

Incapacitation recovery times from a conductive electrical weapon exposure

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Abstract

Purpose Law enforcement officers expect that a TASER[®] CEW (Conducted Electrical Weapon) broad-spread probe exposure will temporarily incapacitate a subject who will then be able to immediately (~ 1 s delay) recover motor control in order to comply with commands. However, this recovery time has not been previously reported. **Methods** A total of 32 police academy students were exposed to a very broad-spread 5 s CEW stimulus as part of their training and told to depress a push-button as soon as they sensed the stimulus. A subgroup also depressed the push-button after being alerted by an audio stimulus. **Results** The response time after the audio trigger was 1.05 ± 0.25 s; the median was 1.04 s (range 0.69–1.34 s). For the paired CEW triggered group the mean response time was 1.41 ± 0.61 s with a median of 1.06 s (range 0.92–2.18 s), which was not statistically different. Only 2/32 subjects were able to depress the button during the CEW exposure and with delays of 3.09 and 4.70 s from the start. Of the remaining 30 subjects the mean response time to execute the task (once the CEW exposure ended) was 1.27 ± 0.58 s with a median of 1.19 s (range 0.31–2.99 s) (NS vs. the audio trigger).

Conclusions With a very-broad electrode spread, a CEW exposure could prevent or delay some purposeful movements. Normal reaction times appear to return immediately (~ 1 s) after the CEW exposure ceases.

Keywords Force · TASER · Weapon · CEW · ECD · ESW · CED · Law enforcement

Introduction

The physiological effects of the CEW (Conducted Electrical Weapon) have been well studied [1–12]. Field studies have shown significant reductions in subject and officer injury [13, 14]. However, there are limited data on the immediate post-CEW exposure voluntary movement recovery. Since the goal of a CEW probe application is to capture or control and then obtain compliance with lawful officer commands, we sought to determine how quickly a subject could comply with commands after a simulated probe-mode CEW exposure.

We also determined the control or incapacitation effects via measurement of ability to perform a button-press test. Finally, we sought to compare subject impressions to their performance via a structured interview after the CEW exposure.

Methods

Study design

Participants were CEW trainees from the Austin (Texas) Police Academy (APA) who had previously volunteered to undergo CEW exposure. The CEW exposure was performed by the APA staff per their normal training methods

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using alligator clips. The study was approved by the Institutional Review Board of Texas A&M University. Consent forms were obtained from all volunteers. Exclusion criteria were recent illness, musculoskeletal injury, pregnancy, lactation or significant cardiovascular, pulmonary, or hematological condition. While largely redundant for a Police Academy population, it provided some further selection. The screening was performed by a licensed physician.

CEW application

Each subject was positioned face-down on a narrow, slightly raised padded mat (approximately 60 cm wide $\times$ 180 cm long $\times$ 30 cm high) such that the torso and legs were supported by the mat but the arms and hands could move easily about the side and front of the mat. The chin was positioned at the end of the mat so that the subject could look forward without hyperextending the neck.

A custom button box, for assessing psychomotor function, was placed in front of the subject and the subject was instructed to practice pressing the button and to position the box to make it comfortable to reach and easy to see. Alligator-clipped electrodes were applied manually to ensure consistency of lead placement throughout data collection. The clips were connected to the subject's shoulder (clamped to the shirt in the mid-scapula region of right shoulder) and waist (clamped to the upper edge of pants mid-way from spine to right margin). Due to the arcing capability of these weapons, this approach delivered similar pulse charges as seen with inserted probes [15].

The probe locations were chosen to achieve maximal CEW-induced control of the subject's upper extremities by covering the full trunk length. This gave an estimated 45–60 cm (18–24 in.) CEW-probe spread which was not measured. In normal operation standard probes are angled apart by 8° and thus spread at a rate of $\tan 8^\circ = 0.14$ or 30 cm for each 2.1 m (1 ft per 7) of flight. Hence this spread represents an ideal placement for probes launched from a distance of about 3–4 m (10–14 ft). The New York City encounter data found a mean distance of 1.4 m (5.5 ft) and thus this spread is not expected in the majority of cases [16].

A standard TASER X26TM CEW was connected to the electrodes and then triggered by an instructor. Electrical current delivery lasted for a standard 5 s duration cycle (single pull and release of the trigger), as used in training and commonly in the field. The majority of field uses are single trigger pulls with only 20–30 % involving multiple pulls [16–18].

Psychomotor protocol

Subjects were instructed to press the button immediately upon the initiation of a 5 s CEW exposure. A virtual instrument created in LabVIEW (National Instruments

Table 1 Summary of post-CEW exposure interviews with 32 study subjects

Question	Response
Were you conscious of your surroundings during the CEW exposure?	Yes (75 %)
	No (19 %)
	Somewhat (6 %)
Were you able to hear during the CEW exposure?	Yes (91 %)
	Not sure (6 %)
	No (3 %)
Were you able to see during the CEW exposure?	Yes (81 %)
	Not sure (16 %)
	No (3 %)
How long do you think it took you to push the button?	0–1 s (41 %)
	2–3 s (41 %)
	4–5 s (16 %)
	Distracted (9 %)
Do you think you could understand commands given during the exposure?	Yes (91 %)
	No (9 %)

Corp., Austin, TX, USA) collected data indicating the response time from stimulus onset to task completion.

A convenience sample of 7 subjects (those being trained on day 3 of the testing) also performed a control task to evaluate normal delays to button activation. These subjects were instructed to push the button after hearing an audio stimulus, to establish a baseline of response times for the particular task (initiate, move arm to the button box, and press the button). A custom circuit delivered the audio stimulus and a trigger to the data acquisition board. The CEW stimulus was evident on the EKG signal (lead II) and collected by the data acquisition board. Execution of the button-press task opened a 9-volt battery circuit connected to the data acquisition board to record the button-press event relative to either the CEW or audio stimulus. Incapacitation was defined as the failure to push the push-button during the CEW exposure.

Symptoms and self-assessment analysis

A structured interview was given immediately after the CEW exposure. The most relevant questions and responses are listed in Table 1.

Statistical analysis

Pooled comparisons were by Student's *t* test. Paired comparisons were also done by the Wilcoxon signed-rank test.

Results

A total of 32 subjects (29 male and 3 female) participated. Subject ages ranged from 21 to 55 years.

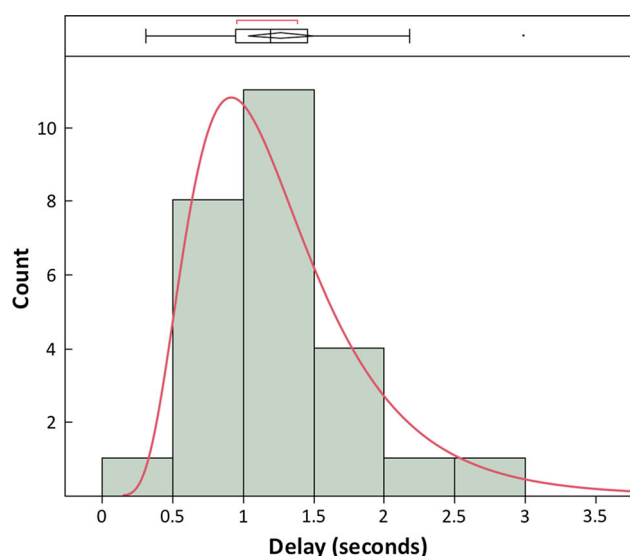


Fig. 1 Effects of CEW on psychomotor function after end of exposure. *Note* that this does not include the 2 subjects who were able to activate the push-button during the exposure. A log-normal fit curve is overlaid and a Tukey whisker plot shown at the top

Psychomotor function was evaluated by visual inspection of the subjects ($n = 32$) and by measuring the time elapsed between the onset of CEW exposure and button box actuation ($n = 28$). Visual inspection revealed that 30 of the 32 subjects were incapacitated during CEW exposure; only 2 subjects were able to push the button during the CEW exposure. Among the 30 incapacitated subjects, 4 button-press waveforms were lost due to data acquisition failures. The results from the 2 subjects that pressed the button during CEW exposure were captured appropriately. The baseline response time, i.e., time to execute the button-press task after audio stimulus (control set), was measured in 7 subjects. However, in 2 of these subjects, the CEW results were not obtained due to data acquisition failure and thus there were 5 paired comparisons.

The mean response time after the audio trigger ($n = 5$ for the paired group) was 1.05 ± 0.25 s; the median was 1.04 s (range 0.69–1.34 s). For all audio responses ($n = 7$) the mean was 0.98 ± 0.25 s with a median of 0.98 s (range 0.69–1.34 s). For the paired CEW triggered group ($n = 5$) the mean response time was 1.41 ± 0.61 s with a median of 1.06 s (range 0.92–2.18 s) after the end of the exposure. The difference was not statistically significant by either the paired t test ($p = 0.37$) or the Wilcoxon signed-rank test ($p = 0.81$).

Of the 28 subjects with full response data for the CEW exposure, there were 2 that retained the ability to move their arms in a purposeful manner yet with slow, coarse movement; they were eventually able to reach and depress the push-button. They had delays of 3.09 and 4.70 s from

the start of the CEW exposure. They were then excluded from the analysis of the post-exposure push-button response times.

Of the 28 subjects with captured timing data, there were 26 that could not depress the button during the CEW exposure. The mean response time to execute the test once the exposure ended was 1.27 ± 0.58 s with a median of 1.19 s (range 0.31–2.99 s). This distribution is shown in Fig. 1 and was well fit by a log-normal distribution (Shapiro–Wilk $p = 0.49$ where a large value indicates a good fit). This delay was not statistically different from the audio-triggered delays ($p = 0.21$ by pooled t test).

The interviews conducted immediately following CEW exposure gave information on the sensory and behavioral effects of CEW exposure. Results are summarized in Table 1. Notably, 75 % of subjects reported being conscious of their surroundings, 91 % retained hearing capabilities, and 81 % maintained vision capabilities (5 subjects closed their eyes during CEW exposure). A majority of subjects (91 %) were able to hear commands given during the CEW exposure.

Discussion

We believe that our study represents the first report of the psychomotor recovery time after a full trunk CEW exposure. This is an important result for law enforcement as officers typically give commands before and after a CEW exposure and hope for prompt compliance. Other researchers have studied the longer-term neurocognitive effects of a CEW exposure [19].

Misunderstandings of CEW effects, electrode spread, and the time required for muscle control recovery are widespread and have led to some tragic results. Most common are cases where criminal suspects allege that they could not comply with officers' commands due to alleged lingering effects of the CEW exposure.

In the case of *McQueen*, a man was suspected of an armed robbery of a liquor store when, in fact, he was performing undercover duties there as a state liquor agent. He then sued the local police department for excessive force arguing that he could not comply 10 s after the first CEW application. The appeals court ruled:

The police officers swarmed McQueen, whose hands remained underneath his body. Four or five officers were on top of him, yelling at him to move his hands that remained out of sight. Believing that McQueen was not being compliant in moving his hands, Johnson tased McQueen again, approximately 10 s after the first tasing. Another officer removed the firearm from McQueen's jacket pocket and placed it a safe

distance away. McQueen had the misfortune of falling on top of his hands after being incapacitated by Johnson's initial tasing. As a result, McQueen's hands were obscured under his body at the same time that the police were yelling at McQueen to reveal his hands, and many officers had already observed that there was a second weapon located in the same area as his hands. Despite McQueen's unfortunate inability to make his hands visible, a reasonable officer in this rapidly evolving situation could perceive that, rather than being incapacitated, the armed robbery suspect, who undoubtedly had at least one firearm on his body, was continuing to resist the officers' orders.

Even though they granted immunity to the officers, it appears the Court of Appeals believed that 10 s post-CEW exposure was insufficient time for a subject to show his hands [20].

In another example, Mr. Baron D. Pikes (also sometimes known as Mr. Collins) sprinted from officers on a drug warrant and thus apparently initiated a sickle cell crisis. After he was captured and handcuffed he received multiple drive-stun (direct contact) exposures to the back and legs. Mr. Pikes probably had great difficulty complying with commands to walk to the squad car due to extreme leg pain caused by the sickle cell crisis. The gaps between the exposures ranged from 13 to 115 s (40 ± 43 s) and hence the officer assumed that there was plenty of time for compliance. While 40 s was more than enough time for almost anyone to comply, no amount of time was enough for someone dying from sickle cell crisis. Approximately 30 min after the last CEW drive-stun exposure, Mr. Pikes died. At autopsy the forensic pathologist found cell sickling and noted the clinical history of sickle cell trait. The local coroner (who is typically different from the forensic pathologist in this jurisdiction) ignored the forensic pathologist's autopsy findings and opined:

Problem. Very serious problem. No time is allowed between shots for normal neuromuscular recovery time. The subject, Collins - could not reasonably be expected to walk, certainly not with any stability after 2 electroshocks - statements indicate that he indeed tried - but muscles are too weak, no stability.

Based on the coroners' misunderstandings, the police officer was criminally prosecuted and charged with negligent manslaughter and faced up to 45 years in prison. After a trial with expert bioelectrical science and pathology opinions, he was acquitted [21].

It is also important for officers to appreciate that the rapid recovery of a violent subject can present a danger to the officer. This is a good reason for "cuffing under power" or applying the handcuffs during CEW current delivery.

Most (30 of 32) of our study subjects experienced a loss of task-directed motor function during CEW exposure; only 2 subjects were able to reach for and trigger the button box during the 5-s exposure period. Observation of these subjects showed that their movements were significantly slowed, and their response times were over 3 s from the start of the CEW exposure. This finding suggests that the CEW may be used to delay or prevent (with >90 % confidence) purposeful movement under ideal probe-deployment circumstances. We did not measure the probe spread but rather used anatomical landmarks to ensure that the spread was equal to the full trunk length. Nevertheless, our results are consistent with other studies showing that a 30 cm (12 in.) probe spread on the back is likely to prevent intentionally purposeful movements [22].

There is also no apparent residual arm motor function impairment once the 5 s CEW exposure period ceases. Although it took the subjects about 1 additional second to press the button after the CEW stimulus ended, this is a typical delay for task execution with CEW exposure. Essentially, upon cessation of the CEW stimulus, all subjects immediately regained normal control and coordination required to trigger the button box with response times comparable to a baseline audio-triggered response.

Limitations

In addition to being volunteers, police academy students undergo extensive physical training and are prescreened to eliminate health problems and drug use. Subjects who have a CEW exposure in the field are a distinctly different cohort that were, presumably, noncompliant with law enforcement. Altered mental status from disease or drug use is a common cause of noncompliant behavior, and relative to healthy subjects, might significantly delay the ability to respond to officer commands—with or without a CEW stimulus. One of the response time comparisons was with an imbalanced test/control group.

The neuromuscular control achieved with the manually placed external electrodes should not be expected with a typical field usage with launched and embedded probes. Lower placed probes, for example in the abdomen and thigh, would not be expected to control the arms. Also, rolling over and presenting the arms for handcuffing involves more thought and steps than merely pushing a button.

Conclusions

With a very broad electrode spread, a CEW exposure could prevent or delay some purposeful movements to execute an

attack. Normal reaction times appear to return immediately after the CEW exposure ends.

Key Points

1. A broad-spread TASER CEW exposure prevented 30/32 subjects from activating a push-button within reach and view.
2. After the end of the CEW exposure, the time delay to activate the button was 1.3 ± 0.6 s showing that muscle control is quickly recovered.
3. This delay was not statistically longer than that from an audio signal suggesting that there is no additional recovery delay from the CEW exposure.
4. Such a broad spread back exposure is an ideal and very powerful application and has a low probability in the field.

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Conflict of interest The authors have no financial involvement with the Funding agency. MWK has financial involvement with the CEW manufacturer but they had no financial involvement in either the study or the manuscript.

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