MECHANICAL AND ELECTROMYOGRAPHICAL ANALYSIS OF A BOXER'S JAB

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INTRODUCTION

Boxing performance is dependent upon several variables. These variables can include muscular strength, muscular endurance, speed, power, quickness, skill, knowledge, and "instinct". Studies have shown that weight training greatly enhances boxing performance (Cordes, 1991; Dengel et al., 1987; Filimonov et al., 1983; Fitzmaurice, 1982; Solovey, 1983), but none have compared which exercises specifically recruit similar muscular patterns. It would, therefore, seem beneficial to be able to prescribe weight training activities that were proven successful in eliciting "jab-like" muscularresponses. Boxing trainers, as a whole, believe that weight training makes for bulkier, slower fighters (Cordes, 1991; Fitzmaurice, 1982; Landis, 1984). Although previous studies have shown increased speed and force as aresult of weight training (Cordes, 1991; Dengel et al., 1987; Filimonov et al., 1983; Fitzmaurice, 1982; Solovey, 1983), many trainers still remain unconvinced.

There is limited research available that discusses the kinematic and/or electromyographical (EMG) analysis of a boxer's jab. It has been stated that the jab consists of three primary movements. These movements have been identified as, 1) leg extension, 2) trunk rotation, and 3) arm action (Cordes, 1991; Filimonov et al., 1985; Solovey, 1983). Filimonov et al. (1985) proved a definite difference in force production between different categories of boxers. Class 11 and Class 111 (amateur) boxers produced the majority of the punching force in trunk rotation, approximately 45.50%, followed by arm action at 37.99%, and leg extension at approximately 16.51%. Forces produced by Masters of the Sport (professional) were; leg extension (38.46%), trunk rotation (37.42%), followed by the arm action with only 24.12% of the total (Filimonov, 1985). In theory, as a boxer becomes more skilled in the profession, the muscular recruitment becomes more efficient.

Solovey (1983) incorporated the use of medicine balls and dumbbells during sport specific movements and found that over a six month training period, "speed (total time, time of the latent period and fist movement time) of single hits of both arms increased significantly, even after three months"

(p. 100). The investigator added that not only does weight training increase the speed of the punching movements, but also the boxer's speed capabilities to initiate a combination of punches (Solovey, 1983). In a U.S. Olympic Boxing Team study, 24 members of the squad were placed on a two-week intensive weight and interval run training program. Punching velocities increased as high as 32% as a result (Dengel et al., 1987). Getke and Digtyarev (1989) tested the effects of strength training on different categories of boxers and on different ages of boxers. The results suggested that the most effective way to increase total explosive strength, force output occurring at relatively high velocities, was to increase total maximal strength. The researchers stated that the most effective means for increasing maximal strength during the early stages of development was through the use of repetitive exercises. But, for increases in maximal strength during the later stages of development, submaximal and maximal workloads must be implemented (Getke & Digtyarev, 1989). In an effort to study explosive muscular power using free weights, Lyttle, Wilson, and Ostrowski (1996) found that using loads of thirty percent of one repetition maximum (30% 1RM) correlated highly with traditional explosive power tests.

The purpose of this investigation was to study the kinematic and electromyographical elements present while executing the jab and specific weight training exercises. Additionally, to determine if differences exist between professional (PRO) and amateur (AMT) boxers during the recruitment of both the upper and lower musculature. And, to determine the validity of a popular punch ergometer, the TKO punching bag (TKO).

METHODS

Four PRO and five AMT male boxers (ages: 24.20+1.02 yrs; weight: 81.7 + 8.13 kg; body fat: 11.99 + 2.60%) volunteered to participate in the study. All subjects jabbed (JAB) with their left hand except one. Markers were placed on the fifth metatarsal, ankle, knee, hip, shoulder, elbow, and wrist joints to aid in the digitizing process. Preamplified surface electrodes were placed on the gastrocnemius (GA), biceps femoris (BF), rectus femoris (RF), external oblique (EO), serratus anterior (SA), pectoralis major-sternal (PEC), anterior deltoid (AD), and triceps brachii (TRI). JAB's were recorded using a Panasonic AG-500 video camera operating at 60 Hz, located 400 cm from the subject, perpendicular to the line of action, Three maximal JAB's were performed per subject. Each JAB's force value, based on the TKO digital read-out, was recorded. One repetition maximums (1RM) of the leg press (LEGP), leg extension (LEGX), standing heel raise (HEEL), bench press (BPR), tricep dip (DIP), and dumbbell front lateral raise (FRLT) was obtained on the first day of testing. An incline twisting crunch (INCR) was also tested for trunk rotation. Thirty percent 1RM was used during the EMG testing of the subjects. Data collection was recorded over a three-second time period in which the subject was instructed to perform as many controlled lifts as possible during that time. Rest periods of at least three minutes were allowed between each trial. EMG data and kinematic data were collected and analyzed using the Ariel Performance Analysis System (APAS). After digitizing each JAB per subject, the JAB with the greatest velocity (VEL) about the wrist (WR) was used for further analysis. Two-tailed t-Tests were conducted to observe differences that existed between PRO and AMT. A significance level of $p<0.05$ was assigned to the study. Linear VEL about the WR, elbow (EL), shoulder (SH), and center of gravity (COG) were studied. The trial with the greatest VEL about the WR was used for analysis. The TKO was tested by dropping four known weights,' from a specified distance, onto the TKO which was suspended horizontally above the floor. Ten trials at each weight (1.14 kg, 2.27 kg, 4.55 kg, and 11.36 kg) were recorded.

RESULTS

Significant differences were observed between PRO and AMT in both one and two-tailed tests for WR VEL and one-tailed tests for EL VEL. VEL about the WR, EL, SH, and COG are summarized in Table 1. These results place some confidence into the theory that PRO JAB have a greater WR VEL than do AMT. No significant differences ($p<0.05$) were found in VEL about the SH and COG, nor in the two-tailed tests about the EL. No significant differences were found between PRO and AMT in t-Tests for EMG activity at each muscle. Full rectified, root mean square EMG values during 30% 1RM and maximum WR VEL during the JAB were compared. A strong correlation ($r=0.72$) existed between the HEEL and JAB, at the GA. At $p<0.10$ ($r=0.58$) a strong correlation ($r=0.61$) existed between the BPR and JAB, at the PEC. The study found no strong correlations between the DIP and JAB ($r=0.51$) at the TRI, LEGX and JAB ($r=0.40$) at the RF, INCR and JAB ($r=0.52$) at the EO, FRLT and JAB ($r=0.35$) at the AD, nor the BPR and JAB ($r=0.42$) at the SA.

Average force (F) value from the TKO of each subject to the full rectified, root mean squared EMG value during the JAB is shown in Table 2. Correlation coefficient of ($r=0.66$) revealed a good relationship between TKO force output and muscular activity. TKO validity was tested using regression line analysis. Figure 1 displays a linear path until an F of 4.47 is reached (the TKO will display values ranging from 1.1 to 9.9, with 9.9 being the highest possible F output). Based on this information, reliability of the TKO is questionable at F values exceeding 4.47.

Table 1.
T-Test: Two-Sample Assuming Unequal Variances

VEL		PRO	AMT
WR			
	Mean	4.292	3.440
	df	7	
	t	2.476	
	one-tail	1.895	
	two-tail	2.365	
EL			
	Mean	3.770	3.062
	df	6	
	t	2.110	
	one-tail	1.943	
	two-tail	2.447	
SH			
	Mean	1.850	1.496
	df	5	
	t	1.876	
	one-tail	2.015	
	two-tail	2.571	
COG			
	Mean	0.638	0.594
	df	4	
	t	1.170	
	one-tail	2.132	
	two-tail	2.777	

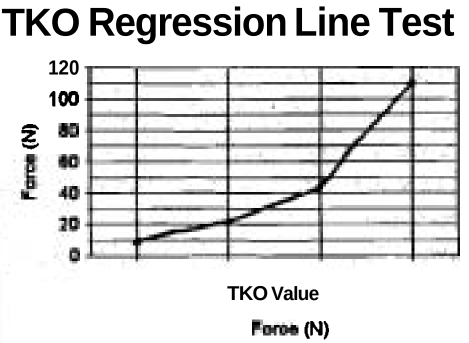
DISCUSSION

This study compared the JAB to seven resistance exercises; LEGP, LEGX, HEEL, BPR, DIP, FRLT, and INCR. Fitzmaurice (1982) suggested incorporating DIP and BPR into a boxer's training. This study found a weak correlation ($p<0.05$) at both the TRI and the PEC when comparing the JAB to the DIP and BPR. Filimonov et al. (1985) reported that the greatest production of F from the JAB was delivered by the extension of the back leg. The present study validated Filimonov et al. by showing that confidence ($p<0.05$) can only be placed in the use of the HEEL as a possible means for increasing the effectiveness of the JAB. Filimonov et al. (1985) also stated that muscular recruitment, as a percentage of a whole body movement, was more efficient as an amateur evolved into the professional ranks. The current study found no significant difference between PRO and AMT during the JAB at each specific muscle. T-tests did, however, show significant differences in F output, WR VEL, and EL VEL between PRO and AMT. Increased neuromuscular adaptations to training (Cordes, 1991) may explain why PRO achieve greater VEL about the WR and EL than do AMT. Neuromuscular adaptations may also explain why F output was greater for PRO than AMT.

Table 2.
EMG per muscle site relative to average TKO value per JAB

			EMG					
F	**GA**	BF	RF	EO	**SA**	PEC	**AD**	TRI
4.90	2.22	3.73	2.58	1.81	1.27	1.70	1.54	1.87
4.50	2.98	5.40	2.27	4.41	1.50	2.77	3.34	3.53
3.90	1.79	2.21	3.59	1.16	1.92	1.59	4.43	2.45
4.70	1.77	2.50	2.98	2.91	2.83	4.98	2.46	1.98
4.30	2.08	5.78	5.56	3.22	1.48	3.10	3.52	1.77
3.20	2.46	3.28	2.09	1.80	3.44	1.40	1.98	2.14
3.70	1.98	2.32	2.74	1.63	1.98	1.57	2.51	1.85
3.20	2.97	2.10	1.37	1.28	1.43	1.71	2.59	2.02
3.20	2.71	2.62	2.70	1.43	2.15	1.66	4.00	1.96

				r-value					
	F	**GA**	BF	RF	EO	**SA**	PEC	AD	TRI
F	1.00								
GA	-0.38	1.00							
BF	0.47	0.19	1.00						
RF	0.35	-0.57	0.49	1.00					
EO	0.59	0.16	0.80	0.27	1.00				
SA	-0.33	-0.24	-0.33	-0.17	-0.13	1.00			
PEC	0.60	-0.32	0.25	0.33	0.64	0.15	1.00		
AD	-0.20	-0.02	0.06	0.43	0.03	-0.19	-0.01	1.00	
TRI	0.18	0.44	0.37	-0.25	0.58	-0.13	0	0.29	1.00



y=a+bx (where a=1.446, b=0.04612)

TKO	Force (N)
1.5	11.18
2.28	22.27
4.47	44.64
6.41	111.44

Figure 1. TKO Regression Line Test

CONCLUSIONS

In conclusion, the present findings suggest that of the seven resistance exercises tested, only the HEEL may benefit the boxer. Some confidence ($p<0.10$) may be placed in the use of the BPR as a means of increasing a boxer's jab. Significant differences existed between the PRO and AMT boxers within this study in regards to linear VEL about the WR and EL, and also F output. Little confidence can be placed on the F values of the TKO above 4.47. Limitations to the study were its limited sample size, the JAB with the greatest WR VEL may not have been appropriate for analysis, using 30% 1RM as the weight training protocol needs further validation, collecting data on three 30% 1RM trials would have increased the sample size, the training method employed was to lunge forward with the lead leg and not to initiate the JAB with the back leg, and also Technical Knock Out, Inc. unwillingness to disclose any data pertaining to its products validity. The results of this investigation warrant further studies on the training protocols specific to boxing.

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