USING AUTOMATED STEP WISE LINEAR REGRESSION TO PREDICT RIGHT HANDED PUNCH PEAK IMPACT FORCE USING SELECT FORCE AND VELOCITY CHARACTERISTICS

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INTRODUCTION. The main objective of boxing is to knock out your opponent or render them unable to stand back up within 10 seconds (KO). To knock an opponent out requires the transfer of energy from the lower to the upper extremities, through the arm, to the fist, and ultimately to the opponent's head or body. (Fuchs, Lindinger, Schwameder., 2018, Guidetti, Musluini, Baldari., 2002, Loturco, Artioli, Kobal, Gil and Franchini., 2014, Lenetsky, Harris, and Brughelli., 2013, Nakano, Lino, Imura, and Kojima., 2014). While punching does involve the movement of the arms to deliver the punch, the ability to incorporate the lower body in skilled performance allows for a more powerful punch (Turner, Baker, and Stuart, 2011, Piorkowski, Lees, and Barton., 2011). By incorporating the lower extremities into a punch prior to the upper extremities, greater power and fist velocity will be produced leading to a higher peak impact forces at contact (Loturco et al., 2014, Turner et al., 2011., Piorkowski et al., 2011) Historically, athletes and their trainers have performed high amounts of aerobic based exercise such as; running or jump rope (Guidetti et al., 2002). However, in recent years, athletes and trainers have looked for more sport specific exercises with the aim of focusing upon improving punch power and resultant impact force that could potentially cross over to in-ring performance (Loturco, Bishop, Ramirez-Campillo, Romano, Alves, Pereira, and McGuigan., 2018,, Lenetsky et al 2013, and Turner et al 2011). There is still some debate over the optimal resistance training approach for boxers. For decades, athletes have used light load resistance (30-50% of 1RM) coupled with moderate to high velocity to improve punching power and dynamic rates of force development (DRFD). However, this type of training is typically performed utilizing higher repetitions which (15+) primarily targets Type 1 fibers and the oxidative qualities of type 2a fibers at the expense of maximizing peak power production (Guidetti et al 2002., Loturco et al 2018, Grgic, and Schoenfeld., 2018). Such training yields minor type 2 fiber hypertrophy and increases in maximal strength compared to strength training with heavy loads (De Oliveria, Rizatto, and Denadi., 2013, Grgic et al., 2018). Therefore, to increase punch power and resultant impact force, Type 2x and 2a fibers need to be targeted more specifically with greater relative loads performed using "maximal movement intent" to maximize the force/velocity and lean mass through planned hypertrophy (De Oliveria et al., 2013, Grgic et al., 2018). Therefore, the purpose of this study was to build upon previous work by these authors (Woodford et al, 2019 in review) using Automated Stepwise Linear Regression to highlight the strongest group of force/velocity variable predictors of peak impact force during three right hand punches (jab, rear punch, and rear hook) taken from sport specific resistance exercises 1RM's, and maximal unloaded and loaded jumps.

METHODS: A total of 30 college students (21 males and 9 females; 21.75 years ± 2.52 y, 176.29 ± 11.75cm, 89.39 ± 22.63kg) signed informed consent approved by Coastal Carolina University IRB prior to participating in the study. Two testing sessions were performed on nonconsecutive days within a 5-day period, with each session lasting up to 85 minutes. Day 1 included measurements of height and weight, select segmental girths, punching, and countermovement jump (CMJ) testing. Day 2 consisted of sport specific resistance exercises including; 15° incline bench press lockout (15BPL), unilateral split stance dumbbell push press (SSPS), and unilateral concentric start partial lunch (CSPL). To record Fmax, Pmax, and Vmax a Myotest Pro (Sion, Switzerland) tri-axial accelerometer was used in trainer mode sampling at 500Hz during 1RM testing. The Myotest Pro was placed on the left side of the bar during 15BPL and CSPL testing to minimize disruption to hand placement. The MyoTest Pro was manually started and stopped by the same researcher at the completion of the exercise. For the Countermovement jumps, body weight, a 10 kg bar (CMJ10), and 20 kg (CMJ20) where used in conjunction with a Bar Sensei (Oranchuk, Switaj, Robinson., 2016) (fixed on the right side of the bar) accelerometer to measure Vmax at takeoff. Maximal peak power was later calculated using jump height (JH) from the Bar Sensei Vmax using the calculation: CMJ JH = $Vmax^2/2g$, where Vmax is CMJ takeoff velocity (m/s) and g is the gravity constant ($9.81 m/s^2$). The resultant JH was then used to estimate the Pmax using the Sayers equation (Sayers, Harman, Frykman, Rosenstein., 1999). The three punching styles were right-hand jab (Rjab), right rear punch (RrPunch), and right rear hook (RrHook). Their respective Pmax, Fmax, and Vmax were recorded via MyoTest Pro, secured in line with the application of force to a 113.5kg Rival Banana punching bag using duct tape. Fmax was recorded over 4 maximal trials with the best two averaged for data analysis. Participants wore Fighting Sport S2 Pro gel under gloves (2.5 oz.) and Rival boxing gloves (10 oz.). The same researcher provided instructions on how to "punch as hard as possible through the target." Right-handed punch styles were used for analysis as most participants self-reported to be right-handed (83%; n=25). Using previously reported force/velocity data (Woodford et al., 2019 in review) from Counter Movement Vertical Jumps (CMJ) and sport specific resistance exercises, an Automated Stepwise Linear Regression was performed to highlight the strongest groupings of predictors of peak impact force for three different punch conditions. Significance for individual variable's entering the model was set at a priori at $p \leq 0.05$.

RESULTS. Automated Stepwise Linear Regression produced best predictor grouping R^2 values ranging from 0.103 – 0.732 for Right Jab (RJab); see table 1, Right rear punch (Rrpunch); see table 2, and Right Hook (RHook); see table 3. The 15BPL was a common positive predictor of peak impact force for all punch types (R^2 range 0.314 – 0.732).

TABLE 1. Automated Stepwise Linear Regression for right lead leg jab.

Predictors	Importance (R^2)	CD (%)
Model	0.610	61.00
RmedPmax_transformed	0.2685	26.85
15BPL1RM_transformed	0.7315	73.15

Note: #denotes negative predictor, ns denotes not significant at .05 level or below.

TABLE 2. Automated Stepwise Linear Regression for right rear hand punch

Predictors	Importance (R^2)	CD (%)
Model	0.686	68.60
BWPmax20CMJ_transformed	0.144ns	14.40
RRmedVpmax_transformed	0.209ns	20.90
15BPLRM_transformed	0.3144	31.44
RlgVmax CSPL_transformed	0.3326#	33.26

Note: #denotes negative predictor, ns denotes not significant at .05 level or below.

DISCUSSION Previous work by this author highlighted moderate to very strong correlations between select force/velocity characteristics, and right handed peak impact force (Woodford et al 2019 in review). Results from the regressions revealed the strongest grouping of predictor's for Condition RHook (R^2 = .698, CD = 69.8%). The strongest single positive predictor was 15BPL which accounted for 45.53% (R^2 = .455, CD = 45.53%) of the total variance. This strong predictive contribution suggests it could be used in special preparation to help increase momentum transfer upon impact by safely overloading the terminal extension of the thrown arm. The only other positive predictor was Pmax during CMJ (BWPmaxCMJ) (R2 = .270, CD = 27.03%). As Pmax is the product of force (N) and velocity, (m/s) increasing such characteristic through training both heavy load, non-ballistic, and lighter load ballistic exercises could have a positive effect upon momentum transfer (Mass x Velocity) during punches. The next strongest predictor grouping was found for RrPunch (R^2 = .686, CD = 68.6%). The best positive single predictor was 15BPL (R^2 = .314, CD = 31.44%). Although not quite as predictive compared to the RrHook, 31.44% represents a large amount of the shared variance with the right rear hand punch Fmax. Right leg Vmax during CSPL produced the strongest predictive properties but as a negative predictor (R^2 = .333, CD = 33.26%). RRmedVmax (R^2 = .209, CD = 20.90%) and BWPmax20CMJ (R^2 = .144, CD = 14.40%) accounted for the remaining 35.30% but didn't reach significance($p > .05$) The bilateral 4.55kg medball throw shares some kinematic similarities to the RrPunch with regards foot stance and reliance upon transverse plane trunk rotation so a predictive relationship was not unexpected. The relationship with BWPmax20CMJ may reflect the plant and "block" nature of the right lead leg, loaded in preparation to accelerate the right arm during the RrPunch. The weakest grouping of predictors was found for the RJab (R^2 = .610, CD = 61.0%). The best single positive predictor was 15BPL1RM (R^2 = .732, CD = 73.20%). The 15BPL produced the greatest contribution to RJab. As the RJab is "thrown" straight out and up from the right lead leg stance, it has the greatest kinematic similarity to 15BPL. Pmax during the unilateral 4.55kg medball throw (Rmedpmax) was also a significant positive predictor (R^2 = .269, CD = 26.85%). The more linear trajectory of the Rmed throw would seem more similar to the linear path of the RJab.

TABLE 3. Automated Stepwise Linear Regression for right rear hand hook.

Predictors	Importance (R^2)	CD (%)
Model	0.698	69.80
RlVmaxCSPL_transformed	0.1031#	10.31
RlFmaxCSPL_transformed	0.1713#	17.13
BWPmaxCMJ_transformed	0.2703	27.03
15BPLFmax_transformed	0.4553	45.53

Note: #denotes negative predictor, ns denotes not significant at .05 level or below.

CONCLUSIONS AND PRACTICAL APPLICATIONS: The rationale behind the 15BPL was to mimic the moment before impact, to the follow through of the punch (Woodford et al, 2019 in review). Although punches are unilateral there appears to be significant carry over form the bilateral 15BPL. Such an exercise could be used by boxers in conjunction with uni and bilateral medball throws during special preparation phases of training focusing upon strength-power transition in support to core structural multi-joint strength/power resistance exercises. Future research could look at the chronic effects of incorporating such exercises into a concentrated block of training, in stand-alone or complex parings (with non-ballistic and ballistic exercises) upon punch impact force.

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