Body-worn cameras: a useful tool for police incident reconstruction

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Abstract: Body-worn cameras are a tool commonly used in many police departments as a way to protect the officers and the public. However, their value has sometimes been questioned. A recent case, presented here, exemplifies the way body-cam footage can be used. Using the footage in conjunction with an injury biomechanics investigation process, it was possible to show that the officers involved delivered submaximal blows in order to control the suspect rather than aiming to deliberately harm the suspect. It was also shown that the duration of the baton intervention was reasonable as the time the officer took to change his response was within the limits presented in literature.

Keywords: police intervention; incident reconstruction; injury biomechanics; body-worn camera; human factors.

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1 Introduction

In this era of technology and under the tense socio-political climate surrounding police use of force, actions of officers often come under scrutiny. In recent years, police officers started wearing body cameras in order to protect both themselves and the public, by offering full transparency in cases where actions are questioned (Coudert et al., 2015; Sousa et al., 2016). Advocates of body-worn cameras also claim that the use of this technology increases accountability and reduces the amounts of unnecessary use of force as well as citizen complaints (Ariel et al., 2015; Headley et al., 2017). Yet, it has been suggested that reductions in complaints and use of force from the implementation of body-worn cameras in police departments are only temporary (White et al., 2017). There has also been pushback on the implementation of such measures from the added burden to the police officers, to cost, concerns for privacy and more (Ray et al., 2017).

However, their potential value in the context of use of force investigations is hard to deny. This manuscript aims to show this value by examining a case where officers chose to use force to subdue a suspect, which led to the latter suffering multiple injuries. Subsequently, the suspect attempted to sue the officers and the police departments. GTD Scientific Inc. was then asked to provide an injury biomechanics and forensic perspective on the matter. The following manuscript details the work that was performed.

2 Case presentation

2.1 Incident

The incident involved an adult male with a criminal history involving previous arrests for carrying a concealed firearm, domestic violence, and resisting arrest. The incident started shortly before midnight when his partner picked up the suspect from work. The couple then got into a verbal confrontation as they returned to the partner's residence.

At the residence, the suspect became angry and violent, eventually expressing death threats to his partner. The suspect then packed a bag and left the residence. Being afraid that the suspect would return, the suspect's partner called the police.

Approximately one hour later, three police officers, arrived at the scene of the domestic violence incident and proceeded to inquire with the suspect's partner. Shortly thereafter, the suspect returned to the residence where he knocked on the door.

One of the officers (Officer A) opened the door. The suspect then attempted to step inside but was instructed to return to the hallway. The suspect quickly became verbally abusive with the officers as the latter attempted to guide him back to the hallway.

A second officer (Officer B) then grabbed the suspect's wrist, which caused the suspect to pull back. Then, the second officer claims to have seen the suspect form a fist with his right hand, and so, feared he was going to be struck. In an effort to control the suspect, the second officer then used his physical strength and moved the suspect against the opposite wall; simultaneously the first officer drew his baton.

Officer A delivered a blow with his baton to the suspect's arm and lower leg. During the struggle, Officer A's third baton strike contacted the right posterior side of the suspect's head. Officer A continued to hit the suspect on the right arm and leg for an additional five strikes for a total of eight strikes. Officer B then managed to get control of the suspect and handcuff him with his hands behind his back, lying face down on the ground.

The officers on the scene immediately noticed that the suspect was bleeding from a head laceration, therefore, medical support was called. Paramedics arrived to provide assistance approximately 10 min later.

Injuries reported for the suspect were as follows:

- 2–6 cm laceration on the upper rear side of the head
- laceration to the right tibia
- Bruises on his right leg and arm.

In the months following the incident, the suspect also had multiple visits to the hospital regarding headaches, migraines and shoulder pain which he claims to be linked to the incident.

2.2 Injury analysis

This section aims to provide background and context to the injuries of interest incurred during the incident by the suspect.

2.2.1 Head laceration

After the suspect's head wound was cleaned and treated by paramedics and hospital staff, it was reported that the suspect suffered no loss of consciousness at the time. Medical records described the head laceration sustained by the suspect as spanning between 2 to 6 cm depending on the source.

Despite knowing that a direct blow to the head delivered using a police baton caused the laceration, fully understanding the nature of the injury requires thorough consideration. Research on the matter (Lee et al., 1997) has reported that head lacerations can be caused by direct blows to the head of a magnitude of approximately 2.2 kN.

It is also important to note that no skull fractures were reported, as the tolerance for skull fracture is higher than for head laceration. For example, blunt impact research on the cranium has shown an average load to fracture of 5.0 kN (Allsop et al., 1991). In the context of this research, such fractures were sustained by applying a load to the temporoparietal region using a 2.5 cm flat circular plate. This research is relevant since the impact location cited is similar to the incident injury and would have a similar contact area with the cranium. Hence, it is expected that the load necessary to cause fracture should also be similar.

No medical records provided suggested that the suspect's head trauma resulted in any traumatic brain injury (TBI) on the day of the incident. Further, upon examination and medical questioning, the suspect denied any headache, or dizziness at the time.

However, in the weeks following, the suspect did report headaches, migraines, shoulder pain and difficulty in cognition, which resulted in medical imaging diagnostics. The imaging revealed cervical radiculopathy and mild multilevel degenerative disc disease but no intracranial hemorrhage to suggest TBI. Cervical radiculopathy, also called pinched nerve, often manifests through pain radiating from the neck and into the upper extremities (Radhakrishnan et al., 1994). The major cause of cervical radiculopathy is a degenerative disease of the spine (Radhakrishnan et al., 1994).

2.2.2 Leg laceration

An additional laceration was found on the suspect's right shin, located at the anterior border of the right tibia bone on the shin. Considering the low thickness of skin covering the tibia and the sharpness of the anterior border (Hansen, 2017), lacerations of this kind are not uncommon (Jones and Sanders, 1983).

As was the case with the scalp laceration previously described, no fractures were found. Typically, fractures of the tibia occur in presence of blunt impact forces higher than 3.3 kN (Kramer et al., 1973).

2.2.3 Arm and leg bruises

It was also reported that the suspect had up to six bruises along his right arm and right leg. When dealing with blunt impact injuries, contusions are often caused by impacts to the skin that generate small scale hemorrhaging beneath the skin which leads to a change in coloration (Sadler, 1999). However, as with this case, contusions are typically improperly documented due to their benign nature, especially when accompanied by more serious injuries.

A study performed by Desmoulin and Anderson produced contusions using impacts forces between 342 N and 874 N (Desmoulin and Anderson, 2011). Due to the violent nature of the study, only one subject was used to gather contusion results. However, this subject was of the same gender and similar age and build as the subject of the incident under examination. Further, the impacts used in the study used a round wooden impactor that is generally comparable to a baton impact with respect to the contact area.

Although this study is limited in its scope, this information is relevant to the injury assessment of this case as it provides insight into the range of forces used to deliver the strikes sustained by the suspect.

3 Breakdown of intervention

Unlike most typical forensic investigations, this incident benefits from video evidence in order to understand the kinematics of the event. Cameras worn by three of the officers captured the events that transpired at the scene of the domestic violence call including the suspect's arrest.

As was previously described, Officer B moved to control and eventually restrain the suspect, while Officer A deployed his expandable baton[1] and proceeded to deliver strikes to the suspect's body. As Officer B was using his physical strength against the suspect, the suspect leaned against the door of the apartment behind him. After the first baton strike delivered by Officer A, the suspect was be seen falling to a crouched position against the same door and adjacent wall. At the same moment, Officer B was seen moving to the side of the suspect opposite Officer A.

The baton-wielding officer then delivered a second strike, to the leg, which was followed by the suspect jerking forward with his upper body. When Officer A started delivering his third strike, the suspect's torso was in the process of leaning towards his knees. The baton then made contact with the back of the suspect's head. Following this, the suspect's weight shifted back against the door as his right arm came up alongside his head. Meanwhile, officers could be heard repeatedly asking the suspect to 'get down'.

Following the fourth strike making contact with the suspect's right leg, the same leg was seen jerking up in a kicking-like motion. Simultaneously, Officer B, off to the left side of the suspect, was seen holding the suspect's left wrist and pulling it towards himself. Officer A then delivered a fifth strike, as Officer B appeared to try and pull the suspect over to his side to apply restraints.

After strike #6, the suspect was heard exclaiming 'alright' as he was moved towards Officer B. Meanwhile, officers continued to instruct the suspect to 'get down on the ground'. Officer A then delivered the last two strikes to the suspect's lower body as Officer B climbed over the suspect and proceeded to restrain him.

A total of eight strikes were observed as making contact with the suspect. From the moment Officer B made contact with the suspect's arm to the moment handcuffs were securely fastened, the struggle lasted for a total of just under 17 s. The time elapsed from the baton being deployed to the final strike was less than 7 s. A thorough breakdown of the intervention can be seen in Table 1.

Table 1 List of important events during the intervention

Event	*Time elapsed* (s)	*Comment*
Initial contact	0.0	Officer B grabs suspect's wrist
Deploys baton	2.8	Officer A deploys his baton
Start of swing #1	3.5	None
Strike #1	*3.9*	Impact to right upper arm
Start of swing #2	4.3	None
Strike #2	*4.7*	Impact to right thigh
Start of swing #3	*5.1*	None
Strike #3	*5.4*	Impact to right posterior side of head
Start of swing #4	*6.0*	None
Strike #4	*6.4*	Impact to right shin/tibia
Start of swing #5	*7.2*	None
Strike #5	*7.4*	Impact to right thigh or arm
Start of swing #6	*8.0*	None
Strike #6	*8.3*	Impact to right thigh
Start of swing #7	*8.6*	None
Strike #7	8.9	Impact to right thigh
Start of swing #8	9.3	None
Strike #8	9.7	Impact to back of lower right leg
End of intervention	16.7	Suspect Restrained

4 Analysis

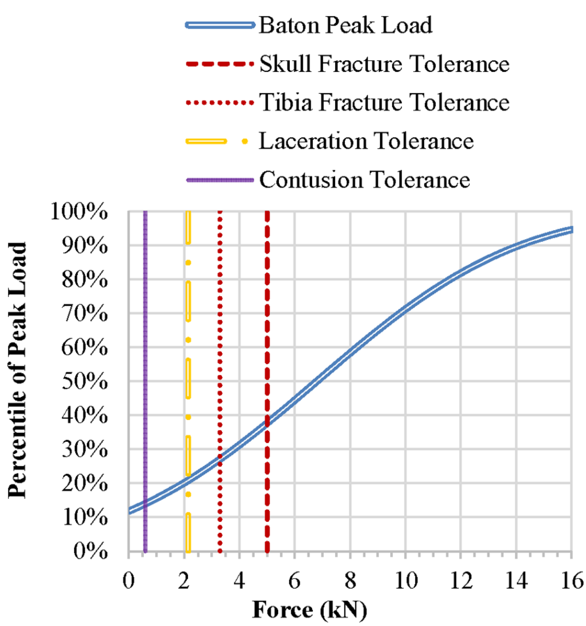
The officers' intervention was analysed by correlating research on police officer baton use with the probability of TBI and human reaction times to a dynamic situation requiring relatively complex decisions.

4.1 Strike force effort

Combining research on the use of batons with knowledge about the magnitude of force required to cause the injuries inflicted allows for quantification of the loads involved in this intervention. Research performed on the use of expandable batons (Macintosh and Desmoulin, 2019) looked at the effectiveness and performance of different batons weights at two different lengths. The techniques implemented in the study were based on ASP Inc. baton training. In this study, data was collected from active-duty New York Police Department (NYPD) Officers delivering downward strikes to a target. Considering the officer involved in this case received baton training from ASP Inc., it is reasonable to consider these test results as representative of Officer A's performance and compare it to injury literature. Also, the baton used by the officer in this incident can be best compared to the baton category labelled as Heavy/26 in, which weighed 735 g.

As was previously reported, the suspect sustained multiple limb contusions, as well as a head and shin laceration with no presence of a fracture. Although the suspect did come in contact with his environment, these contacts were mostly with the posterior side of his body and are not believed to have caused any of the reported injuries.

Figure 1 Injury risk compared to baton peak force for a 26″ baton of heavy weight (735 g) (see online version for colours)



By combining injury research and baton performance data, it is possible to estimate the effort used by the officer. As shown in Figure 1, bruises are known to occur at relatively low forces, when compared to lacerations and similarly when lacerations are compared to fractures. Contusion research (Desmoulin and Anderson, 2011) reported an injury tolerance of approximately 600 N. Meanwhile, post mortem studies have suggested that blunt force impacts generate lacerations at approximately 2.2 kN (Lee et al., 1997). Fracture tolerances are 5.0 kN for the skull (Allsop et al., 1991) and 3.3 kN for the tibia (Kramer et al., 1973). Hence, in the presence of lacerations but absence of fractures, the range in which the force generated by each impact can be implied to lie somewhere in-between the two limits. Similarly, in the presence of contusions but the absence of lacerations, the force generated by each impact can be implied by the values to create both.

As seen in Figure 1, each injury tolerance can be associated with a striking force percentile. In the case of the tibia laceration, the graph suggests that the force generated by the baton at the suspect's shin would have likely been at least 2.15 kN and no higher than 3.3 kN. This would suggest that Officer A used a force that was in the 21st to 27th percentile for average strikes by a Police Officer with an expandable baton of similar weight and length. Similarly, for the skull laceration, the load would likely have been in the area of the 21st to the 38th percentile necessary to reach the skull fracture tolerance.

Considering the other six strikes reportedly only generated contusions, their impact would have remained under the 21st percentile in order not to result in any laceration of the skin. Rather, forces would have been closer to the 14th percentile of force, which corresponds to the range available for contusions forces.

4.2 Risk of traumatic brain injury

Given that the suspect developed symptoms of TBI such as frequent headaches, it is relevant to examine the risk of possible TBI to the suspect as a result of the baton impact.

To estimate the risk involved, the impact can be modelled using the force of a head laceration previously presented, as a 'blow' to the centre of mass of the suspect's head. Under such conditions, the head would be subjected to a linear head acceleration of 30 G, assuming the suspect's head was proportional to his total body mass (Yoganandan et al., 2009).

According to data reported by Zhang et al. (2004), this magnitude of head impact represents a less than 1% chance of suffering a TBI. This is demonstrated in Figure 2, which depicts the extrapolated risk for the suspect, alongside Zhang's research data. It is important to note that the Zhang research is validated by the work of both the JARI Human Head Impact Tolerance Curve (JGTC) (Ono et al., 1980) and the data used as part of the Wayne State Tolerance Curve (WSTC) for head injury (Lissner et al., 1960).

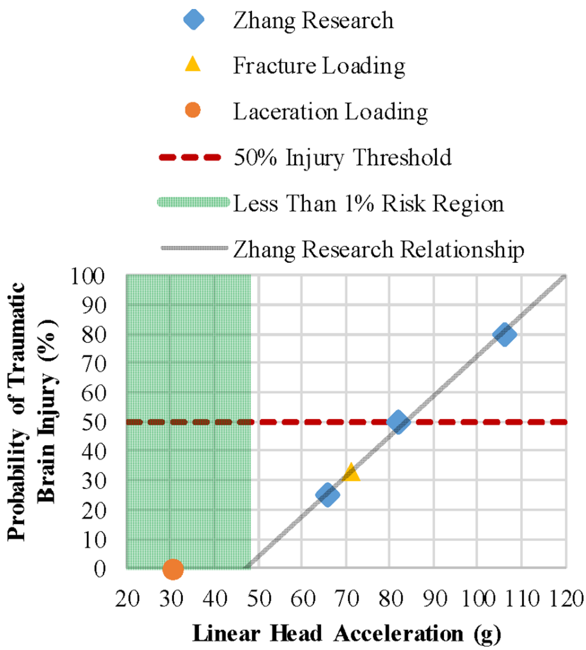
These findings are consistent with medical imaging results revealing non-TBI related pathology such as cervical radiculopathy and mild multilevel degenerative disc disease but no intracranial hemorrhage to suggest TBI.

4.3 Human factor analysis

While the suspect was struggling with the officer restraining him, officers can be heard instructing the suspect to 'get down on the ground' on numerous occasions (6+). Although the suspect does not comply initially, at approximately 8 seconds into the altercation, the suspect can be heard loudly exclaiming 'alright'. This exclamation by the suspect may be taken as the potential start to his submission. At this point, one officer is in the process of pulling the suspect to the ground in order to immobilise him and apply restraints.

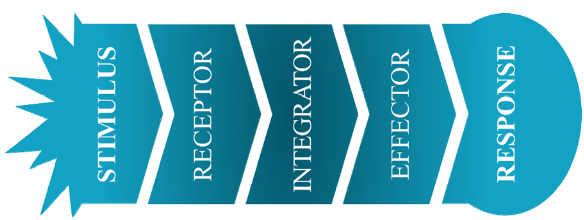
Given the dynamic nature of the situation, it is unclear whether the officer delivering baton strikes heard the suspect's exclamation and if he interpreted it as a definitive sign of submission. However, this instant can be used as a theoretical earliest stimulus, which would have allowed the officer to change his response.

Figure 2 Probability of traumatic brain injury (see online version for colours)



On the basis of this information, it is possible to estimate the time necessary for the officer to react to this event. However, research assessing reaction time to dynamic situations does not provide a finite time as it is composed of various phases which change based on the situation. Before being able to generate a response or, in this case, stop performing an action, the stimulus must be received, analysed and a response command must be produced as exemplified by the flowchart shown in Figure 3.

Figure 3 Human reaction workflow (see online version for colours)

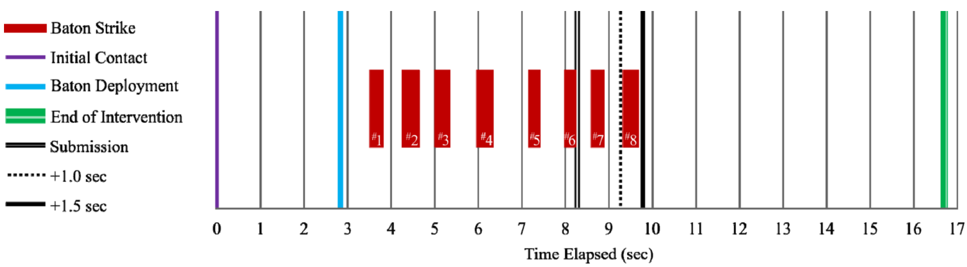


The time required for each step of this reaction workflow varies in different situations, but the most important variations come from the nature of the decision involved at the integrator stage. The complexity of the decision affects the time required to send out the command to the effector, which drives the response. In more complex decision-making experiments, it has been found that reaction times increased linearly with each added stimuli (Nickerson, 1972).

In fact, in a real-life altercation, officers must make decisions to stop or change their response based on cues like body language, which require longer deliberation than a simple reflex reaction to a change in light condition for example. Recent development in complex reaction time research (Lewinski and Redmann, 2009) pointed out that the delay in noticing a change in the nature of a threat and having the officer adapt his or her response to that threat could take as long as 1.0–1.5 s when confronted with a real-world encounter.

Using the timeline presented previously, the suspect's verbal exclamation of 'alright' may be considered as the first potential change in threat and from there, the reaction times proposed by human factors research can be applied in order to determine a minimal time for the officer to cease using his baton. As seen in Figure 4, the 8th and last strike delivered by the officer started approximately one second after the suspect exclaimed 'alright'. After this last strike was delivered, the full 1.5 seconds had elapsed and as suggested by the research, the officer ceased to strike.

Figure 4 Timeline of key events during baton intervention. Red boxes represent the time from start of swing to impact (see online version for colours)



5 Discussion

In this section, the results presented in the analysis are discussed in order to understand the outcome of the incident under observation.

On the basis of the force percentile results extrapolated from both baton performance research and injury research, it can be suggested that the officer's strikes were delivered at lower than average forces for similar strikes compared to other Police Officers. Batons of the weight and length used by the subject officer are capable of generating forces sufficient to break both the tibia and skull if maximum effort is used. In fact, as shown in Figure 1, even at the 50th percentile, strikes are sufficiently powerful to cause fractures of both the skull and tibia. However, in the absence of those injuries, the average strike effort can be correlated to a 20th percentile force.

This demonstrates that the officer did not use maximal force but rather may have been delivering submaximal strikes aimed at assisting his colleague in restraining the suspect rather than causing injury. If the officer had in fact been delivering harder strikes, more lacerations would have been produced on the arms and legs as well as potential bone fractures.

In the process of restraining the suspect, 1 of 8 strikes delivered made contact with the posterior side of the suspect's head. However, as was previously shown, the risk of TBI from this blow is negligible. In fact, a loading up to 150% larger (47 G) than the laceration tolerance would still have resulted in a risk below 1%, further confirming the minimal risk of TBI as best illustrated by Figure 2.

It is important to remember, however, that when dealing with injury criteria, the values presented represent the average of the population used to determine each criterion. The variability inherent to each subpopulation or even between each individual cannot be easily accounted for. In this case, it is relevant to remember that the victim was a healthy adult male of large stature. Such an individual's skeletal structure would, therefore, likely be more tolerant of stresses than the average subject.

The human factors analysis highlighted that as the complexity of a situation increases, so does one's response time. Considering the speed at which events can unfurl in the field and how it can affect the ability of an officer to react rapidly to a changing situation, it was shown that an officer might take 1.0–1.5 s to stop firing their weapon when faced with a change in threat (Lewinski and Redmann, 2009). These studies mainly looked at the changes in threat level following a firearm discharge, which can be dramatic. However, changes in the threat level to a baton intervention may be more subtle and dynamic due to the reduced level of force and the close nature of the intervention. Therefore, the reaction time necessary for the officer to adapt their response may be more likely closer to the higher limits of the (1.5 s) range proposed.

On the basis of this information, it was appropriate to say that the officer's decision to stop delivering strikes with his baton came within the time frame proposed even when considering the first sign of potential compliance exhibited by the suspect.

6 Conclusion

In the end, the footage from the body-worn cameras allowed us to show that the police officer's intervention was reasonable through two different metrics. First, it was shown that the force employed by the officer was submaximal. This was done using research on baton strikes and using data related to the injuries sustained by the suspect. Second, it was shown that the time the officer took to react and modify his response during the intervention, fell within the range expected for this kind of situation.

Again, this case shows the value of body-worn cameras in analysing police interventions. Additionally, it shows the value of injury biomechanics in providing contexts to injuries sustained.

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Note

[1]Monadnock AutoLock Expandable Baton (Safariland Group, Jacksonville, FL): Fully extended length is 26 1/2 inches and weight is 684.6 g.