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The traumatic potential of a projectile shot from a sling

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ABSTRACT

Herein, we analyze the energy parameters of stones of various weights and shapes shot from a sling and based on this data evaluate its traumatic potential. Four police officers proficient in the use of a sling participated in the trials. The following projectile types, shot using an overhead technique at a target 100 m away were: round steel balls of different sizes and weights (24 mm, 57 g; 32 mm, 135 g; 38 mm, 227 g); different shaped stones weighing 100–150 g and 150–200 g and a golf ball (47 g). Our data indicated that projectiles shot from unconventional weapons such as a sling, have serious traumatic potential for unprotected individuals and can cause blunt trauma of moderate to critical severity such as fractures of the trunk, limb, and facial skull bone, depending on the weight and shape of the projectile and the distance from the source of danger. Asymmetrically shaped projectiles weighing more than 100 g were the most dangerous. Projectiles weighing more than 100 g can cause bone fractures of the trunk and limbs at distances of up to 60 m from the target and may cause serious head injuries to an unprotected person (Abbreviated Injury Scale 4–5) at distances up to 200 m from the target. Due to the traumatic potential of projectiles shot from a sling, the police must wear full riot gear and keep at a distance of at least 60 m from the source of danger in order to avoid serious injury. Furthermore, given the potential for serious head injuries, wearing a helmet with a visor is mandatory at distances up to 200 m from the source of danger.

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1. Introduction

Interest in the damaging effects of flying projectiles (foreign objects shot from a sling or thrown by hand) on the human body has increased due to the increasing use of this unconventional weapon by offenders and participants in various types of demonstrations against the agents of law enforcement authorities. According to Israel Police data, in 2007–2008, 6477 people sustained injuries of various types in the above circumstances, 737 (11.4%) of them sustained head injuries. Law enforcement authorities face an important task—to protect police officers from the damaging effect of flying projectiles.

The traumatic potential of the unconventional weapons used by individuals opposing the police has not been sufficiently studied. This is also true with regard to evaluating the traumatic effects from projectiles shot from a sling. A number of studies have reported on the dangerous effects of a shot thrown from a sling, however, these studies have only evaluated the historical and sporting aspects of the sling [1–15]. These reports do not define the general criteria and predictors of the damaging effects of projectiles shot from a sling on protected and unprotected parts of the body. Specifically, what is missing is a definition of the potential damage that could help the police determine the level of police protection, choose adequate personal protective equipment, plan the logistics of police confrontation with crowds and assist police officers in the field avoid injury.

Herein, we attempt to analyze the energy parameters of stones of various weights and shapes shot from a sling and based on this data, evaluate its traumatic potential.

2. Material and methods

Four police officers proficient in using a sling participated in the trials. The following projectile types, shot using an overhead technique, at a target 100 m away (Fig. 1) were used: round steel

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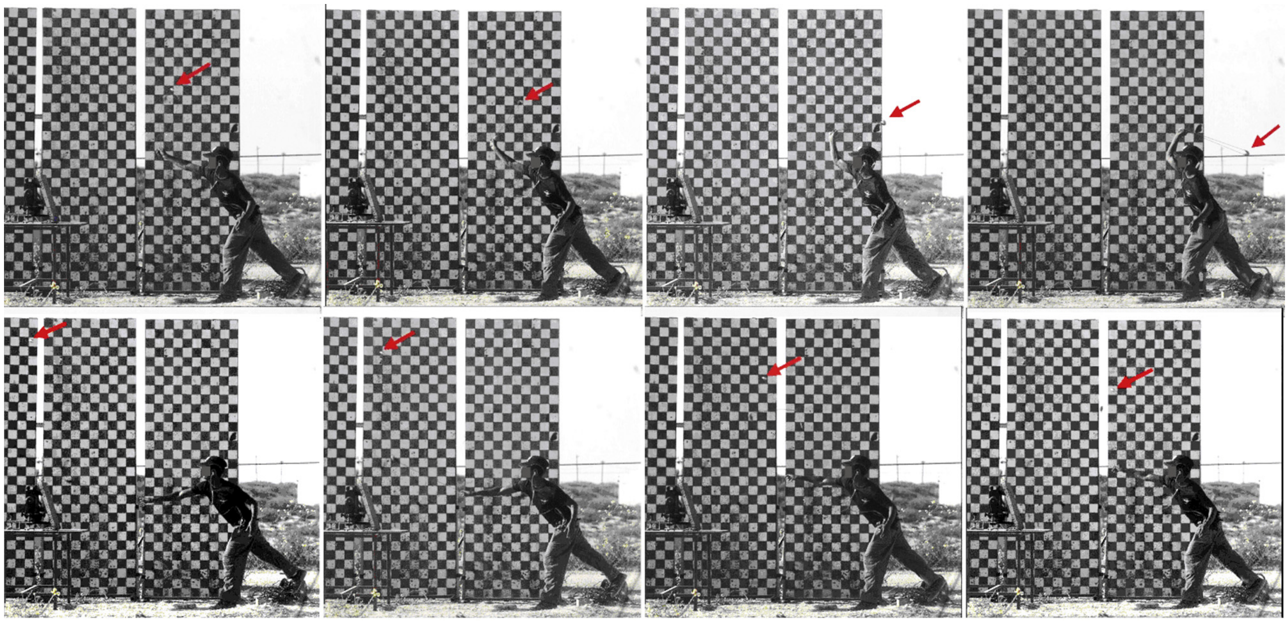

Fig. 1. Sling-shoot setup.

balls of different sizes and weights (24 mm, 57 g; 32 mm, 135 g; 38 mm, 227 g); different shaped stones weighing 100–150 g and 150–200 g and a golf ball (47 g).

All projectiles were weighed, measured and photographed. Each shot at the target was recorded, including the throwing distance and type of projectile used (steel ball/stone/golf ball). The velocity of stones and other projectiles was determined using radar (Weibel Equipment A/S, GP-80 Copenhagen, Denmark) and a high-velocity video camera (Vision-VR511 294V51CG).

2.1. Predictors of injury

The severity criteria of injuries caused by thrown stones have not been specifically studied by ballistic specialists. However, if stones are regarded as projectiles, a number of criteria used in assessing the severity of ballistic and non-ballistic trauma apply to the injuries caused by stones. Impact force is most frequently employed as a predictor of non-penetrating injuries of the human body (bone fractures and tissue damage): Peak Force = $m \times v/\Delta t$, where m = mass; v = velocity and Δt = impact time.

Furthermore, the following parameters were used as predictors of penetrating trauma: energy and specific kinetic energy: projectile energy ($E = 0.5m \times v2$ [J]) and specific kinetic energy (projectile energy density)—$SE = 0.5m \times v2/S$ [J/m2]. The blunt trauma criterion (BC) was used for blunt trauma [16,17].

2.2. Specific energy as a predictor

The specific kinetic energy of the projectile (E/impact area-J/cm^2) is widely used in evaluating the traumatic potential of lethal and less than lethal ballistic weapons as a predictor of penetration into the soft tissues of the human body [18–21]. Savran [22] demonstrated that a projectile hitting the middle of the chest with a specific kinetic energy of 6–8 J/cm^2 causes abrasions; 14–17 J/cm^2—superficial wounds; 32–36 J/cm^2—non-penetrating chest wounds with fractures of the sternum; 54–60 J/cm^2—penetrating injuries of the chest; and 134–145 J/cm^2—penetrating wounds of the chest with damage to the posterior chest wall. Later, a number of studies [23–27] that evaluated the values of the specific kinetic energy of less than lethal weapons presented the traumatic potential in terms of Abbreviated Injury Scale (AIS).

2.3. BC as a predictor

BC, designed by Sturdivan [17,22,23], is a criterion in which the severity of the injury is determined by acceleration value and impact duration and is often used for assessing the severity of blunt trauma. In our calculations of this criterion, we used the algorithm and model anthropometric parameters of the human body and head used by Sturdivan [23] and Frank et al. [28]. Borovsky & Belkin [27] applied the ($AIS = 1.33 \times BC + 0.60$) equation obtained from Bir & Viano [16] to convert BC values into AIS levels.

2.4. Statistical analysis

All results are expressed as means ± SD. The analysis included descriptive statistics, correlation analysis and one-way analysis of variance (ANOVA). Posteriori multiple comparisons of means were applied by the Tukey honest significant difference (HSD) test. The P-values indicated the post hoc significance levels for the respective pairs of means. A P-value <0.05 was considered significant. The aforementioned calculations were performed using the STATISTICA package.

3. Results and discussion

The average fluctuations of velocity and energy of the projectiles over the thrown distance are shown in Table 1. The data were limited to 60 m—the distance at which it was possible to adequately determine the velocity of the projectile over its trajectory using recording devices. It is worth mentioning that almost all the projectiles shot at the target, located 100 m away, successfully covered this distance. Several stones were found at a distance of 128 m (the distances of these projectiles were determined using a distance-measuring device).

An analysis of the data in Table 1 shows that the average muzzle velocity values ($V_{0\,m}$) of projectiles shot from a sling are comparable with the velocities demonstrated by Richardson

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