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Report on work carried to establish airsoft threshold lethality

Introduction

Test firings were conducted using two Japanese electrically operated airsoft guns, a Tokyo Marui Co. designed to look like a Heckler and Koch G3 and a Systema M4-A1 designed to look like a Colt M4A1. Both were supplied to the FSS by Fire-Support Ltd. Ballistic soap covered with a skin simulant[1] was used to assess the wounding potential of the discharged 6 millimetre diameter plastic pellets. The velocity of the pellets was varied by using different piston cylinders also supplied by Fire-Support Ltd. The velocities of the discharged pellets were measured by using a calibrated chronograph. The pellets were discharged in both semi and full auto modes; previous experience has shown that the potential wounding capacity of full-auto fire exceeds that of semi-auto fire when the pellets are targeted on a single area. The kinetic energy of each discharged pellet was then calculated using the measured velocity and mass.

Results

The below table shows values for skin penetration and perforation from the literature, theoretical calculations and known lethality velocities and associated kinetic energies for various projectiles together with the measured velocities (V) and calculated kinetic energies (KE) for the airsoft test firings. The calculated cross sectional kinetic energy density (E/A) is also given.

Source	Weight (gns)	V (fps)	KE (ftlb)	KE (J)	Diameter (mm)	E/A (J/cm^2)
Background Data: Minimum velocities for steel BBs and lead air weapon pellets						
EYE PENETRATION (Powley, pig, .17"BB)[2]	5.5	214	0.6	0.8	4.4	5.0
SKIN PERFORATION (Di Maio, human, .177awp)[3]	8.25	331	2.0	2.7	4.5	17.1
SKIN PERFORATION (Di Maio, human, .22awp)[3]	16.5	245	2.2	3.0	5.5	12.5
SKIN PERFORATION (Haag, pig, .17BB)[4]	5.24	350	1.4	1.9	4.4	12.7
Lowest known fatality *Paediatrics* 1990 (non-FSS, estimated KE, .17BB)[5]	5.24	420	2.1	2.8	4.4	18.3

6mm plastic BB: Calculated Velocity required to give E/A values as above						
Min EYE penetration velocity	3.04	392	1.0	1.4	6	5.0
Min SKIN perforation velocity	3.04	621	2.6	3.5	6	12.5

6mm plastic BB: Minimum theoretical velocity for skin perforation
using sectional density formulae from separate studies collated in *Jussila et al Forens Sci Int 150 (2005) p.65*

Sellier(1994)[6], Jauhari(1976-8)[7]	3.04	**554**	**2.1**	2.8	6	9.9
Sperrazza(1968)[8]	3.04	**661**	**2.9**	4.0	6	14.1
Mattoo(1984)[9]	3.04	**718**	**3.5**	4.7	6	16.7

6mm plastic BB: Minimum velocity for perforation of skin simulant (x10 tests)

1mm natural rubber at surface of ballistic soap; FSS NFU 9/12/10	3.04	**562**	**2.1**	2.9	6	10.2

6mm plastic BB: Full-auto burst of 6 pellets, 1 of 6 perforated
MV measurements not contemporaneous; MV figures are min, mean, max.

1mm natural rubber at surface of ballistic soap; FSS NFU 27/1/11	3.04	**410**	**1.1**	1.5	6	5.4
1mm natural rubber at surface of ballistic soap; FSS NFU 27/1/11	3.04	**418**	**1.2**	1.6	6	5.7
1mm natural rubber at surface of ballistic soap; FSS NFU 27/1/11	3.04	**424**	**1.2**	1.6	6	5.8

Colour Key		References
Minimum velocity calculated using E/A derived from Powley		Velocity Necessary for a BB to Penetrate the Eye: an Experimental Study Using Pig Eyes'; Powley, Kramer, D., Dahlstrom, Dean B., Atkins, Valerie J., and Fackler, Martin L.; Wound Ballistics Review, vol. 3, No. 1, pp. 10-12.

Colour Key		References
Minimum velocity calculated using E/A derived from Di Maio		'Minimal Velocities Necessary for Perforation of Skin by Air Pellets and Bullets"; Di Maio, V.J.M., Copeland, A.R., Besant-Matthews, P.E., Fletcher, L.A., & Jones, A.; Journal of Forensic Sciences, vol. 27, No. 4, October 1982, pp. 894-898.
Minimum velocity calculated using published formula		Sellier & Kneubuehl 'Wound Ballistics and the Scientific Background' Elsevier, 1994, ISBN 0-444--81511-2
		Sperrazza & Kokinasis, Ballistic limits of tissue and clothing, Am NY Acad Sci 152(1) 1968, 163-167
		Mattoo, Minimal velocities necessary for perforation of skin by air gun pellets and bullets, J. Forens Sci 29(3) 1984, 700-703
NFU tests: measured velocity		

Conclusions

The results clearly indicate that pellets, with a given velocity, discharged at a single area of a target, in full auto-fire, can cause greater damage than pellets discharged in semi-auto fire. This is not surprising as one is concentrating multiple impacts at the same part of the target leading to cumulative damage.

A precise determination of a lethal threshold has not been possible as the equipment used, i.e. the supplied guns were not capable of being tuned to give specific pellet velocities. Also experiments to assess eye injuries have not been carried out as part of this assessment but theoretical values have been taken into account. However given the results obtained we believe it is possible to give values for full and semi-auto fire which would be extremely unlikely to result in a fatal injury. These values are 1J for full-auto fire and 2J for semi-auto fire.

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[1] *Ballistic Skin Simulant*, Jussila et al, Forens Sci Int 150 (2005) p.65
[2] Velocity Necessary for a BB to Penetrate the Eye: an Experimental Study Using Pig Eyes'; Powley,

Kramer, D., Dahlstrom, Dean B., Atkins, Valerie J., and Fackler, Martin L.; Wound Ballistics Review, vol. 3, No. 1, pp. 10-12

[3] 'Minimal Velocities Necessary for Perforation of Skin by Air Pellets and Bullets"; Di Maio, V.J.M., Copeland, A.R., Besant-Matthews, P.E., Fletcher, L.A., & Jones, A.; Journal of Forensic Science, vol. 27, No. 4, October 1982, pp. 894-898

[4] Standard Steel BB Perforation of Fresh Pigskin Over Standard Ordnance Gelatin: L. Haag, AFTE Journal Vol 42 No1 (2010) p56-60

[5] 'Fatal Non Powder Firearm Wounds: Case Report and Review of the Literature'; H. Steven Lawrence, Pediatrics, Vol 85 No2, February 1990.

[6] Sellier & Kneubuehl 'Wound Ballistics and the Scientific Background' Elsevier, 1994, ISBN 0-444--81511-2

[7] Jahauri & Mahanta, Wound Ballistics: Study of the rupture of human skin membrane under the impact of a projectile: 8th International Meeting of International Association of Forensic Science 1978, p218

[8] Sperrazza & Kokinasis, Ballistic limits of tissue and clothing, Am NY Acad Sci 152(1) 1968, 163-167

[9] Mattoo, Minimal velocities necessary for perforation of skin by air gun pellets and bullets, Journal of Forensic Science, 29(3) 1984, 700-703