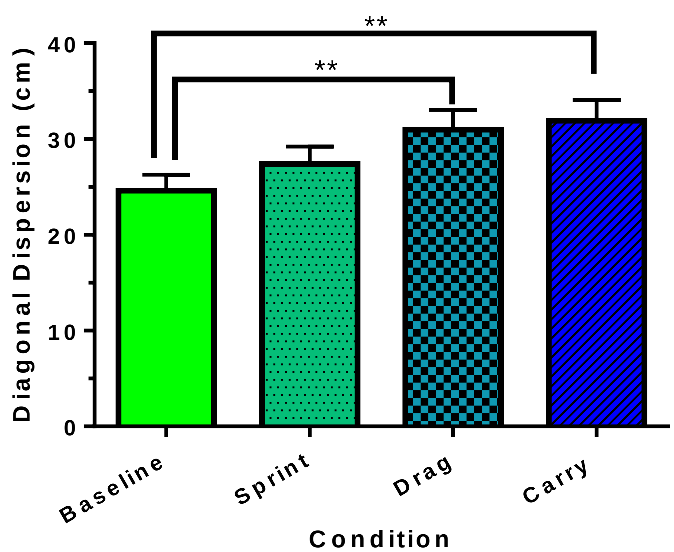

Figure 15: DD marksmanship secondary precision values between baseline, post-sprint, post-drag, and post-ram carry conditions. Significant differences were found between baseline and post-drag conditions (**p < .01), and post-ram carry (**p < .01) conditions, but not post-sprint conditions.

Salivary Cortisol

Paired t-tests were conducted to compare salivary cortisol levels pre-protocol to immediately post-protocol. Pre-protocol salivary cortisol level ($\bar{x}$ = 0.47 ± 0.13) was not significantly different compared to post-protocol salivary cortisol values ($\bar{x}$ = 0.56 ± 0.12; see Figure 16).

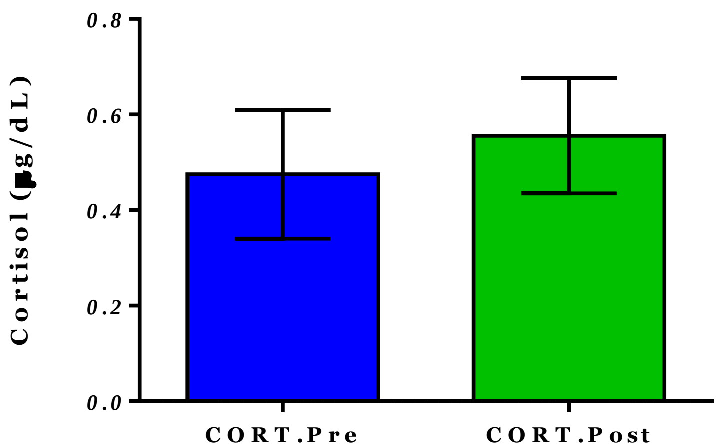

Figure 16: Salivary Cortisol Levels (CORT) pre- and post-testing protocol. CORT was used to determine stress levels of completing the testing protocol. No significant difference was seen prior to or post completion of the three-law enforcement tactical tasks.

Psychometrics

Paired t-test we used to examine differences between pre-protocol and post-protocol measures of FS and FAS. Pre-protocol FS ($\bar{x}$ = 2.86 ± 0.26) compared to post-protocol FS ($\bar{x}$ = 3.28 ± 0.31) was not significantly different (see Figure 17b). However, pre-protocol FAS ($\bar{x}$ = 3.47 ± 0.19) was significantly different than post-protocol FAS ($\bar{x}$ = 4.44 ± 0.16), (t_{31}= 4.89, p < 0.001; see Figure 17a). Post-protocol, SWAT operators scored higher in their perception of feeling more excited or anxious but did not feel different regarding pleasure-displeasure of the task.

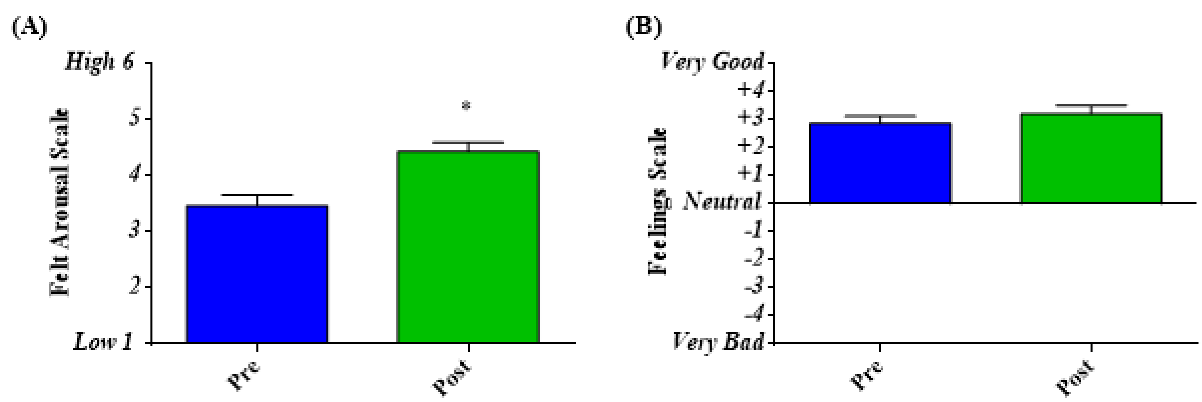

Figure 17: (A) Felt Arousal Scale (FAS) pre- and post-testing protocol results. FAS scores represent arousal levels of participants prior to and after completing the three-law-enforcement related tactical exercise, which was significantly different post protocol compared to pre-protocol scores (*p < .05). (B) Feeling Scale (FS) pre- and post-testing protocol. FS scores represent feelings of participants prior to and after completing the three-law-enforcement related tactical exercises, which were not significantly different.

Task Demands

To determine the contributions the contributions of each workload, the task load rating for each measure was multiplied by the weighted score of the task. The resultant values were analyzed using a MANOVA to investigate the contributions of the six NTLX subscales towards participants' perceptions of the task workload. Only the subscale of frustration was found to not be a significant contributor to the overall workload, SWAT operators perceived their workload in the tasks to be more demanding relative to the subscales of mental demands ($F_{1, 31} = 49.72$, $p < .001$), physical demands ($F_{1, 31} = 86.97$, $p < .001$), temporal demand ($F_{1, 31} = 66.53$, $p < .001$), effort ($F_{1, 31} = 144.30$, $p < .001$), and performance ($F_{1, 31} = 76.74$, $p < .001$; see Figure 18).

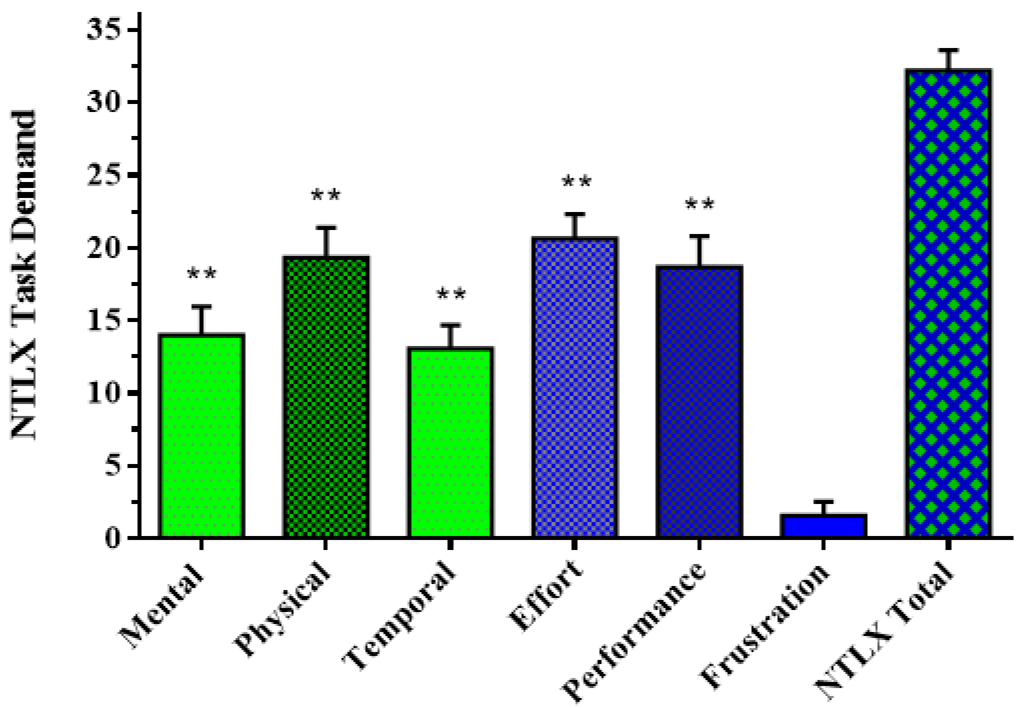

Figure 18: The NASA Task Load Index subscale scores post-testing protocol. Participants perceived physical demands, effort, and performance to complete the task to be the most important to workload compared to frustration in the task after completing the tactical exercise protocol. Total values were calculated by the individual ranking of the contribution multiplied by pairing selection of demands.

Correlations

The Pearson-Product Moment correlations were used to determine relationships among the participants' SWAT team experience, time to complete the protocol, the reported RPE score, post-FS, post-FAS, and post-salivary cortisol levels, NTLX scores (overall and subscales), and marksmanship primary accuracy and precision values (DCM_{SG}, DCM_{S}, MR_{S}, CSG_{X}, CSG_{Y}) during baseline and after the three tactical exercises (sprint, drag, carry).

SWAT Team Experience, Total Protocol Time, RPE & NTLX

Relationships between SWAT team experience, total protocol time, RPE, and NTLX subscale scores and NTLX overall score can be seen in Table 5. There were no significant relationships between SWAT team experience and time to complete the protocol, RPE, NTLX subscale scores, or NTLX overall score. There were also no significant relationships between time to complete the protocol with RPE, NTLX subscale scores, or NTLX overall score.

RPE was significantly correlated with NTLX scores of mental demand ($r = .39$, $p < 0.01$), physical demands ($r = .52$, $p < 0.01$), time demands ($r = .47$, $p < 0.01$), task effort ($r = .60$, $p < 0.01$), overall NTLX score ($r = .61$, $p < 0.01$), but not for the subscales of performance demand or task frustration.

NTLX subscale of mental demand was significantly correlated with the NTLX subscales of time demand ($r = .57$, $p < 0.001$) and task effort ($r = .41$, $p < 0.05$), but not physical demand, task performance, or task frustration.

The NTLX subscale of physical demand was not significantly correlated to task performance or task frustration but did demonstrate a significant relationship with time demand ($r = .64$, $p < 0.001$), task effort ($r = .65$, $p < 0.001$). Further, the NTLX subscale of time demand was significantly correlated to NTLX task effort ($r = .75$, $p < 0.001$).

Table 5.
Correlations of SWAT experience, protocol time, RPE, and NTLX subscale scores and NTLX overall score.

	SWAT Exp.	TT	RPE	MD	PD	TD	Effort	P	F	NTLX
SWAT Exp.	-	.34	-.05	-.17	.13	-.13	.19	-.12	.09	-.02
TT		-	-.36	.23	-.01	.06	-.13	.28	.08	.17
RPE			-	.39*	.52**	.47**	.60**	-.02	.35	.61**
MD				-	.32	.57**	.41**	-.08	.16	-
PD					-	.64**	.65**	-.11	.31	-
TD						-	.75**	-.06	.18	-
Effort							-	-.16	.33	-
P								-	.001	-
F									-	-
NTLX										-

Note. *Correlation significant at the 0.05 level. **Correlation significant at the 0.01 level. SWAT Exp.= Time on Swat; TT = total protocol time; RPE = rating of perceived exertion; MD = mental demand; PD = physical demand; TD = time demand; P = performance; F = frustration; NTLX = overall NASA task load index score.

SWAT Team Experience, Total Protocol Time, RPE & Primary Accuracy Measure

Correlations between SWAT team experience (SWAT EXP.) and primary marksmanship accuracy (DCM_{SG}, DCM_S) during baseline and after each of the tactical exercises did not result in any significant relationships, can be found in Table 6. Further, correlations between total protocol time (TT) and primary marksmanship accuracy and precision values (DCM_{SG}, DCM_S) for baseline shooting and after the tactical exercises also did not result in any significant relationship. RPE was not correlated to baseline and the three tactical exercises for any of the marksmanship accuracy measures of DCM_{SG} or DCM_S.

Table 6.
Correlations of SWAT experience, protocol time, RPE, and baseline and post tactical exercise primary accuracy measures of DCM_{SG} and DCM_S.

	Baseline DCM_{SG}	**Baseline DCM_S**	**Sprint DCM_{SG}**	**Sprint DCM_S**	**Drag DCM_{SG}**	**Drag DCM_S**	**Ram DCM_{SG}**	**Ram DCM_S**
SWAT Exp	.19	.21	.14	.18	.12	.08	.09	.09
TT	-.09	.08	-.05	-.04	.07	.19	.24	.17
RPE	.05	-.07	-.00	.00	-.02	-.02	.18	.09

Note. *Correlation significant at the 0.05 level. **Correlation significant at the 0.01 level. SWAT Exp.= Time on Swat; TT = total protocol time; RPE = rating of perceived exertion; Baseline = baseline shooting; Sprint = tactical exercise sprint; Drag= tactical exercise adult dummy drag; Ram = tactical exercise ram carry; DCM_{SG}= distance from center of mass for shot grouping; DCM_S= distance from center of mass per shot.

SWAT Team Experience, Total Protocol Time, RPE & Primary Precision Measures

Correlations between SWAT team experience (SWAT EXP.) and primary marksmanship precision measure (MR_S) during baseline and after each of the tactical exercises did not result in any significant relationships, can be found in Table 7. Further, correlations between total protocol time (TT) and primary marksmanship precision values (MR_S) for baseline shooting and after the tactical exercises did not result in any significant correlations. RPE was not correlated to either baseline or the three tactical exercises for the marksmanship precision measure of MR_S.

Table 7.
Correlations of SWAT experience, protocol time, RPE, and baseline and post tactical exercises primary precision measure of MR_S.

	Baseline MR_S	**Sprint MR_S**	**Drag MR_S**	**Ram MR_S**
SWAT Time	.04	-.05	-.02	.01
TT	.22	.07	-.07	.14
RPE	-.29	-.12	.02	.08

Note. *Correlation significant at the 0.05 level. **Correlation significant at the 0.01 level. SWAT Exp.= Time on Swat; TT = total protocol time; RPE = rate of perceived exertion value; Baseline = baseline shooting; Sprint = tactical exercise sprint; Drag = tactical exercise adult dummy drag; Ram = tactical exercise ram carry; MR_S= mean radius of the shot grouping.

Correlations between SWAT team experience (SWAT EXP.) and primary marksmanship precision measures (CSG_X and CSG_Y) during baseline and after each of the tactical exercises did not result in significant correlations, can be found in table 8. Further, correlations between total protocol time (TT) and primary marksmanship precision values (CSG_X, CSG_Y) for baseline shooting and after the tactical exercises did not result in any significant relationships. RPE was not correlated to the baseline measure or after the three tactical exercise for any of the marksmanship precision measures of CSG_X and CSG_Y.

Table 8.
Correlations of SWAT experience, protocol time, RPE, and baseline and after tactical exercise primary precision measure of CSG_X and CSG_Y.

	Baseline CSG_X	**Baseline CSG_Y**	**Sprint CSG_X**	**Sprint CSG_Y**	**Drag CSG_X**	**Drag CSG_Y**	**Ram CSG_X**	**Ram CSG_Y**
SWAT Time	-.24	-.15	-.23	.07	-.21	-.16	-.29	-.22
TT	-.14	-.31	.27	.31	-.05	-.12	-.26	-.19
RPE	-.11	.27	.07	.07	.14	.06	.10	.09

Note. *Correlation is significant at the 0.05 level. **Correlation is significant at the 0.01 level. SWAT Exp.= Time on Swat; TT = total protocol time; RPE = rate of perceived exertion value; Baseline = baseline shooting; Sprint = tactical exercise sprint; Drag = tactical exercise adult dummy drag; Ram = tactical exercise ram carry; CSG_X = center of shot grouping X-coordinate; CSG_Y = center of shot grouping Y-coordinate.

Primary Accuracy & Precision Measures with NTLX

Relationships between primary accuracy measures (DCM_{SG}, DCM_S) and NTLX subscale scores and overall NTLX score can be found in Table 9. A negative relationship was revealed between baseline DCM_{SG} and task performance ($r = -.36$, $p < 0.05$). Correlations between the post drag tactical exercise marksmanship measures revealed positive relationships with DCM_S with NTLX subscale task performance ($r = .38$, $p < 0.05$). No other relationship was seen between NTLX subscales, overall NTLX score and primary measures DCM_{SG} or DCM_S.

Table 9.
Correlations of NTLX subscale and overall scores and accuracy measurements DCM_{SG}, DCM_S for baseline and the three tactical exercises of sprint, weighted dummy drag, and battering ram carry.

	Baseline DCM_{SG}	**Baseline DCM_S**	**Sprint DCM_{SG}**	**Sprint DCM_S**	**Drag DCM_{SG}**	**Drag DCM_S**	**Ram DCM_{SG}**	**Ram DCM_S**
MD	.16	.162	.05	.10	-.20	-.13	.01	.06
PD	.12	-.05	.00	.01	.03	.10	.02	-.01
TD	.02	-.02	-.04	-.03	-.07	-.07	-.06	.02
Effort	.23	.11	-.01	.01	-.09	-.06	-.10	-.09
TP	-.36*	-.25	-.02	-.12	.30	.38*	.20	.31
TF	.21	.13	-.04	-.24	-.20	-.15	.03	-.04
NTLX	.08	.02	-.01	-.07	-.05	.04	.04	.09

Note. *Correlation is significant at the 0.05 level. **Correlation is significant at the 0.01 level. MD = mental demand; PD = physical demand; TD = time demand; TP = performance; TF = frustration; NTLX = overall NTLX score B. = baseline; S. = tactical exercise sprint; D.= tactical exercise adult dummy drag; R. = tactical exercise ram carry; DCM_{SG}= distance from center of mass for shot grouping; DCM_S= distance from center of mass per shot.

Correlations between primary precision measure MR_S and NTLX subscale scores and overall NTLX score can be found in Table 10. Sprint MR_S was negatively correlated with NTLX subscale task frustration ($r = -.39$, $p < 0.05$). No relationships were seen between primary precision measure MR_S and NTLX subscales or overall NTLX scores.

Table 10.
Correlations of NTLX subscale and overall scores and precision measurement MR_S for baseline and the three tactical exercises of sprint, weighted dummy drag, and battering ram carry.

	Baseline MR_S	**Sprint MR_S**	**Drag MR_S**	**Ram MR_S**
MD	-.08	.01	-.17	.10
PD	-.30	-.08	.12	.08
TD	-.09	-.10	-.09	.15
Effort	-.16	-.03	-.08	.05
TP	.12	-.12	.29	.34
TF	-.02	-.39*	-.04	.02
NTLX	-.13	-.20	.02	.22

Note. *Correlation is significant at the 0.05 level. **Correlation is significant at the 0.01 level. MD = mental demand; PD = physical demand; TD = time demand; TP = performance; TF = frustration; NTLX = overall NTLX score; B. = baseline; S. = tactical exercise sprint; D.= tactical exercise adult dummy drag; R. = tactical exercise ram carry; MR_S= mean radius of the shot grouping.

A positive relationship was revealed between baseline CSG_Y with NTLX subscale physical demand ($r = .37$, $p < 0.05$) and CSG_Y with NTLX subscale task frustration ($r = .42$, $p < 0.05$). Statistical analysis resulted in no other significant relationships between NTLX subscale scores, overall NTLX score with CSG_X and CSG_Y after tactical exercises.

Table 11.
Correlations of NTLX subscale and overall scores and precision measurements CSG_X and CSG_Y for baseline and the three tactical exercises of sprint, weighted dummy drag, and battering ram carry.

	Baseline CSG_X	**Baseline CSG_Y**	**Sprint CSG_X**	**Sprint CSG_Y**	**Drag CSG_X**	**Drag CSG_Y**	**Ram CSG_X**	**Ram CSG_Y**
MD	-.07	.15	.02	.29	.11	.14	.04	.20
PD	.07	.37*	-.08	.05	.11	.03	.15	.11
TD	-.03	.06	.05	.05	-.08	-.04	.01	-.02
Effort	-.21	.16	-.03	.07	.03	.12	-.03	.12
TP	.10	-.10	.04	.02	-.24	-.33	.20	-.30
TF	.11	.11	.05	.13	.42*	.30	.15	.30
NTLX	-.00	.19	.02	.18	.08	.04	.15	.10

Note. *Correlation is significant at the 0.05 level. **Correlation is significant at the 0.01 level. MD = mental demand; PD = physical demand; TD = time demand; TP = performance; TF = frustration; NTLX = overall NTLX score; B. = baseline; S. = tactical exercise sprint; D.= tactical exercise adult dummy drag; R. = tactical exercise ram carry; CSG_X = center of shot grouping X-coordinate; CSG_Y = center of shot grouping Y-coordinate.

Post FAS, Post FS, Post Cortisol, SWAT EXP., RPE, & Total Protocol Time

A positive relationship was revealed between post-FAS and RPE ($r = .40, p < 0.05$). Correlations between salivary cortisol levels with total protocol time revealed a positive relationship ($r = .68, p < 0.01$) but no relationship between post-FAS, post-FS, RPE, or SWAT experience. No relationship was revealed between post-FS with RPE, post-FAS, total protocol time, or SWAT experience.

Table 12.
Correlations of post-FS, post-FAS, post-salivary cortisol levels and SWAT experience, total protocol time, and post protocol RPE values.

	FS	**FAS**	**Cort.**	**SWAT Exp.**	**TT**	**RPE**
FS	-	.06	.28	-.14	.12	.16
FAS		-	-.19	-.01	-.19	.40*
Cort.			-	.15	.68**	-.28
SWAT Exp.				-	.34	-.05
TT					-	-.36
RPE						-

Note. *Correlation is significant at the 0.05 level. **Correlation is significant at the 0.01 level.

Primary Accuracy & Precision Measures with Post-FS, Post-FAS, Post-Cortisol

No relationships were seen between the three tactical exercises' accuracy and precision measurements (DCM_{SG}, DCM_S, MR_S, CSG_X, CSG_Y) and post-FS, post-FAS, and post-salivary cortisol levels for measure of sprint (see Table 13), drag (see Table 14), and ram carry (see Table 15).

Table 13.
Correlations of post-FS, post-FAS, post-salivary cortisol levels and tactical exercise sprint's DCM_{SG}, DCM_S, MR_S, CSG_X, CSG_Y.

	Sprint DCM_{SG}	**Sprint DCM_S**	**Sprint MR_S**	**Sprint CSG_X**	**Sprint CSG_Y**
FS	-.04	-.23	-.28	.12	.05
FAS	.01	-.00	-.05	-.07	-.07
Cort.	-.23	-.11	.10	.08	.00

Note. *Correlation is significant at the 0.05 level. **Correlation is significant at the 0.01 level.

Table 14.
Correlations of post-FS, post-FAS, post-salivary cortisol levels and tactical exercise drag's DCM_{SG}, DCM_S, MR_S, CSG_X, CSG_Y.

	Drag DCM_{SG}	**Drag DCM_S**	**Drag MR_S**	**Drag CSG_X**	**Drag CSG_Y**
FS	.01	-.05	-.05	.05	-.07
FAS	.00	-.03	.01	.08	.08
Cort.	.03	.11	.03	-.06	-.28

Note. *Correlation is significant at the 0.05 level. **Correlation is significant at the 0.01 level.

Table 15.
Correlations of post-FS, post-FAS, post-salivary cortisol levels and tactical exercise ram's DCM_{SG}, DCM_S, MR_S, CSG_X, CSG_Y.

	Ram DCM_{SG}	Ram DCM_S	Ram MR_S	Ram CSG_X	Ram CSG_Y
FS	.09	.05	.10	-.05	.02
FAS	-.14	-.21	-.11	.04	.06
Cort.	.14	.03	.05	-.14	-.17

Note. *Correlation is significant at the 0.05 level. **Correlation is significant at the 0.01 level.

CHAPTER V

The purpose of the study was to determine the effects of three law enforcement related tactical task exercises on the accuracy and precision of firearm shooting of SWAT team members relative to their perceived levels of stress and effort needed to complete the tactical exercises. Active SWAT operators were asked complete the tactical tasks of a 73.31-meter sprint, a 79.73 kg weighted adult dummy drag, and a 17.5 kg battering ram carry all while wearing their duty uniforms. After completion of each tactical task, SWAT operators were asked to fire five rounds at a static paper target for marksmanship calculations to compare to static baseline marksmanship measures taken prior to the start of the tactical tasks. Prior to and upon completion of the protocol, SWAT operators completed the FAS, FS surveys and provided salivary samples to assess relationships between perceived stress and affect during the study. The NTLX was completed after completion of the protocol to evaluate how various demands impacted participants' overall perception of the tasks.

The results from this study suggest that after performing the tactical exercises employed in this study there is a decrease in marksmanship accuracy and precision measures compared to static baseline marksmanship. The most significant differences were demonstrated as a result of the adult dummy drag and battering-ram carry. Hypothesis one suggested that accuracy would decrease due to the law enforcement tactical tasks, and this hypothesis was partially supported. Such that, there was a decrease in marksmanship accuracy seen post-drag and post-ram exercises, but post-sprint accuracy was not significantly impacted compared to baseline. This suggests that the accumulation of effort and task demands could influence marksmanship accuracy.

Law enforcement officers must be able to utilize their firearm with utmost accuracy and consistency due to the liability which could be faced by them upon improper usage (Ryan, 2007). Marksmanship accuracy in the field that does not have an abundant scientific research base to draw from. While the results of this study agree with past research from Donner and Popovich (2018), who report that an officer may be less accurate when using their service weapon due to a number of possible reasons. However, Donner and Popovich's research was conducted by reviewing incident reports filed by officers, and thus was limited by categorizing shots as either "hit" or "miss", meaning the shot's actual location of impact was not recorded. In terms of marksmanship accuracy, a "hit" does not indicate whether the shot incapacitated the suspect from causing more danger or firing their weapon at the LEO or was fatal to the suspect.

The current study measured and calculated the accuracy of the SWAT operator's marksmanship and found that while it was not impacted by the initial sprint, it was seen that the drag and carry did impact accuracy. These results could indicate the type of exercises or actions involved in the tactical exercise could impact the accuracy of SWAT operators. Sprinting is a lower body dominant exercises, while the adult dummy drag, and the battering-ram carry utilize the upper body to a greater extent. According to Mason et al. (1990), total body movement accounted for 30% of the variance in the shooting accuracy of elite-pistol shooters, while research by Heinula (1996) found that pistol hold has been identified as the most important success factor in terms of marksmanship accuracy. The upper body dominant tactical exercises of the adult dummy drag, and the battering-ram carry both initiated fatigue in both the arms and trunk which could have impacted the stability of the trunk and grip of the pistol, which resulted in decrease in marksmanship accuracy after the exercises.

Static shooting during baseline compared to three tactical task exercise marksmanship also supports the suggestion of Muirhead, et al. (2019) that static shooting training is not transferable to dynamic shooting. However, little differences was found post-sprint which could support past research when examining sprinting and shooting performance (Hoffman, Landau, Stout, & Hoffman, 2015), which did not see a significant change in dynamic shooting (shoot-and-move) task.

Brown et al. (2013) investigated different training techniques employed by law enforcement officers and including physical and psychological stress during active shooting situations and found that most firearm training and qualifications for police officers takes place on a shooting range under standardized conditions with little to no pressure. However, Oudejans (2008) stated that qualification on the shooting range is not well correlated with shooting performance under pressure in the field. Effective and accurate shooting while under pressure, for instance when in pursuit of a suspect, requires situational awareness, quick decision making, and judgment. Consistency in form, movement, and shot location are considered characteristics of highly skilled and trained marksmen (Walmsley & Williams, 1994). Exercise induced fatigue and physiological arousal can be considered distractions, which could lead to negatively impact performance, and expert performers in pistol shooting are able to narrow their attentional focus to the target, so as not to be distracted by their surroundings (Rose & Christina 1990; Vickers & Williams, 2007).

Past research has often only assessed marksmanship skills via one method of testing in either a static scenario or a scenario under duress and/or fatigue (Nibbeling, Oudejans, Cañal-Bruland, Wurff & Daanen, 2013; Ito, Sharp, Johnson, Merullo, & Mello, 1999; Evans, Scoville, Ito, & Mello, 2003; Carbone, Carlton, Stierli, & Orr, 2014). It should be noted that during the tactical exercises employed in this study there were no possible repercussions to the officers as seen with other simulations, including marker ammunition fired back at the officers or the use of electric shock to establish the threat of harm to the officer due to the lack of equipment Nieuwenhuys, Savelsbergh, & Oudejans, 2015; Gamble, et al. 2018). However, in this study shooting exercises did take place under the eye of a departmental Rangemaster as well as other SWAT team operators who would provide feedback once the scenario concluded, which may have increased the level of stress and/or anxiety of the participants.

Marksmanship precision measurement MR_S decreased after all three tactical exercises, which would support the second hypothesis, in a limited manner, that marksmanship precision would decrease post tactical task exercises. All other marksmanship precision measures were only significantly different after the adult dummy drag and the battering-ram carry. There is a limited amount of past research that has specified changes in marksmanship precision since marksmanship precision is considered a secondary measure. Marksmanship precision refers to how close multiple shots on a single target are clustered together (Keefe & Tikuisis, 2003).

A study conducted by Brown et al. (2013) examined how physical activity inducing fatigue affects shooting performance and found that shooting accuracy and precision were unchanged from pre-exercise to post-exercise after repeated anaerobic bouts of exercise at 85% VO_{2max}. While the current study does not fully support these findings, post-sprint marksmanship accuracy and precision would not be in conjunction with these findings. The post-sprint marksmanship precision measure of MR_S was impacted compared to baseline marksmanship; however, no other marksmanship measures were significantly different for both accuracy and precision.

While marksmanship accuracy is important, it is typically only assessed by a single shot. When multiple shots are fired, marksmanship precision is just as important. When in pursuit of a suspect or during a deadly force situation, police have been found to fire multiple rounds. The Federal Bureau of Investigation (FBI) reported that between the years 2008 and 2017, among officers involved in an assault, victim officers in the assault fired on average 3.3 rounds, while responding and support officers can fire an average 14.7 rounds at a suspect (FBI, 2017, Table 106). These numbers suggest that multiple shots are fired in cases of self-defense and precision would play a factor in limiting liability and injury to those involved and in the surrounding area of these deadly situations.

During these deadly situations, stress can play a factor in how law enforcement officers react, reaction time, and marksmanship performance (Vila & Samuels, 2011). For this current study, SWAT operators perceived that their effort and performance, along with physical demands of completing the task as being more influential on their overall workload on the task compared to mental or temporal demands or frustration involved with performing the tactical exercises. These findings would support hypothesis four, however, frustration did not contribute to participant's perception of the workload demands for completion of the tactical exercise protocol.

One factor that could influence their perception of the physical demands, effort and performance on the task could be the fact that the SWAT operators were competing informally with each other for the best time to complete the task with the most accuracy while being watched by their co-workers and team leaders. Effort in completing the task could also be linked to the competition brought on by the SWAT team leaders. This study did not include awards for the fastest completion time, but participants were aware that time was being kept and participants were told their time upon completion of the tactical task protocol. Competition within each other is a common contagion in the performance of real effort tasks (Kunter & Mak, 2018) when participants are able to see or view other's scores, even with no reward is given for best performance. In the current study, SWAT operators were able to view and give feedback to those that had performed the task prior to or after themselves. The low levels of frustration reported may result from the SWAT operators' prior knowledge and experience with the tactical exercises, the lack of evaluative feedback provided to participants, and/or the low level of risk involved with the protocol.

Hypothesis three of this study is also partially supported due to the levels of arousal perceived by the SWAT operators after the tactical tasks when measured by psychometric surveys. Levels of affect for this study were analyzed using the FS and FAS scales, and stress was measured via salivary cortisol to determine the respective levels of these variables prior to and after tactical exercises. FS scores did not change significantly as a result of the tactical exercises; however, FAS was found to be significantly greater after the exercises. These results suggest that while there was an increase in the SWAT operators feeling more "worked-up", they did not feel any better or worse after completing the task. These findings could be due to the limitations presented by the specific tactical exercises performed and the knowledge the SWAT operators had of the task being conducted. Utilizing valance scores (Ekkekakis, Parfitt, & Petruzzello, 2011; Russell & Barrett, 1999) the results suggest that participants in this study were in a "low activation-pleasure" state (calm/relaxed) prior to the exercises, and the tactical exercises resulted in the SWAT operators being in a "high activation-pleasure" state (energy, vigor), suggesting they found enjoyment in completing the task exercises.

Cortisol levels in this study were found not to be significantly different as a result of the tactical exercises. Thus, hypothesis five, that salivary cortisol levels would increase as a result of the tactical exercise protocol, was not supported to a statistically significant level. This could suggest that the SWAT operators may not have perceived the tactical exercises as a psychologically stressful condition, or that the SWAT operator's experience may have influenced their stress response. While completing the tactical exercises, SWAT operators were not in immediate danger, meaning there were no shots or live rounds being fired at them to cause a psychologically stressful response. Rather, the demands placed on them were more towards competitive nature between each other rather than a risk of life and safety.

One other factor that may contribute is the non-finding of significant difference may be the timing of the collection of the cortisol samples. 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 prior to completing baseline static shooting, however, due to factors beyond the researcher's control SWAT operators provided saliva samples at different time points during the testing session. As cortisol has a circadian rhythm, this variation in collection times likely impacted the saliva values. 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.

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. This may also suggest that those with more experience, due to the tactical task exercises being a part of their regular monthly training, might not have perceived the conditions as being a stress inducing task.

One limitation in this study is the SWAT team that participated in this study is considered a collateral team, meaning that the SWAT operators in this study serve in on-call status. Otherwise these SWAT operators are full time law enforcement officers in other departments, whereas a full-time team could result in different marksmanship accuracy and precision values.

Further investigation is warranted to determine the impact of "real-world" stress on marksmanship of SWAT operators. An increase in the unknown, limited prior knowledge of the study and the expectations of the SWAT operators could also lead to more realistic stress induced and would align with what could be seen and needed while in the line of duty. It must be noted that the unique occupational demands of SWAT operators are difficult to replicate in a laboratory setting. The three specific tactical task exercises in this study were chosen by the SWAT team leaders in conjunction with SWAT team training, which are performed regularly during training. Due to the SWAT operators knowing what is expected of them during the study and their knowledge and experience performing the task, their stress levels were likely not as great as would be expected in an actual active-shooter situation.

Future research regarding SWAT teams and marksmanship should also include moving targets to simulate "real world" situations as well as the use of non-lethal ammunition return fire, where the operators are being fired upon, rather than not facing eminent danger to themselves or others in the situations.

Conclusion and Summary

Overall, this study found that target shooting accuracy decreased as a result of the tactical exercises and the reduced accuracy was greater in the tactical exercises that demanded upper-body involvement. This suggests that with pistol shooting it may be important to enhance upper-body endurance in order to reduce muscular fatigue among these operators.

The results of this study also suggest that static baseline shooting is not a good determinate for testing law enforcement officers, due to the lack of “real-world” stress and fatigue that can be faced while on patrol or during deadly force situations. Physically demanding calls could increase fatigue and stress factors in officers and thus cause a decrease in marksmanship accuracy and precision. This is not an ideal situation when officers and bystander lives are in danger, and it is important for officers to maintain their physical fitness, especially when they may be forced into dealing with dangerous situations.

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LIST OF APPENDICES

Appendix A

Office of Research Compliance Institutional Review Board (IRB) Approval for Human Subjects

Webb, Heather

From: irb@tamucc.edu <donotreply@redcap.tamucc.edu>
Sent: Monday, January 4, 2021 11:55 AM
To: Webb, Heather
Cc: IRB
Subject: Expedited IRB Approval

Dear Heather Webb,

On 01-04-2021, the Texas A&M University-Corpus Christi Institutional Review Board reviewed the following submission under expedited category Expedited Category 3, Prospective collection of biological specimens for research purposes by noninvasive means.

IRB #:	TAMU-CC-IRB-2020-12-138
PI Name:	Heather Webb
Study Title:	Effects of Acute Physical Exertion on Law Enforcement Officers Policing Skills
Initial submission date:	12-21-2020
Expedited Category:	Expedited Category 3, Prospective collection of biological specimens for research purposes by noninvasive means
Expedited Date Approved:	01-04-2021
Annual Check-in Due Date:	01-03-2022

The IRB has approved this submission on 01-04-2021. **You may now begin the research project**.

Reminder of Investigator Responsibilities: As principal investigator, you must ensure:

1. **Informed Consent: Ensure informed consent processes are followed** and information presented enables individuals to voluntarily decide whether to participate in research.

2. **Amendments:** This approval applies only to the activities described in the IRB submission and does not apply should any changes be made. **Any planned changes require an amendment** to be submitted to the IRB to ensure that the research continues to meet criteria for exemption. The Amendment must be approved before being implemented.

3. **Annual check-in:** Provide an annual check-in to the IRB by 01-03-2022.

4. **Completion Report: Upon completion of the research project (including data analysis and final written papers), a Completion Report must be submitted**.

5. **Records Retention: All research related records must be retained for three (3) years** beyond the completion date of the study in a secure location. At a minimum these documents include: the research protocol, all questionnaires, survey instruments, interview questions and/or data collection instruments associated with this research protocol, recruiting or advertising materials, any consent forms or information sheets given to participants, all correspondence to or from the IRB, and any other pertinent documents.

6. **Adverse Events:** Adverse events must be reported to the IRB.

7. **Post-approval monitoring:** Requested materials for post-approval monitoring must be provided by dates requested.

Please do not hesitate to contact the Office of Research Compliance with any questions at irb@tamucc.edu.

Respectfully,

Germaine Hughes-Waters

Office of Research Compliance

Appendix B

Informed Consents

Effects of Acute Physical Exertion on Law Enforcement Officers Policing Skills
Dr. Heather E. Webb & Kristina Woodford, Texas A&M University – Corpus Christi

Introduction
The purpose of this form is to provide you information that may affect your decision to participate in this portion of the research study. If you decide to participate in this study, this form will also be used to record your consent.

As a member of the CCPD SWAT team, you have been briefed on the research study that is being conducted by the researchers. As a part of the research project, the purpose of this portion of the study is to collect information regarding your health history, perceived stress level, and law enforcement history prior to the in-person portion of the data collection. This part of the study includes an online survey performed using a secured online survey system (Qualtrics) and should take no more than 15 minutes to complete.

What are the risks involved in this study?
This portion of the research project involves minimal risks or risks that are no more than what you may experience in everyday life. The main risk includes:

- ***Confidentiality risk:*** Your participation will involve collecting information about you. There is a slight risk of loss of confidentiality. Your confidentiality will be protected to the greatest extent possible. You do not have to give any information to the study that you do not want to give.

What are the alternatives to being in this study?
Instead of being in this study, you may choose not to be in the research study.

What are the possible benefits of this study?
There may be no direct benefit to you from being in this research study. By being in this study, you may help researchers learn more about how your experience in law enforcement may be related to information regarding shooting accuracy and precision after repeated acute bouts of anaerobic exercise in law enforcement officers.

Do I have to participate?
No. Your participation is voluntary. You may decide not to participate or to withdraw at any time with no penalty or loss of benefits. You may decide not to participate or quit at any time without your current or future relations with Texas A&M University-Corpus Christi or any cooperating institution being affected.

What about protecting my information?
When information collected about you includes identifiers (such as your name, date of birth, email, phone number), the study can involve confidential information.
Your information will be protected by:

- All data collected from the Qualtrics Survey is encrypted. The survey data will be downloaded from Qualtrics, any identifying information will be deleted after your personal information with recoded to an alphanumeric code and will be stored on password protected equipment after completion of the project. The key that links the code to your personal identifiers are stored separately from the research record under restricted access.
- No identifiers linking you to this study will be included in any sort of report that might be published.
- Research records will be stored securely, and only the researchers will have access to the records.
- We will share your information only when we must, will only share the information that is needed, and will ask anyone who receives it from us to protect your privacy.
- No identifiers linking you to this study will be included in any report that might be published or presentation.

Once data analysis is complete, your identifiers will be removed from the collected research data, and after such removal, the de-identified information could be used for future research studies or distributed to another investigator for future research studies without additional informed consent from the subject or the legally authorized representative

Whom do I contact with questions about the research?
If you have questions regarding this study, you may contact Dr. Heather Webb at heather.webb@tamucc.edu or 361-825-3749. You may also contact Kristina Woodford at kwoodford@islander.tamucc.edu.

Whom do I contact about my rights as a research participant?
This research study has been reviewed by the Research Compliance Office and/or the Institutional Review Board at Texas A&M University-Corpus Christi. For research-related problems or questions regarding your rights as a research participant, you can contact the Office of Research Compliance/Institutional Review Board at Texas A&M University-Corpus Christi at IRB@tamucc.edu.

Consent to Participate
To participate in this research study, click continue to begin this portion of the study. By clicking continue and filling out the survey, you are agreeing to participate in this portion of the study. By participating in this study, you are also certifying that you are 18 years of age or older.

If you do not agree to participate in this portion of the research study, please click "Exit Survey" or close the tab.

TEXAS A&M UNIVERSITY
CORPUS CHRISTI

DEPARTMENT OF KINESIOLOGY
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CONSENT TO PARTICIPATE IN A RESEARCH STUDY AT TEXAS A&M UNIVERSITY-CORPUS CHRISTI

Effects of Acute Physical Exertion on Law Enforcement Officers Policing Skills

Investigators: Heather E. Webb, Ph.D., ATC, LAT & Kristina M. Woodford, B.S.

WHO IS DOING THIS STUDY?

A study team led by Dr. Heather E. Webb and Kristina M. Woodford is doing this research study. A research team including additional faculty advisors, graduate- and undergraduate-level student researchers will also be assisting in this study.

We are asking you to be a part of this research study. Please read the information below and ask questions about anything that you do not understand before you make a choice to participate in the study.

WHY IS THIS STUDY BEING DONE?

You are being asked to participate in a research project studying how shooting accuracy and precision may be impacted after acute bouts of anaerobic exercise in law enforcement officers.

WHO CAN BE IN THIS STUDY?

To be eligible to be in this study, you should not:

- have a history of chronic illnesses or take any medications that may impact the measures we are taking.
- have any musculoskeletal injuries that may impact your ability to perform the activities involved in the study.
- be pregnant or attempting to become pregnant.

There are other possible reasons you may not qualify to be in this study, and these reasons are detailed in the addendum. This information will be gathered during the initial testing session.

WHAT WILL HAPPEN TO ME IN THIS STUDY?

Your participation will include a total of one meeting with research team members during a CCPD SWAT training session. Below is an explanation of what you will be asked to do during the session. We have included a more detailed timeline of the procedures in the ***Appendix – Research Protocol Timeline.***

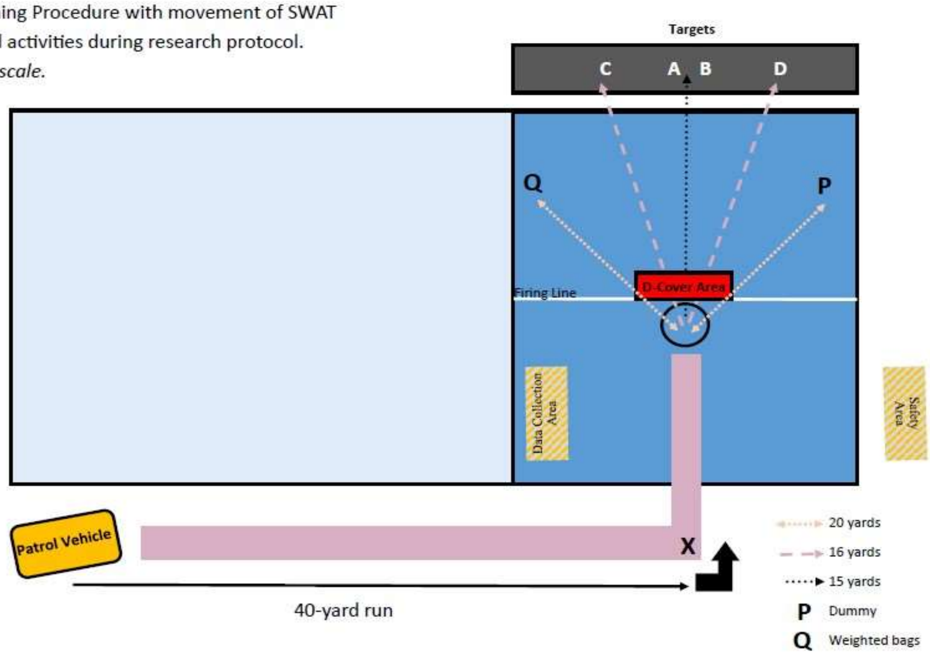
At the beginning of session, you will be introduced to the research team, informed of the protocols involved within the research testing session, consent to your participation in the study, and then complete a health history questionnaire, physical activity questionnaire, a short questionnaire regarding your

feelings and thoughts during the previous month, and a questionnaire about your law enforcement experience, if you have not already completed this, via the online questionnaire.
Next, you will be measured for height and weight and then you will be asked to complete four questionnaires about how you are feeling, along with providing a saliva sample for measurement of stress hormones.

Upon completion of this you will go to the to the covered shooting range on site. You will don hearing and eye protection and move to the designated location (Point **O**) to shoot 5-rounds at target **A** located 15-yards from the firing line (as detailed below). Upon competition of baseline shooting, you will be asked to load 15 rounds of ammunition into the magazine of your handgun. You will then go to the starting point of the protocol, which is seated in a patrol vehicle with the doors shut. Once in position, you will be given a signal to start the training & research protocol as outlined below:

1) You will exit the patrol car and run 40-yards to the turning point, turn 90-degree and swiftly enter the shooting range.
2) After reaching Point **O**, you will engage with target **B**, positioned 15-yards in front, shooting 5-rounds at the target, in less than 25 seconds.
3) You will move from point **O** to either point **P** or point **Q** (roughly at a 60° angle from current position) and retrieve and return to point **O** with the weighted-bags or weighted dummy.
4) Depending on which point (**P** or **Q**) was chosen, you will then engage with the target on the designated side, target **C** or **D** (roughly 45°,15-20 yards from position **O**) firing 5-rounds at the target.
5) You will then move to the opposite position (**P** or **Q**) and retrieve and return to point **O** with the remaining weighted-bags or weighted dummy.
6) You will then fire 5-rounds at the remaining target, on the same side of the last retrieval, either target **C** or **D** (roughly 45°,15-20 yards from position **O**).

Figure 1: Training Procedure with movement of SWAT personnel and activities during research protocol.
Not drawn to scale.



After the completing the last bout of target-shooting, you will move the data collection area be asked to provide another saliva sample. You will then be asked to complete five questionnaires about how hard you worked and how you feel. After you complete the questionnaires, the monitoring equipment will be removed from your person, and you will be free to leave. Total testing time will be approximately 20 minutes.

We may ask your permission to photograph or digitally record your participation in the study. We will do our best to ensure that you cannot be identified in these recordings (these recordings will be taken from between the 4- and
8-o'clock positions relative to your body). You will be allowed to review and delete any recordings or photographs after completing the session.

I agree to allow photographic and video-graphic recording of my participation in the study entitled, "*Effects of Acute Physical Exertion on Law Enforcement Officers Policing Skills"*.

_______ I agree to be photographed and/or video recorded.

_______ I do not want to be photographed and/or video recorded.

WHAT ARE THE RISKS OF THE STUDY?
Your participation in this study may involve some risks. The most common are the possibility of feeling a "shortness of breath", dizzy/lightheaded, and general fatigue during one or all of the testing procedures. If you cannot tolerate the feeling of "shortness of breath", dizziness, or fatigue, you can stop at any point during the experiment. In addition, due to the activity you will be participating in, musculoskeletal injury could occur. A certified, state-licensed athletic trainer will be available on-site should a musculoskeletal injury occur and will evaluate and recommend treatment or referral as necessary should an injury occur.

WHAT ARE THE BENEFITS OF BEING IN THIS STUDY?
You will also receive information on how your body composition measures relate to your health and shooting performance. Shooting performance during testing will allow you to understand your performance after an anaerobic bout of exercise.

WHAT ABOUT EXTRA COSTS?
Participation in this study will not result in any extra costs to you. You will not have to pay anything extra if you are in this study aside from the personal time and travel costs it will take to come to the study visits.

WHAT WILL I RECEIVE FOR BEING IN THIS STUDY?
If you complete the study, you will receive a coupon that you can redeem to receive a free beverage of any size and type from either Roasted Coffee shop or Wired Coffee shop. Additionally, you will also be entered into a drawing to win one of four $50 gift cards from a retailer of your choice.

WHAT ARE THE ALTERNATIVES TO BEING IN THIS STUDY?
Instead of being in this study, you may simply choose not to participate.

WHAT ARE MY RIGHTS AS A STUDY PARTICIPANT?

Being in a research study is voluntary. You do not have to be in this study. If you choose not to participate, there will be no penalty or loss of benefits to which you are otherwise entitled.

WHAT IF I CHANGE MY MIND?

You may withdraw from the study at any time without penalty or loss of benefits to which you are otherwise entitled.

We will inform you of any new information that develops during this study. This information may affect your decision to stay in the study. If you choose to withdraw from the study, you must tell the study team as soon as possible. See ***Appendix: Study Withdrawal*** for more information about what to expect if you withdraw.

WHO SHOULD I CALL IF I HAVE QUESTIONS OR PROBLEMS?

Dr. Heather Webb oversees this research study. You may call or contact her at 361-825-3749 or heather.webb@tamucc.edu with questions at any time during the study.

You may also call Texas A&M University-Corpus Christi Institutional Review Board (IRB) with questions or complaints about this study at irb@tamucc.edu or 361-825-2497. The IRB is a committee of faculty members, statisticians, researchers, community advocates, and others that ensures that a research study is ethical and that the rights of study participants are protected.

CONSENT TO PARTICIPATE

The purposes, procedures, and risks of this research study have been explained to me. I have had a chance to read this form and ask questions about the study. Any questions I had have been answered to my satisfaction. A copy of this signed form will be given to me.

________________________________ ________________

Signature of Participant Date

STUDY PERSONNEL

I have explained the purposes, procedures, and risks involved in this study in detail to:

____

Print name of Participant

Any questions that have been raised have been answered to the individual's satisfaction.

________________________ ________________ __________

Signature of Person Obtaining Consent Date Time

Appendix: ***Study Participants***

Up to 75 law enforcement officers will be asked to be in this study. Due to the nature of this research protocol, we have specific criteria for excluding individuals from being participants in this study. These criteria to be a participant include:

- being younger than 18 years old or older than 55 years of age
- that you report no history of psychological disorders or chronic illness (metabolic, cardiovascular, neuromuscular, pulmonary, kidney, or liver diseases) which may impact the measurements we are collecting
- that you do not report the use of any prescription or non-prescription medications that specifically impact or may impact cardiometabolic, pulmonary, and/or kidney function,
- that you do not use certain ergogenic (anabolic steroids) or health-related supplements (not including vitamins, calcium, or birth control),
- that you are not consuming an average of greater than 10 alcoholic beverages per week
- that you have not experienced any recent major life events [e.g. death in family, divorce, wedding] in the past three months month
- that you have not suffered a musculoskeletal injury within the previous 6-months or have a chronic musculoskeletal injury or condition that limits your ability to perform the exercises described safety
- that you are not pregnant or attempting to become pregnant.

Appendix: ***Study Procedures - Collecting Information***

Your participation will involve collecting information.

- You do not have to give any information to the study that you do not want to give. By signing this form, you are authorizing the collection and use of the information outlined in this form.
- We will ask for your contact information, including your telephone number and emergency contact information, so that we can call you to remind you of your next testing session or contact your designated individual should you become injured. This contact information will be destroyed after your completed participation in the study,
- The information specified above collected for this study will be shared with only those researchers involved in the research study.

Appendix: ***Study Procedures - Questionnaires***

You will be asked about how you feel in terms of overall mood, stress, and anxiety, and how hard you feel like you had to work both physically and mentally, as well as how well you feel you performed. Some questions may be embarrassing or uncomfortable to answer. Sample questions that you may be asked are:

- In the last week, how often have you felt nervous and "stressed"?
- In the last week, how often have you been angered because of things that were outside of your control?

You do not have to answers questions you do not want to. You can exit the survey and stop at any time.

Appendix: ***Confidentiality***

When information collected about you includes identifiers (like names, addresses, phone numbers), the study can involve confidential information.

A research record will be created and kept in a locked file cabinet in 146 Island Hall at Texas A&M University – Corpus Christi. The research record may include documents that have your name, assigned study ID number, telephone number, date of birth, and email address. When we are at the training range, this information will be kept in a locked clipboard or file box, and then returned to the locked file cabinet at Texas A&M University – Corpus Christi in 146 Island Hall after the data collection session concludes.

All research records will be maintained in a confidential manner. The research team will share your information only when we must, will only share the information that is needed, and will ask anyone who receives it from us to protect your privacy.

Appendix: ***Withdrawal***

If you withdraw from the study early for any reason, the information that already has been collected will not be used for the research study. The information collected from you will be de-identified (the information cannot be traced back to you individually). Because you cannot be identified from the information there is no further risk to your privacy.

Appendix: ***Research Protocol Timeline for Data Collection***

Time	Participant Activity
0 min	Arrival: Equipment fitting (HR monitors), collection of height & weight, psychometric measures, & saliva sample collection
5 min	1st bout of Target Shooting (5 rounds)
6.5 min	Move to patrol vehicle and take a seat in vehicle (and load 15 rounds of ammunition into magazine). Participant will be reminded of protocol by research assistant.
7.5 min	Training Protocol begins:
	40 yd. run from patrol vehicle to Point X. Enter range area and approach point O.
	2nd bout of Target Shooting (5 rounds)
	Move to retrieve dummy or weighted bags from location P or Q and return to point O.
	3rd bout of Target Shooting (5 rounds)
	Move to retrieve dummy or weighted bags from location P or Q and return to point O.
	4th bout of Target Shooting (5 rounds)
12 min	Training protocol ends
12.5 min	Collection of saliva sample & psychometric measures
15 min	Removal of monitoring equipment & completion of protocol

Appendix C

Law Enforcement History Questionnaire

Law Enforcement Experience Questionnaire

Participant # ___________

Shooting Accuracy and Precision After Repeated Acute Bouts of Anaerobic Exercise in Law Enforcement Officers

This study is to understand the effects anaerobic exercise has on the accuracy and precision of law enforcement officers. To better understand the background of those participating, this questionnaire is being used. Please fill out this questionnaire to the best of your abilities.

Current Position Title:	
Year Graduated from the Police Academy:	
Location of Police Academy (State):	
Number of Years in Law Enforcement:	
Amount of Time on SWAT team (Years/Months):	
Current position on SWAT team:	
Additional Law Enforcement Training:	
Do you have Military Experience? *Y N*	**Which Branch(es)?**
How many years?	**Rank/Class?**
Military Occupation(s)?	
Additional Military Training:	
Brand/Model of Issued Sidearm:	
Caliber of handgun:	
How long have you used this style of weapon?	
How many times a month do you practice with the above firearm at a range?	
How many rounds do you typically shoot during practice sessions?	

Appendix D

Health and Wellness Questionnaires

PARTICIPATION AND HEALTH HISTORY QUESTIONNAIRE

Complete each question accurately. All information provided is strictly confidential.

Part I: Participant Information

Name (Print):		Work/Cell Phone #
Preferred Name:		Email Address
Date of Birth (mm/yyyy)		Age (years):
Female Male	Height (in.):	Weight (lb.):

Part II. Health History

List any physical injuries/limitations you currently suffer from or have sustained in the LAST SIX (6) MONTHS: ____

____

Have you ever experience any adverse responses during or after exercise (i.e. dizziness, difficulty breathing, racing heartbeat, fainting, concerns regarding safety, burning sensations in limbs)? If yes, please list your symptoms.

- ◯ No
- ◯ Yes ____

Please circle any of the following for which you have been diagnosed or treated by a physician or health professional:

Anemia	Arrhythmia	Bypass Surgery	Heart Attack
Heart Murmur	Heart Palpitations	Heart Rhythm Abnormalities	Heart Valve Problems
Pacemaker/Implantable Defibrillator	Shortness of Breath	Stroke	Chest Pain

Do you have any form of respiratory (breathing) ailments? Please circle those that apply.

Asthma	Bronchitis	Common Cold
COPD	Emphysema	Pulmonary Disease`

Have you been diagnosed with any of the following? If yes, please circle the appropriate ailment.

Diabetes/Metabolic Disease	High Cholesterol	High Blood Pressure	Hemophilia
Kidney / Liver Disease	Neuromuscular Disease	Obesity	Rheumatic Fever

Has your mother, father, siblings, or children been diagnosed with any of the following (please select all that apply):

Heart attack or heart surgery prior to age 55.	High cholesterol	Stroke prior to age 50.
Diabetes	Congenital heart disease or left ventricular hypertrophy.	Obesity
Hypertension		Leukemia or other cancers prior to age 60.

Please identify who in your family (father, mother, sister, brother, child) has been diagnosed with or treated for the disease(s) or condition(s) marked above.

____
____

Is your mother living? _____ Yes _____ No (age at death _____; cause_____________)

Is your father living? _____ Yes _____ No (age at death _____; cause_____________)

Do you have any allergies (latex, food, drug, etc.)? _____ Yes _____ No

If yes, please list: ____
____

Part III. Health Related Behavior

Do You Smoke? _____ YES _____ NO

If yes, indicate number of cigarettes per day?

_____ Less than ½ a pack _____ 1 pack ____ Greater than 1 pack

Do You Drink Alcohol? _____ YES _____ NO

If Yes, Indicate Number of Alcoholic Beverages Per Week?

_____ Less than 10 _____ 10 _____ Greater Than 10

Do You Drink Caffeine? _____ YES _____ NO

If yes, indicate amount consumed per day?

_____ LESS THAN 400mg* _____ MORE THAN 400mg*

*400mg of caffeine = 4 cups of brewed coffee, 10 cans of cola OR 2 “energy shot” drinks.

Are you currently taking any of the following medications, vitamins, or supplements?

Cardiovascular related	Pulmonary related	**Metabolic/Endocrine related**
Neuromuscular	Kidney/Liver related	Vitamin E
Vitamin K	Iron	Beta-Alanine
Branched-Chain Amino Acids (BCAAs)	Anabolic Steroids	HMB (B-Hydroxy B-Methylbutyrate)
Sodium Bicarbonate	Creatine	L-Carnitine
Recreational Drugs/Hormones	Nonsteroidal Anti-Inflammatory Drugs (NSAIDS)	
Other		None of the Above

If OTHER is chosen, please identify these:
____

<u>Part IV. Exercise Related Behavior</u>

Do you exercise regularly (30 minutes, 3 times weekly, or greater)? _____ Yes _____ No

What forms of exercise do you regularly perform?

Running/Jogging (outdoors)	Cycling (outdoors)		Walking
Running/jogging (indoors - treadmill)	Cycling/Spin (indoors)		Resistance training
Crossfit, MMA, Boxing, Martial Arts			Swimming
Rowing	Golf	Tennis	Other(s)

Please provide what your other form(s) of exercise are:

____

____

____

____

Have you recently (within the previous 3 months) experienced a major life event (i.e., death in family, divorce; wedding; birth of a child)? _____ Yes _____ No

INTERNATIONAL PHYSICAL ACTIVITY QUESTIONNAIRE

We are interested in finding out about the kinds of physical activities that people do as part of their everyday lives. The questions will ask you about the time you spent being physically active in the **last 7 days**. Please answer each question even if you do not consider yourself to be an active person. Please think about the activities you do at work, as part of your house and yard work, to get from place to place, and in your spare time for recreation, exercise or sport.

Think about all the **vigorous** activities that you did in the **last 7 days**. **Vigorous** physical activities refer to activities that take hard physical effort and make you breathe much harder than normal. Think *only* about those physical activities that you did for at least 10 minutes at a time.

1. *During the **last 7 days**, on how many days did you do **vigorous** physical activities like heavy lifting, digging, aerobics, or fast bicycling?*

   _____ **days per week** ☐ No vigorous physical activities → ***Skip to question 3.***

2. *How much time did you usually spend doing **vigorous** physical activities on one of those days?*

   _____ **hours per day** _____ **minutes per day** ☐ Don't know/Not sure

Think about all the **moderate** activities that you did in the **last 7 days**. **Moderate** activities refer to activities that take moderate physical effort and make you breathe somewhat harder than normal. Think only about those physical activities that you did for at least 10 minutes at a time.

3. *During the **last 7 days**, on how many days did you do **moderate** physical activities like carrying light loads, bicycling at a regular pace, or doubles tennis? Do not include walking.*

   _____ **days per week** ☐ No moderate physical activities → ***Skip to question 5.***

4. *How much time did you usually spend doing **moderate** physical activities on one of those days?*

   _____ **hours per day** _____ **minutes per day** ☐ Don't know/Not sure

Think about the time you spent **walking** in the **last 7 days**. This includes at work and at home, walking to travel from place to place, and any other walking that you have done solely for recreation, sport, exercise, or leisure.

5. *During the **last 7 days**, on how many days did you **walk** for at least 10 minutes at a time?*

   _____ **days per week** ☐ No walking activities → ***Skip to question 7.***

6. *How much time did you usually spend **walking** on one of those days?*

_____ **hours per day** _____ **minutes per day** ☐ Don't know/Not sure

The last question is about the time you spent **sitting** on weekdays during the **last 7 days**. Include time spent at work, at home, while doing course work and during leisure time. This may include time spent sitting at a desk, visiting friends, reading, or sitting or lying down to watch television.

7. *During the **last 7 days**, how much time did you spend **sitting** on a **weekday**?*

_____ **hours per day** _____ **minutes per day** ☐ Don't know/Not sure

This is the end of the questionnaire, thank you for participating.

Booth, M.L. (2000). *Assessment of Physical Activity: An International Perspective*. Research Quarterly for Exercise and Sport, 71 (2): s114-20.

Psychometric Measures – *Perceived Stress Scale Month (PSS-M)*

The questions in this scale ask you about your feelings and thoughts during the last month. In each case, please indicate with a check how often you felt or thought a certain way.

	Never	Almost Never	Sometimes	Fairly Often	Very Often
In the last month, how often have you been upset because of something that happened unexpectedly?	0	1	2	3	4
In the last month, how often have you felt that you were unable to control the important things in your life?	0	1	2	3	4
In the last month, how often have you felt nervous and "stressed"?	0	1	2	3	4
In the last month, how often have you felt confident about your ability to handle your personal problems?	0	1	2	3	4
In the last month, how often have you felt that things were going your way?	0	1	2	3	4
In the last month, how often have you found that you could not cope with all the things that you had to do?	0	1	2	3	4
In the last month, how often have you been able to control irritations in your life?	0	1	2	3	4
In the last month, how often have you felt that you were on top of things?	0	1	2	3	4
In the last month, how often have you been angered because of things that were outside of your control?	0	1	2	3	4
In the last month, how often have you felt difficulties were piling up so high that you could not overcome them?	0	1	2	3	4

Appendix E

Psychometric Instruments

Psychometric Measures – *Felt Arousal Scale (FAS)*

Felt Arousal Scale – Estimate on this scale how aroused or "worked-up" you actually feel. High excitement might be anger, excitement, or anxiety. Low excitement might be boredom, relaxation, or calmness.

1	***Low Arousal***
2	
3	
4	
5	
6	***High Arousal***

Psychometric Measures – *Feelings Scale (FS)*

Feeling Scale – On this scale, please rate how you feel. This experience may be pleasurable at times while unpleasurable at others. It is natural for the feelings to fluctuate across time.

+5	***Very Good***
+4	
+3	***Good***
+2	
+1	***Fairly Good***
0	***Neutral***
-1	***Fairly Bad***
-2	
-3	***Bad***

Psychometric Measures – *Rating of Perceived Exertion (RPE)*

Instructions: Estimate how hard you feel the work is, including total inner feelings of exertion, combining all sensations and feelings of physical stress and effort.

6	
7	Very, very light
8	
9	Very light
10	
11	Fairly Light
12	
13	Somewhat Hard
14	
15	Hard
16	
17	Very Hard
18	
19	Very, very hard
20	

Psychometric Measures – *NASA Task Load Index (NTLX)*

SUBJECT INSTRUCTIONS FOR RATINGS

We are not only interested in assessing your performance but also the experiences you had during the different task conditions. Right now we are going to describe the technique that will be used to examine your experiences. In the most general sense we are examining the "Workload" you experienced. Workload is a difficult concept to define precisely, but a simple one to understand generally. The factors that influence your experience of workload may come from the task itself, your feelings about your own performance, how much effort you put in, or the stress and frustration you felt. The workload contributed by different task elements may change as you get more familiar with a task, perform easier or harder versions of it, or move from one task to another. Physical components of workload are relatively easy to conceptualize and evaluate. However, the mental components of workload may be more difficult to measure.

Since workload is something that is experienced individually by each person, there are no effective "rules" that can be used to estimate the workload of different activities. One way to find out about workload is to ask people to describe the feelings they experienced. Because workload may be caused by many different factors, we would like you to evaluate several of them individually rather than lumping them into a single global evaluation of overall workload. This set of six rating scales was developed for you to use in evaluating your experiences during different tasks. Please read the descriptions of the scales carefully. If you have a question about any of the scales in the table, please ask me about it. It is extremely important that they be clear to you. You may keep the descriptions with you for reference during the experiment.

After performing the task, six rating scales will be displayed. You will evaluate the task by marking each scale at the point which matches your experience. Each line has two endpoint descriptors that describe the scale. Please consider your responses carefully in distinguishing among the task conditions. Consider each scale individually. Your ratings will play an important role in the evaluation being conducted, thus, your active participation is essential to the success of this experiment, and is greatly appreciated.

MENTAL DEMAND	/ Low High
PHYSICAL DEMAND	/ Low High
TEMPORAL DEMAND	/ Low High
EFFORT	/ Low High
PERFORMANCE	/ Good Poor
FRUSTRATION	/ Low High

SUBJECT INSTRUCTIONS FOR SOURCES-OF-WORKLOAD EVALUATION

Throughout this experiment the rating scales are used to assess your experiences in the different task conditions. Scales of this sort are extremely useful, but their utility suffers from the tendency people have to interpret them in individual ways. For example, some people feel that mental or temporal demands are the essential aspects of workload, regardless of the effort they expended or the performance they achieved. Others feel that if they performed well the workload must have been low, and vice versa. Yet others feel that effort or feelings of frustration are the most important factors in workload; and so on. The results of previous studies have found every conceivable pattern of values. In addition, the factors that create levels of workload differ depending on the task. For example, some tasks might be difficult because they must be completed very quickly. Others may seem easy or hard because of the intensity of mental or physical effort required. Yet others feel difficult because they cannot be performed well, no matter how much effort is expended.

The evaluation you are about to perform is a technique that has been developed by NASA to assess the relative importance of six factors in determining how much workload you experienced. The procedure is simple: You will be presented with a series of pairs of rating scale titles (for example, Effort vs. Mental Demands) and asked to choose which of the items was more important to your experience of workload in the task(s) that you just performed. Select the Scale Title that represents the more important contributor to workload for the specific task(s) in this experiment.

Circle "1" to select the top item in the pair, and "2" to select the bottom item.

After you have finished the entire series we will be able to use the pattern of your choices to create a weighted combination of the ratings from that task into a summary workload score. Please consider your choices carefully and make them consistent with how you used the rating scales during the particular task you were asked to evaluate. Don't think that there is any *correct* pattern; we are only interested in your opinions. If you have any questions, please ask them now. Thank you for your participation.

Which scale (1 or 2) was a more important contributor to the workload for you:

1 Effort or
2 Temporal Demands

1 Effort or
2 Mental Demands

1 Temporal Demands or
2 Frustration

1 Frustration or
2 Performance

1 Physical Demands or
2 Temporal Demands

1 Mental Demands or
2 Temporal Demands

1 Physical Demands or
2 Frustration

1 Effort or
2 Physical Demands

1 Effort or
2 Frustration

1 Performance or
2 Temporal Demands

1 Performance or
2 Mental Demands

1 Effort or
2 Performance

1 Frustration or
2 Mental Demands

1 Performance or
2 Physical Demands

1 Mental Demands or
2 Physical Demands