# Kinematics and Motor Responses of Law Enforcement Officers in a Spontaneous Lethal Threat Scenario

MICHAEL A. KANTOR[1], DANE BARTZ[1,2], WILLIAM J. LEWINSKI[3], ROBERT W. PETTITT[1].

[1]Office of Research & Sponsored Projects, Rocky Mountain University of Health Professions, Provo, UT, 84601, USA
[2]Linked Fit, Rochester Hills, MI, 48309, USA
[3]Division of Research, Force Science® Institute Ltd, Mankato, MN, 56001, USA

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*Advisor / Mentor: Pettitt, Robert (Robert.pettitt@rm.edu)*

ABSTRACT

When law enforcement officers (LEOs) face the spontaneous acts lethal force, there is no “warning or foreperiod;” as in typical assessments of motor response, which rapidly evokes a startle response.  The Firearms draw in controlled settings is; however, such an analysis when under duress has not been examined for motor response. **PURPOSE**: The purpose of the present study was to evaluate LEOs firearm draw and motor response following a spontaneous presentation of lethal force in a training scenario.  **METHODS**: A total of 22 active duty LEOs engaged in training scenario under the ruse of a “communication experiment.”  The officers were instructed to take the report from a woman that was struck by her husband. The first trial was terminated with a whistle below at approximately 1 min.  In the second trial, a door in the back of the room slams and a husband enters the room yelling.  When the husband entered the visual field of the LEO (~20 ft away), he drew and fired a training pistol armed with training ammunition at the LEO.  The LEOs were video recorded (Go Pro) and their kinematics were measured using wearable sensors (OPAL).  A third gun draw trial, not under duress, was recorded to act as a control. **RESULTS**: The threat of lethal force evoked a startle response of 0.78 ± 0.44 s with the most common startle responses characterized by shielding of the body with the non-shooting arm and flexion of the neck and/or back to “dodge” the gun shot.  Initiation of the tactical response, i.e., moving to draw their weapon to return gun fire, occurred during the startle suggesting the startle is an open-loop motor program and the tactical responses is a close loop motor program. Draw times were 0.35 ± 0.29 s slower under duress vs. the control trial ($t=3.40$, $p=0.003$, $d=1.05$). The elbow kinematic profiles of the practice draw were observed being more efficient and faster, whereas the ambush draw displayed characteristics of over emphasizing each phase of the gun draw kinematic profile, causing the gun draw to take longer ($r= -0.111$, $p=0.622$). **CONCLUSION**: More dynamic environment training in ambush type situations is needed based on our findings that suggest no performance or kinematic efficiency carry over to the ambush trial compared to the practice draw, due to the novel observation of the startle response and firearm draw overlapping.

## BACKGROUND

The examination of human performance movements in law enforcement officers (LEOs) under life-threatening scenarios are pivotal concepts to understand, educate, and to better train those who protect society against crime. LEOs can develop firearm skills in different environments, whether in a control and stable environment (Closed Skills), or in an uncontrolled and changing environment (Open Skills) (Schmidt et al., 2018). Also, motor skill can be performed within these two environments as either Open looped system, which are pre-programmed, previously learned skills, that are executed rapidly with insufficient time for feedback from the nervous system. The other system, Closed-loop systems contain the neurological processing of feedback against a reference of correctness for a skill during the execution (Schmidt et al., 2018). *Bona fide* assessment of reaction time includes a warning and foreperiod, as demonstrated in the Reaction Time Paradigm (Schmidt et al., 2018). When LEOs are facing a spontaneous threat of lethal force, there is no warning nor foreperiod. Indeed, when faced with an ambush-type situation, it takes approximately 0.46-0.70 seconds for LEOs to identify and process a threat to begin a physical response (Lewinski et al., 2015; Ripoll et al., 1995; Vickers, 2007). It has been observed that it can take LEOs between 1.68 to 1.94 seconds to draw from a holster and discharge a pistol when provided a warning and visual signal (Campbell et al., 2013). How fast LEOs can respond when facing a spontaneous and unanticipated threat of lethal force is unknown.

## PURPOSE

In a previous study involving simulated threat of lethal force, many subjects exhibited a "startle response" (Dysterheft Robb et al., 2013). Hypothetically, a startle is reflexive (i.e., an open-loop motor program) and not part of the tactical response. Thus, with differences between a laboratory reaction time experiment, we sought to evaluate active duty LEOs motor response and firearm draw kinematics in the present study and how they respond to the simulated spontaneous threat of lethal force.

## METHODS

A total of 22 male LEOs (Age = 34 ± 7.3 y; Body Mass = 91.5 ± 12.2 kg; Height = 180.9 ± 9.3 cm) volunteered to participate in the study. All subjects were recruited from a local police department located in Utah. The LEOs were asked to remove all gear from their duty belt and person, and were only provided with a practice pistol in their current holster. All subjects provided informed consent, and all procedures were approved by the host's University's Institutional Review Board prior to data collection. A classroom in the Police Department's training center was arranged to simulate the dining area of a house. To ensure measurement of authentic responses, we did not disclose the true intention of the study in advance; rather, the officers were told the study was a "communication exercise." The LEOs we informed to take the report of a women who had called and complained that her husband hit her and left the property. The first trial was terminated with a whistle below at approximately 1 min. In the second trial, a door in the back of the room slams and a confederate enters the room yelling. When the confederate entered the visual field of the LEO (~20 ft away), he drew and fired a training pistol armed with training ammunition toward the LEO. A final session of data collection was done by having the LEO remove the training pistol from their holster and fire at a stationary target ~6 m away as fast as possible to act as a control trial.

A tripod-mounted video camera (GoPro, California) was placed in the corner and used to time-stamp the appearance of the threat. Kinematic data was collected using a 15-sensor, wearable motion capture system (ADPM Wearable Technologies, Portland, OR), sampling at a rate of 128 Hz. The (OPAL) sensors were strapped to each subject according to the manufacturer's guidelines. Data were retrieved using the manufacturer's software (Moveo, ADPM Wearable Technology, Portland, OR). Time points for the initiation of the motion and the firing of the weapon were made by viewing joint angular-time plots by the initiation of the movement indicated by the start of elbow flexion, and the termination of the firing was indicated by peak elbow flexion.

Descriptive statistics for experimental trial, and control trial where initiation of the motion, termination, kinematics profiles of the shooting arm were examined, and startle response times of the motions were reported in mean ± SD. A paired sample t-test and Pearson product correlation test were completed to compare times between the practice draw and room draw. Statistical significance was set at the $p<0.05$ level.

**RESULTS**

When faced with the threat of lethal force, during the experimental condition, the reaction time to initiate motion was 0.20 ± 0.21 s. The startle response was observed subsequent to the confederate's behavior, i.e., either the action of him drawing his weapon or the noise of the pistol being discharged. The startle response was 0.78 ± 0.44 s in duration, and was observed as shoulder shrugs, arm shielding body, jumping, etc. The mean times for the LEOs (n=22) to draw and extend their firearm during the control (0.91 ± 0.11 s) trial exceeded the times for the experimental trial (1.27 ± 0.47). Total draw time performance was 0.35 ± 0.29 s slower when under duress ($t_{21} = 3.42$, $p = 0.003$, $d = 1.05$) and observed poor correlation between the two conditions ($r = -0.111$, $p = 0.62$).

When examining kinematics of the gun draws, majority demonstrated a double hump kinematic profile, depicting each phase of the gun draw, reaching for gun (first hump), gun pulled out of holster (second hump), and gun extension (time to shoot) towards the target/confederate. In the experimental trial, the gun-draw kinematics observed higher levels of elbow flexion and extension (Figure 2, Right Panel) compared to the control trial.

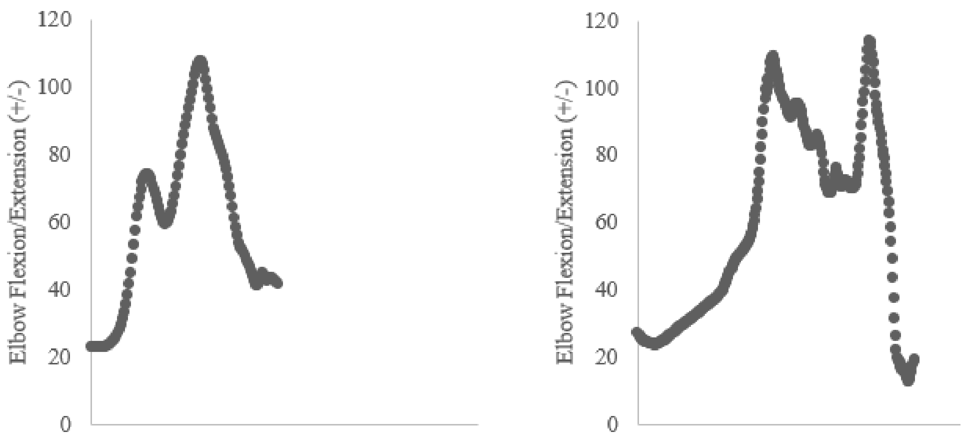


**FIGURE 2.** Kinematic Profile of practice draw (Left Figure) and Room draw (Right Figure). The X-axis represents the amount of data points that were collected at the rate of 128 Hz per second, and Y-axis is the degrees of the elbow joint.

## DISCUSSION

What was observed in the current study was how the startle response directly affected draw time, and gun draw kinematic profiles quality. LEOs are likely experiencing a startle response that impairs their ability to begin a proper physical response as fast and efficiently as in closed skill environments under no duress. What was novel in majority of the subjects regardless of the duration of the startle, was this continuation of the startle response movement while the LEO was beginning to draw their weapon in experimental trial, different from the current Reaction Time Paradigm (Schmidt et al., 2018). The overlap, which has never been observed, is what is potentially causing the increase time to draw their weapon and simultaneously negatively impacting firearm draw motion kinematics. Many of the startle responses were of the opposite arm used for their gun draw, which makes it possible, yet challenging to draw their weapon while the startle response was occurring. This increase in limb movement is one of the factors that could have caused the draw time to be extended in the experimental trial. Our findings support the recommendations to train motor patterns in realistic levels of occupational stress to train out the perceptual and movement strategies (i.e., startle response movements) that put a LEO at risk for assaults, and minimizing incorrect responses when spontaneous stimulus' are presented in open skill environments (Di Nota & Huhta, 2019).

Furthermore, total draw time performance in the experimental trial was 0.35 ± 0.29 s slower, demonstrating the lack of performance consistency in the experimental trial. The current study's results are informative for law enforcement leaders who train LEOs to understand that the recommendations of open skill training to develop a higher capacity to process environmental cues to efficiently respond to lethal threats with fast gun draws and better manage a startle responses.

**CONCLUSION**

The current study provides the first understanding of performance times and motion kinematics comparisons of a LEO firearm draw in both a closed and open skill environment. In addition, LEOs who performed fast in the closed skill environment in the case of a control trial, had no carry over affect into the experimental trial which represents an open skill environment. There may be a lack of open-skill training, causing the LEO to be unable to process the high levels of environmental feedback being sent to the brain in dynamic environments. This may cause a startle response that can negatively impacts a LEO's firearm draw time and efficient motion kinematics that may put LEOs and civilians' life at risk if unable to respond appropriately when lethal force is spontaneously presented while on duty.

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