DIFFERENCES IN LEAD AND REAR HAND PUNCHING FORCES, DELIVERED AT MAXIMAL SPEED RELATIVE TO MAXIMAL FORCE, BY AMATEUR BOXERS

Rosemary Dyson, Marcus Smith, Lisa Fenn and Christopher Martin
University College Chichester, Chichester, West Sussex. PO19 6PE. UK

Six male competitive amateur boxers (mean ± SD age: 24.6 ± 3.3 years; height 1.82 ± 0.05 m; mass: 73.3 ± 19.0 kg) participated. Straight lead and rear hand punches at maximal speed or force were thrown in turn to the head and body of a calibrated boxing dynamometer designed with the sport-specific requirements in mind (Smith et al. 2000). Punches were thrown either singularly or in two/three punch combinations in a prescribed sequence from an audio cue. Punching force for the maximal speed punches with the lead hand to the head and body were significantly lower ($p < 0.001$) compared to the rear hand (Head: lead 2082 ± 62 N vs rear 2623 ± 100 N; Body: lead 1869 ± 42 N vs rear 2359 ± 67 N). Rear and lead hand punches delivered for maximum force were greater.

KEY WORDS: boxing, force, impact, punch, speed

INTRODUCTION: Successful amateur boxing performance is characterised by an ability to deliver scoring punches at different speeds and of varying degrees of force. Boxing punching forces reported in the literature refer to measurements of maximal force in a straight punch (Atha et al. 1985; Joch et al. 1981). The change in amateur boxing from an "impression" to a "computer" scoring sport in 1989 caused greater emphasis during training to be placed on the development of punching force in the straight rear hand (Smith,1998). However, performance in boxing is also dependent on the speed at which a punch can be delivered. Punch forces thrown when there is an emphasis on maximum speed are likely to be different to those thrown for maximum force. Also, there may be changes in the force production by the rear and lead hands to the head target, compared to the body.

Measurement of the force of impact in human contact sports is a complex issue due to the need to ensure that participants do not moderate their striking force to ameliorate potential injury. The design of any measurement device must therefore be sport specific (Davids, 1988) in that it allows normal body movements to occur and must also have a surface interface which is representative of the usual kinaesthetic perception at impact.

Punch force measurements based upon punch bag dynamometers utilising water displacement have been used by Fritsche (1978) and Joch (1981). However the kinaesthetic perception at impact when water is struck is quite different to human body parts. Karpilowski (1984) also highlighted the inherent weaknesses and difficulties of using such systems in boxing with the inherent need for control, stabilisation, containment and degassing of large quantities of water. Bäagrev and Trachimovich (1981) and Broker and Crowley (2002) utilised an accelerometer within a punch bag, but such systems do not allow accurate force measurement due to the compliance of the punch bag as well as the inertia and movement of the bag during impact. In a dynamic repeated effort sport such as boxing the bag movement is a particular concern in relation to striking force measurement. Measurement of the boxing punch force of a heavyweight boxer has been reported by Atha et al. (1985) from a study of single strikes of a relatively small padded ballistic pendulum device. More dynamic indications of boxing activity and impacts were reported by Karpilowski et al (1994) from a static uniaxial strain gauge based system. Smith et al. (2000) reported on the calibration and discrimination efficacy of a triaxial sport-specific boxing dynamometer.

The aims of this study were to measure the punch force profiles of straight punches delivered with the lead and rear hand, to head and body target areas, using maximal speed or force.

METHODS: Six male competitive amateur boxers (mean ± SD age: 24.6 ± 3.3 years; height 1.82 ± 0.05m; mass: 73.3 ± 19.0 kg) gave their informed consent before participating in the study. Subjects wore 0.284 kg Top Ten competition gloves over their normal hand bandages, and adopted a lead left hand and rear right hand boxing style. The height of the boxing dynamometer manikin was matched to each subject's shoulder height from the floor. A 20 minute self-selected warm-up comprising stretching, jogging and striking hand held coaching pads was performed. All subjects were habituated to punching the boxing dynamometer. Following this each subject was given 30 seconds to throw straight lead and rear hand punches at maximal speed or force in turn to the head and body of a calibrated boxing dynamometer. Punches were thrown either singularly or in two/three punch combinations in a prescribed sequence from an audio cue (Akai, AJ-W248). The Kistler triaxial force data were sampled at 330 Hz and recorded using punch data acquisition software specified to run within Provec 5.0 software (Orthodata Ltd, Ludenscheid, Germany). Typically 19-20 punches were thrown by each hand during a punch sequence. For each subject, six punches were chosen from the middle phase of the punch sequence to determine the mean peak total triaxial punch force. Systematically punches at the beginning and end of the punching task were excluded from the statistical analysis because preliminary inspection of the data indicated that these punches were initially atypical, or subsequently affected by fatigue. Two-way analysis of variance was used to analyse the data. Differences between punches delivered by the rear and lead hands were located by a post-hoc Scheffe test at the $p < 0.05$ level.

RESULTS: The highest force values were recorded for the straight rear hand punch to the head as shown in Table 1. Practically this gives confirmation of a main coaching objective, which is to create a forceful rear hand strike.

Table 1 Mean ± SE peak total punching forces (N) recorded during delivery of straight punches (n = 36) at either maximal speed or maximum force to the head and body and the lead to rear hand ratio percentage.

	Head			Body		
	Rear	Lead	Ratio	Rear	Lead	Ratio
Speed	2623 ± 100	2082 ± 62	79%	2359 ± 67	1869 ± 42	79%
Force	4236 ± 181	2722 ± 75	64%	3465 ± 77	2471 ± 47	71%

When the aim was to deliver at maximum speed, rear hand straight punches to the head and body were greater than lead hand forces (Head: $p < 0.001$; Body: $p < 0.001$) as indicated in Table 1. At maximum speed, for both the rear and lead hands the forces impacting on the head were greater than those on the body (Rear: $p < 0.002$; lead $p < 0.001$). Interestingly the lead to rear hand ratio percentage was the same when punches were thrown to the head or body. This similarity, during a maximal speed response, in the lead to rear hand ratio to the head and body may indicate an optimal ratio arising from coaching methods and boxing technique.

When punches were delivered with maximal force the mean measured rear hand punch force was greater than the mean lead hand punch force ($p < 0.001$). For both the rear and lead hands, straight measured mean maximal forces were higher when delivered to the head in comparison to the body ($p < 0.001$). Lead to rear hand ratios indicated the higher efficacy of the rear hand strike in delivery of a forceful punch.

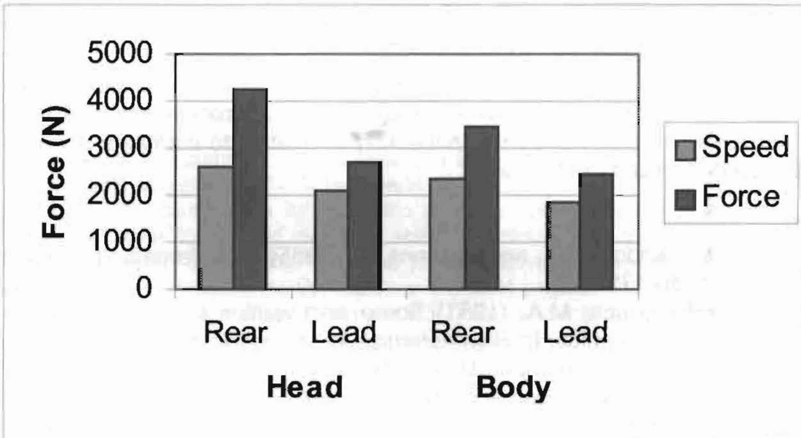

Figure 1 Comparison of mean peak lead and rear hand punches delivered to the head and body with the aim of delivery at either maximal speed or maximal force.

Consideration of Figure 1 confirmed that the mean peak forces recorded when punches were delivered with the aim of achieving a maximum speed of delivery were always less than those delivered with the aim of delivering a maximum force. It is also evident that punches delivered by the rear hand to the head were greatest whether delivery was for maximal speed or maximal force. Notably the rear hand punch force to the body appeared to be relatively considerably less when delivered for maximal speed.

DISCUSSION: A significant difference in punch force profile was evident when comparing punches thrown with maximal speed versus force, lead versus rear hand and head versus body target area. The maximum rear hand punching force to the head for this group of intermediate boxers was 4236 ± 181N on a calibrated system. This is lower than the 6320N reported by Atha et al (1985) for a heavyweight professional boxer delivering a punch in a non-sport specific situation but higher than the 2697 N reported for a Polish heavyweight amateur boxer (Karpilowski et al. 1994). Reported differences in peak punching force may be related to body mass, punching technique, physical conditioning or method of data acquisition. Karpilowski et al. (1994) also reported a range of punching force (295-1456 N) for a light-flyweight (48kg) amateur boxer varying speed and force. However, it is unclear whether the data relates to punches thrown at the head, body or both target areas. Punch force profiles for heavier boxers have not been reported. In this study the comparison of maximal speed versus force punch data showed lead hand punches thrown at the head or body with maximum speed contained 76% of the mean total force measured compared to punches thrown for maximum force. For the rear hand mean total forces were lower when delivered with maximum speed (Head: 62%; Body: 68%) than when delivered for maximum force. This latter result indicated that the largest reduction and moderation of punch force, arising from the need to maximize speed of response, occurred in the rear hand punch to the head. Despite this, the mean rear hand straight punch to the head was still 11% greater than the rear hand punch thrown to the body. The mechanics of punching is a critical component of generating speed or force (Hickey, 1980). Future studies using kinematic analysis could provide a valuable insight into the physiological and biomechanical differences associated with punch force profiles of maximum speed and force punches.

CONCLUSION: The highest mean force recorded was for the straight rear punch to the head (4236 ± 181 N). Important differences in mean punching force were observed between punch type (maximal speed versus force, lead hand versus rear and head *versus* body target area).

The existence of computer scoring in International amateur boxing, where the force of the punch is critical, demands that coaches and boxers become increasingly knowledgeable about the different punch force profiles associated with different types of punch. Whether a scoring punch is recorded due to a surprise lead hand speed punch to the head (2082 ± 62 N) or a maximum force rear hand to the head (4236 ± 181N) is not a major concern. From a tactical perspective it is important for the boxer and coach to appreciate the different ranges of force generated between types of punch, especially in relation to computer scoring where the force of a punch is a discriminating factor.

REFERENCES:

Atha, J., Yeadon, M.R., Sandover, J., and Parsons, K. (1985). The damaging punch. *British Medical Journal*, 291, 1756-1757.

Baagrev, V.V. and Trahimovitch, M.A. (1981) Some peculiarities in the measurement of dynamic pressures in biomechanics. In *Biomechanics VII-A* (edited by Morecki, A., Fidelius, K., Kdzior, K., Wit, A.). pp 511-3.Baltimore: University Park Press.

Broker, J.P.and Crawley, J.D. Advanced sport technologies:Enhancing Olympic performance. In Biomechanics XIX (edited by Blackwell, J.R.) pp 323-327.University of San Francisco.

Davids, K. (1988). Ecological validity in understanding sports performance. Some problems and definitions. Quest. 40, 126-136.

Hickey, K (1980). Boxing - The amateur boxing association coaching manual. London: Kaye and Ward.

Fritsche, P. (1978). Ein dynamographisches informationssystem zur messung der schlagkraft beim boxen. *Leistungssport*, 2, 151-156.

Joch, W., Fritsche, P., and Krause, I. (1981). Biomechanical analysis of boxing. In *Biomechanics VII-A*. (edited by Morecki, A., Fidelius, K., Kdzior, K., and Wit, A.) pp 343-9.Baltimore: University Park Press.

Karpilowski, B. (1984) Dynamometric boxing bag. *Biology of Sport*, 1, 171-176.

Karpilowski, B.M., Nosarzewski, Z., and Staniak, Z. (1994). A versatile boxing simulator. *Biology of Sport*, 11, 133-139.

Smith, M. S. (1998). Sport Specific ergometry and the physiological demands of amateur boxing. PhD Thesis, Southampton University.

Smith, M.S., Dyson, R.J., Hale, T. and Janaway, L. (2000). Development of a boxing dynamometer and its punch force discrimination efficacy. *Journal of Sports Science*, 18, 445-450.