The damaging punch

J ATHA, M R YEADON, J SANDOVER, K C PARSONS

Abstract

The mechanical properties of a boxing punch have been determined using several techniques. The results are consistent with the medical consequences of boxing discussed in the report of the Board of Science and Education Working Party on boxing. Data were gathered from a world ranked British professional heavyweight, Frank Bruno, as he punched an instrumented, padded target mass suspended as a ballistic pendulum. Within 0.1 s of the start the punch had travelled 0.49 m and attained a velocity on impact of 8.9 m/s. The peak force on impact of 4096 N (0.4 ton), attained within 14 ms of contact, represents a blow to the human head of up to 6320 N (0.63 ton). The transmitted impulse generated an acceleration of 520 m/s² (53 g) in the target head. For comparison an equivalent blow would be delivered by a padded wooden mallet with a mass of 6 kg (13 lbs) if swung at 20 mph.

Introduction

The BMA report on boxing identified two main causes of structural damage to the brain attributable to boxing¹: one, the cumulated effects of sustained exposure to the sport, the other, the acute and direct result of a severe blow. In the report emphasis was placed on the importance of gathering "comprehensive, relevant medical data about all boxers and ex-boxers." This paper seeks to contribute to this database not on the medical issues as such but on the characteristics of the damaging blow that gives rise to the medical issues.

Attempts to measure the physical properties of a boxer's punch have been reported. Baagreev and Trahimovitch used a three component accelerometer in the centre of a boxing bag and a Kistler force plate fastened to the wall.² Joch, Fritsche, and Krause used an elastic walled, water filled punch bag with a built in pressure gauge.³ Unterharnscheidt attached accelerometers to the heads of two inexperienced students and monitored them as they fought.⁴

The above methods, although informative, are not without their drawbacks. Thus, for instance, an elastic walled bag does not provide a realistic time history of forces of impact on the head; a wall mounted force plate is a daunting target to punch even if gloves are worn; head mounted accelerometers trail leads, which inhibit movement, and it is unethical to hold these targets still to standardise measurement conditions; and untrained amateurs are unlikely to generate information that is relevant for the trained professional.

This study, which seeks to determine the properties of the punch of a heavyweight professional boxer, overcomes many of the above disadvantages by combining several techniques of measurement. The scope of the work is limited to one subject, the highest rated heavyweight boxer in Britain, so, although generalisations cannot be applied to the boxing population, the results are of value and will reflect the upper limits of forces to be expected from the boxing punch.

Subject and methods

The subject, a world ranked British professional heavyweight boxer, Frank Bruno, punched with maximum force an instrumented target suspended as a ballistic pendulum. After preliminary work seven punches were recorded over the course of one morning.

The target was a cylindrical metal mass of 7 kg (16 lb) (fig 1)—that is, roughly equivalent to the head and associated neck segments of a heavy-weight opponent. At its front end was attached a target plate (0.8 kg) mounted on a shaft that moved freely on lubricated bearings. The face of the

FIG 1—Instrumented target mass. Accelerometer on hanging plate, force transducer behind target plate, retroreflective prism of 3D Coda scanner, and digitising markers used in film analysis.

plate was initially padded with felt and leather to a thickness and yield approximating that of the human face. After preliminary trials, however, extra padding was added to make it acceptable to the boxer. An allowance was made for this additional padding from paired records of equivalent submaximal punches made with and without its protection.

The punches were filmed in colour with a high quality video news film or in black and white, with a 16 mm, variable shutter Bolex camera at a nominal 64 Hz and also with a Hycam rotating prism camera operating at either 400 or 1500 Hz. A millisecond timer and a fiducial system were included in the field of view to permit the timing and scaling of events. Reference points were marked on the mass and on the boxer's glove for use in digitising the filmed records. The films were analysed with a Vanguard analyser linked to a Minc minicomputer. The punch was measured from the moment the blow was committed—that is, from the moment the elbow first began to extend—until the completion of the follow through (fig 2). The coordinates of each point were digitised eight times and quintic splines fitted to produce the displacement, velocity, and acceleration time histories of fist and mass.

Additional measurements were also taken. With a 3D Coda scanner the real time cartesian coordinates of the fist and target mass were monitored throughout selected punches. A piezoresistive accelerometer was enclosed within the boxer's fist and positioned to record accelerations normal to the impact surface of his knuckles. A piezoelectric accelerometer continuously recorded the accelerations of the target. A piezoelectric force transducer, sandwiched between the target plate and the central mass, monitored the forces of contact. All leads from the fist and target transducers were carried to appropriate amplifiers and to S E Laboratories (Engineering) Ltd ultraviolet light recorder and Racal frequency modulated tape recorder.

The films and other records when developed were examined to select for analysis only punches when the delivery was in line with the longitudinal axis of the target mass, when the point of contact was central, when the mass was displaced without undue rotational energy, and for which all records were intact. These criteria were met best by the third punch, and this punch was analysed in detail.

Department of Human Sciences, University of Technology, Loughborough, Leicestershire LE11 3TU

J ATHA, MA, PHD, senior lecturer
M R YEADON, MA, PHD, research student
J SANDOVER, BSC, PHD, lecturer
K C PARSONS, BSC, PHD, lecturer

Correspondence to: Dr Atha.