X-FACTORS IN STRAIGHT PUNCHES

Rat Tong-lam and Chaipat Lawsirirat
Faculty of Sports Science, Chulalongkorn University, Bangkok, Thailand

Straight punches are proven to be one of the most effective punches in boxing especially when boxers aim for far-reaching targets. Powerful straight punches require boxers to produce a series of force transfers from lower limbs to fists. Mechanically, the forces created from the lower limbs are approximately perpendicular to the forces created by fists. Hence, the forces from fists may not be derived from forces created from lower limbs as traditionally believed. This paper attempted to find the kinetic link of force transfer from lower limbs to fists. Three elite boxers were recruited in this study. Six high speed camera and two force platforms were used to collect data and 3D analysis was performed. The results showed that an X-factor contributed to the acceleration of straight punches resulted in the force of a straight punch.

KEYWORDS: boxing, straight punches, X-factor, kinematic analysis, velocity, acceleration

INTRODUCTION: Powerful straight punches create advantage to boxers or even knock their opponents out and win a match. Straight punches are usually used for far-reaching target aiming at head or body of opponents (AIBA Coaches Commission, 2010). Ashker (2011) showed that winning boxers threw more straight punches than losing boxers in rounds 1 and 3. In general, throwing straight punches starts from the favorite leg (right leg for the right-handed and left leg for the left handed) before moving to upper limb and end in fists (Hicky, 2004 and Dyson, et al.,

Figure 1: Force vectors of ground reaction force and punching force.

2006). However, when we consider Figure 1, we can see that punching force and ground reaction force (GRF) from the favorite leg are not in the same direction. In fact, they are almost perpendicular to one another. As a result, these two forces are independent from one another, and ground reaction force may not transfer to fists as a punching force as expected. This hypothesis is supported by Hall (2011) and McGinnis (2013) when they showed that the force from the behind leg slightly contributed to the punching force. Thus, there should be other factor that helps transferring forces from the behind leg to the punching force. In this paper, we attempt to explain how ground reaction force interacts with the punching force via X-factor (relative hip-shoulder rotation) of boxers.

METHODS: Three Thai amateur boxers whose ranks were in 1-30 from AIBA, WBA, WBC or WBO were recruited in the study. The boxers were between 22-24 years old. Six high speed cameras (300 fps, Qualisys Oqus 7, Qualisys AB, Sweden) and two force platforms (1500 Hz, Kistler 9286BA, Kistler Group, Switzerland) were used in this study. The participants were asked to stepping on two force platforms and then threw ten straight punches to a 0.5-kg punching ball while their feet were on the two force platforms. Thirty-five markers were placed over the whole body of the participants. Before throwing straight punches, the participants were asked to do their general warm-up. After warm-up, the participants threw 10 straight punches with 30 second resting between punches. Ground reaction forces for both legs were recorded as well as displacement, velocity and acceleration of ankle, knee, hip, shoulder, elbow, and fist, and the acceleration of the punching ball. The punching force was calculated using the second law of Newton from the acceleration of the punching ball. In addition, the X-factor and its angular velocity were calculated from the shoulder and hip lines projected to transverse plane also collected. After obtaining the data, we selected the punch which provided the maximum punching force per body weight of each participant to report and discuss.

RESULTS AND DISCUSSIONS: The three participants yielded the same pattern in throwing a straight punch which can be divided into three phrases as shown in Figure 2. The first phase started from the starting position when two feet were put firmly. The participants placed their weight in the leading leg as seen by ground reaction force in Figure 2a before the participants shifted their weight to the behind leg. The first phase ended when the body weight was totally shifted to the behind leg (Figure 2b). At this point, the leading leg acted as a pivot point where it bore no weight. At the second phase, the participants started moving forward. The participant shifted their weight from the behind leg to the leading leg (Figure 2c). The second phase ended when the participant's leading leg began to bear weight. Lastly, the third phase started from when the leading leg began bearing weight until the impact of straight punch. At this phase, only the leading leg exerted the force. The behind leg bore no force (Figure 2d). Moreover, the leading leg acted similar to the break because the direction of ground reaction force was not in parallel with the punching force. On average, the participants spent 36% of their straight punching time in the first phase, and 67% in the last two phases.

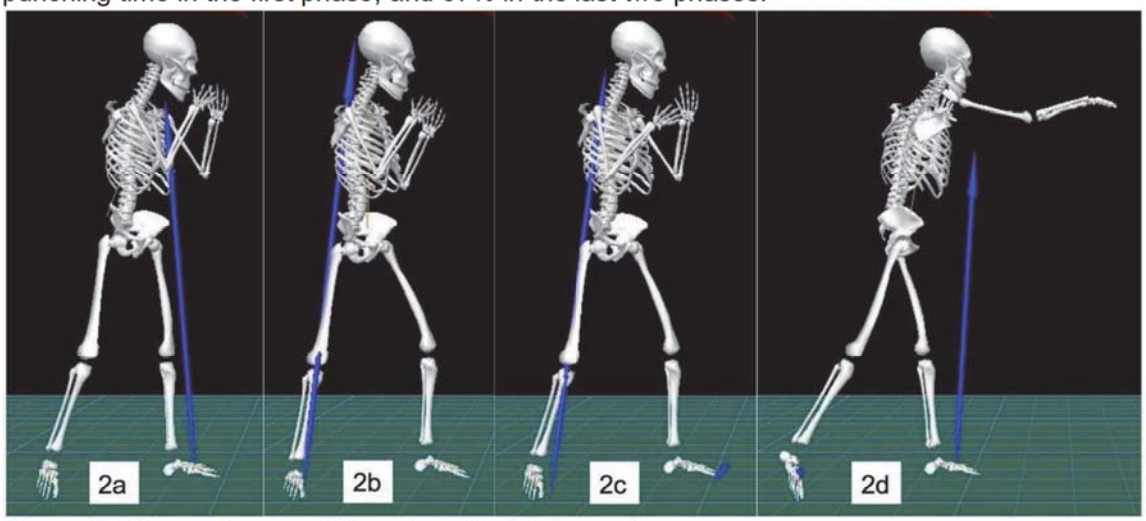

Figure 2: Three phases of throwing straight punches

Table 1 reports the X-factor angle and its angular velocity and the acceleration of the punching force. It can be seen clearly from Table 1 that Participant B2 had the highest punching force because the acceleration of the punching ball was highest. For Participant B2, his X-factor was

wider than the other two participants which may lead to higher punching force. Because X-factor determines how wide a hip needs to travel, the wider the angle results in longer distance in throwing straight punch as a result it helps create higher punching force.

Table 1
The kinematics of X-factors and punching ball

	X-factor Kinematics		Punching Ball	
	Angle (deg)	ω (deg/s)	a (ms^{-2})	a/BW (ms^{-2}/kg)
B1	39.21	592.83	263.36	4.54
B2	53.53	506.46	321.00	4.90
B3	41.37	612.21	209.59	3.61

Table 1 poses an interesting question when the highest angular velocity of straight punch did not create the maximum punching force. We hypothesized that because the highest angular velocity did not occur at the impact point, it did not create the maximum punching force. However, a more careful investigation is required to answer this question.

CONCLUSIONS: Throwing straight punches poses a theoretical dilemma when coaches suggest that powerful straight punches start from the legs. In principle, the ground reaction force is perpendicular to the punching force resulting in tiny contribution or no contribution from ground reaction force to punching force. This paper shows that an X-factor is one explanation to bridge the gap in this theoretical dilemma where the wider an X-factor yields the higher punching force. Equipped with this finding, boxers should exercise to wider their X-factor

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