TERMINAL AND EXTERIOR BALLISTIC EVALUATION OF ACTIVE SHOOTER COUNTERMEASURES OF CONVENIENCE IN A BIOMECHANICS CLASSROOM OR LABORATORY

Garrett T. Duffin and William P. Ebben
Exercise Science Research Laboratory, Lakeland University, Plymouth, WI

This study assessed the terminal and exterior ballistics of numerous school shooter countermeasures of convenience (COC) that may be present in a classroom or applied biomechanics laboratory. In this case study, the subject threw eight COC with maximum effort at a wall mounted force plate, with concomitant assessment with Doppler radar. Peak reaction forces and velocity of the projected objects were analyzed. Large, compared to smaller mass COC generally produced more force, but were slower to the target. Some COC produce highly variable flight characteristics likely due to forces such as surface drag, yaw, and oscillation. These forces can reduce and make variable the velocity and impact forces. Therefore, small, high density, uniform surface area, and symmetrical countermeasures may display superior ballistics and should be evaluated.

Keywords: kinetics, force, velocity, school shooter

INTRODUCTION: Projectile force production is an important concept in the field of biomechanics. Contributing to the force production of projectiles are terminal and exterior ballistics. Terminal ballistics refers to the contact between the projectile and another surface, while exterior ballistics refers to the flight of the projectile. These ballistic variables can be considered when assessing the countermeasures of convenience and their potential impact on an active shooter in an academic environment.

An active shooter, as defined by U.S. government agencies, is an individual actively engaged in killing or attempting to kill people in a confined and populated area. The FBI has comprehensively documented each active shooter incident over the past two decades, providing detailed accounts of all incidents, including where each one took place, including educational institutions (U.S. Department of Justice, 2013). Research specific to active shooters at institutions of higher education shows that there have been a total of 190 active shooter incidents resulting in one or more casualties from 2001 to 2016. Based on these data, during that time span approximately one out of 33 universities or technical colleges had an active shooter incident resulting in one or more casualties (Cannon, 2016).

There is no optimal countermeasure response to an active shooter scenario. Therefore, prevention of an active shooter situation must be the top priority at every institution. Avoiding an active shooter incident is one way to attempt to maximize the safety of students and faculty. However, in order to maintain a sense of safety on campuses in the event such an incident does occur, there must be development of preparedness and response strategies and tactics (Greenberg, 2007). Actively fighting active shooters with countermeasures is one of the response options (Department of Homeland Security, 2015). Due to the need for fast action, the use of countermeasures already in the environment is essential. However, no study has evaluated the potential effectiveness of such countermeasures.

Research has assessed the kinetics of non-school shooter countermeasure activities and projected objects, using wall mounted force platforms. For example, punching power of boxers has been assessed (Smith et al., 2000). Additionally, peak forces of projected medicine balls has been studied (Laskowski, 2014). The purpose of this pilot study was to assess elements of the terminal and exterior ballistics of countermeasures of convenience (COC) that could be found in a classroom or applied biomechanics laboratory. This study was also used to evaluate the methodological issues associated with this type of research.

METHODS: A male university student (age = 21 years; height = 193.04 cm; mass = 85.35 kg) participated in this case study. The subject participated in one research session. The subject performed static and dynamic stretching. The subject then performed two throwing repetitions of eight COC conditions, in random order. The subject threw each COC as fast and as forcefully as possible at approximately five meters from a wall mounted force platform, resting one minute between each repetition. The subject was instructed to use self-determined throwing mechanics in an attempt to increase external validity. Countermeasures of convenience included implements that may be found in a classroom or an applied biomechanics laboratory, including a tennis shoe, 1.09 kg hard cover text book, 1.91 kg soft cover text book, stainless steel cup, three-hole punch, 1.82 kg medicine ball, 2.72 kg ream of paper, and a 1.36 kg dumbbell.
Terminal ballistics of each COC were assessed using a wall mounted force platform (Accupower, Advanced Mechanical Technology, Inc. Watertown, MA). The force platform was covered by a soft vinyl encapsulated 4 cm open cell foam pad, in an attempt to preserve the platform. The force platform was calibrated prior to the study. Peak reaction forces were acquired at 600hz and analyzed in real time. Data were then saved to a computer, as well as manually recorded, and further analyzed after completion of the research session. Elements of exterior ballistics of each COC were assessed via a handheld Doppler radar (Speedster III, Bushnell Outdoor Products, Overland Park, KS). Velocity of the COC during each repetition was analyzed in real time then recorded manually for further data reduction after the completion of the research session.

RESULTS: Kinetic analysis of terminal ballistics are shown in Figure 1. Also included, for reference, is the kinetic energy of a 158 g .38 special + P round (Hawks, 2016). Figure 2 depicts the velocity of each COC used in the current study. Values represent the mean of two trials.

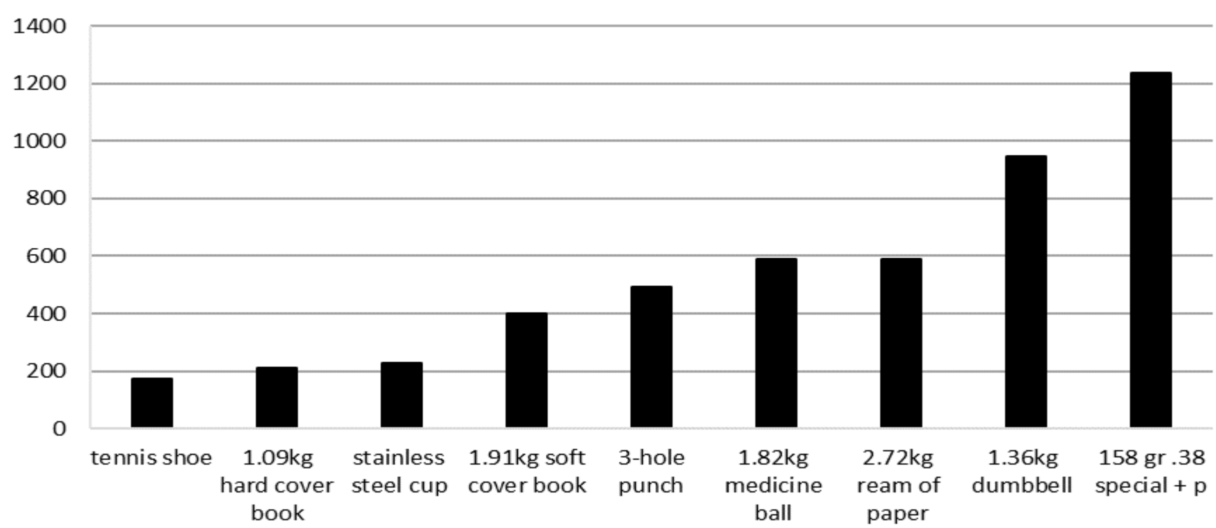

Figure 1. Countermeasures of convenience peak force in Newtons

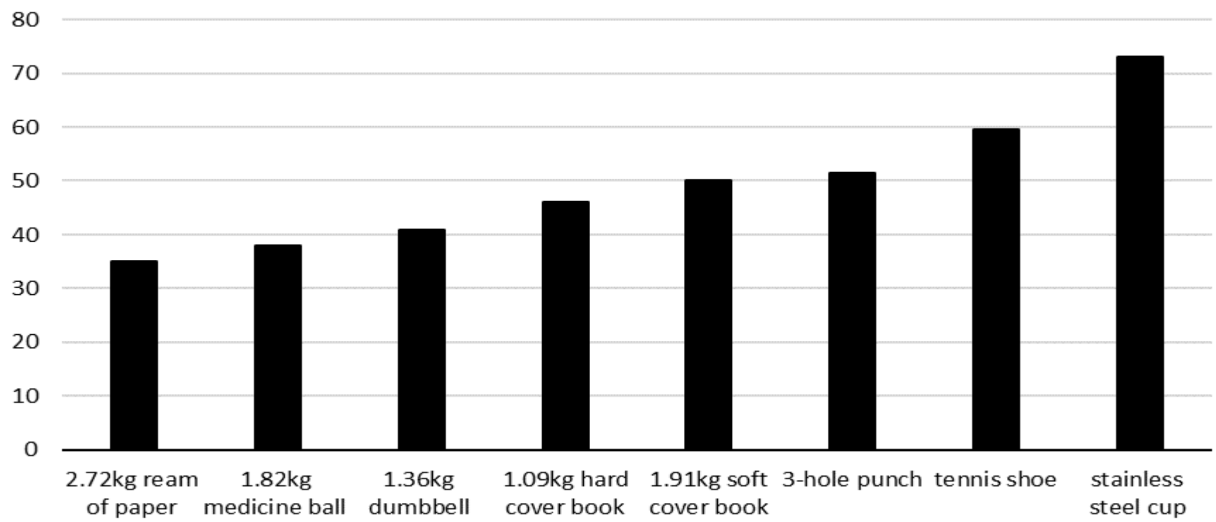

Figure 2. Countermeasures of convenience mean velocity in kilometers per hour

DISCUSSION: Large, compared to smaller mass COC generally produced more force. This is consistent with a previous study which found that as thrown medicine balls increase in mass, the force produced also increases (Laskowski, 2014). Velocity seems to be less important in determining impact forces for projected objects. However, a number of the high mass objects with superior kinetics were slower to the target. This finding is consistent with cadaveric studies of blunt force trauma, which showed that lower load and higher velocity impacts produced less tissue deformation (Bir et al., 2004). However, projectile velocity is likely to be important in active shooter scenarios, since COC must be deployed instantaneously due to active shooting situations requiring immediate reactions (Greenberg, 2007).

Some COC produce highly variable flight characteristics. Forces such as drag cause yaw, and transverse forces produce oscillation (Green, 1951). Surface drag, yaw, and oscillation reduce and make variable the velocity and impact forces. For example, in the present study, the hard and soft covered books opened during flight yielding inconsistent flight velocities and variability of the surface area striking the force platform. The amount of surface area striking the force platform likely influenced peak force production. For example, items such as the 1.36 kg dumbbell and 3-hole punch produce nearly 100% to 150% differences in peak reaction force based on whether or not they impacted the force platform with a concentrated surface area along the end of its longitudinal axis.

Some of the kinetics of the COC in the present study were similar to values obtained in research assessing the kinetics of non-active shooter activities. In the present study, the 1.36 kg dumbbell produced nearly 60% of force produced by a boxing punch (Smith et al., 2000). Additionally, some of the COC used in the present study produced forces that were similar to thrown medicine balls. For example, the 1.91 kg soft covered book produced 43.56 more Newtons of force than a 0.91 kg medicine ball thrown in a bilateral overhead position (Laskowski, 2014). The 1.82 kg medicine ball COC used in the current study, produced just over 80% of the amount of force of a 3.63 kg medicine ball thrown in the unilateral chest pass position (Laskowski, 2014). The specific type of medicine ball throw, and thus throwing mechanics, influences the forces produced (Laskowski, 2014). Both individual variation in throwing mechanics, and the specific methods of throwing the medicine ball or any of the COC used in this study, will influence the results.

The COC need to have a substantial, invariable impact in a very short amount of time. Therefore, easy to deploy, small, high density, uniform surface area, and symmetrical countermeasures may display superior terminal and exterior ballistics and should be evaluated. Destruction of the COC used during testing and the potential compromise of the force platform surface create challenges during this type of research.

CONCLUSION: The present study demonstrates terminal and exterior ballistics that are highly variable with the COC used. In general, larger mass objects that may be found in a classroom or applied biomechanics laboratory, produce greater peak reaction force, but travel at lower speeds than smaller mass objects. High density small mass objects are quicker to the target. Additional studies should be conducted as an attempt to find COC that produce significant force while traveling at high velocities in order to quickly combat an active shooter.

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