Increasing the Impact Force of the Rear Hand Punch

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SUMMARY

ONE OF THE MOST RENOWNED STRIKES WITHIN COMBAT SPORTS IS THE REAR HAND PUNCH. ITS IMPACT FORCE IS SUBJECT TO 5 TRAINABLE VARIABLES: (A) INCREASE REAR LEG DRIVE, (B) FOLLOWING THE STEP FORWARD, LAND WITH A RIGID LEG TO INCREASE BREAKING AND TRANSMISSION OF FORCES, (C) INCREASE THE STRETCH-SHORTENING CYCLE ACTION OF THE TRUNK MUSCULATURE, (D) INCREASE THE VELOCITY OF THE PUNCH, AND (E) INCREASE THE EFFECTIVE MASS. IT IS POSSIBLE, THROUGH APPROPRIATE STRENGTH AND CONDITIONING PROGRAMMING, TO TARGET THE DEVELOPMENT OF EACH.

INTRODUCTION

One of the most renowned strikes within combat sports, especially boxing, is the rear hand punch (RHP). Although it may not be the fastest, it is likely the hardest. Smith et al. (33) have analyzed this punch across a range of abilities in male boxers and have compared it with the commonly thrown and more rapid lead hand jab (Table 1). As expected, maximal punching forces were significantly greater in the elite than the intermediate group and greater in the intermediate than the novice group ($p < 0.05$). In the elite, intermediate, and novice groups, the maximal punching force of the RHP was greater than that of the jab (all $p < 0.001$).

The aim of this article is to describe the technique (kinetics and kinematics) of the RHP and contemporary approaches within strength and conditioning aimed at increasing its impact force.

KINETICS AND KINEMATICS OF THE PUNCH

Analyses of the kinetics and kinematics of the punch have primarily focused on the motion of the arm (38), the impact, and subsequent forces experienced by the target (33). There is very little empirical evidence focusing on how the puncher produces the force. Filimonov et al. (15) presented the progression in technique across 3 levels of boxers and suggested that the more experienced the boxer, the greater the contribution of the legs to the force production. Although no methodology was included in that article, this line of thinking (i.e., elite punchers use a distal to proximal movement sequence to produce the most powerful punch) agrees with the kinematical profile of comparable sports, which impart force onto an object via the hand; for example, baseball pitching (29), javelin (39), tennis (13,30), and shot put (37).

Similar to the sports identified above, one may argue that a maximum effort RHP is initiated with a front foot lift and subsequent step forward (Figure 1). By lifting the front foot, the athletes place their center of mass (CM) in front of the base of support (rear foot), resulting in a forward rotation because of gravity accelerating the CM down. Upon landing, the front foot is in front of the CM to produce an anterior-posterior breaking force, similar to baseball pitchers (24). By braking the fall with a rigid front leg, force will transmit through the body. This same sequence of movements has been recorded in baseball pitchers (29) and javelin throwers (39). It has also been shown in javelin throwers that by landing with a stiffer front leg on the final stride results in greater force being applied to the javelin (39).

Simultaneous to the step forward, the pelvis and shoulder rotate away from the target (Figure 1). This is quickly followed by pelvis and then shoulder rotation to the target. Stretching of the trunk muscles during the rotation away allows for a more powerful rotation forward through employment of the stretch-shortening cycle (SSC). Actions using the SSC allow the muscle to be in a more optimal length for force production and for a greater storage and reuse of energy within the series elastic component (22). The rotation away and then toward the target is very similar to a baseball pitch and the opening of a quarterback before the forward motion of the throw.

The combination of a transmission of breaking force through the body and use of the SSC within the trunk musculature (25) allows for a greater force production during the punch. More experienced boxers may increase

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punch; combat; impact; strike

Table 1
Results collected by Smith et al. (33) on British boxers (mean ± standard deviation)

Ability	Elite	Intermediate	Novice
N	7	8	8
Age (y)	23.1 ± 1.2	23.5 ± 3.3	23.6 ± 3.2
Height (cm)	178 ± 6	175 ± 5	179 ± 2
Body mass (kg)	69.9 ± 8.6	73.4 ± 8.2	78.5 ± 8.9
Participation (y)	11.5 ± 1.4	5.7 ± 1.3	1.5 ± 0.2
RHP (punch units)	4,800 ± 601	3,722 ± 375	2,381 ± 328
Jab (punch units)	2,847 ± 596	2,283 ± 355	1,604 ± 273

Punch force was expressed in "punch units," as an ecologically valid and safe boxing dynamometer must include an impact-absorbing pad between the gloved hand and the dynamometer impact surface (33).

RHP = rear hand punch.

this forward movement (lifting the front foot and rotating forward) through a simultaneous and more active rear leg extension (15). Faster pitches in baseball are highly correlated with a greater emphasis on pushing off with the rear foot, and on higher landing forces of the front foot, suggesting a greater transference of force in the direction of the target (24). Similarly, tennis players are advised to increase racquet velocity (and ball speed) during the serve through increases in leg drive (13,30).

A decrease in hand velocity just before impact has been recorded (24). McGill et al. (26) also showed a double peak in muscular activity during both punches and kicks of mixed martial artists; the first peak occurs during initiation of limb motion with the second occurring close to impact. It has also been shown that the athlete will produce a greater activation of the triceps brachii, but not the biceps brachii (which stays the same), during punches with impact compared with punches without impact (28). The increased muscle activity (for all muscles, i.e., agonists, antagonists, and stabilizers) allows for a "stiffening" of the body before impact. This stiffening produces a greater effective mass (24) that allows for a greater impulse (force × time) to be imparted onto the target. This is emphasized in a palm strike, for example, where a greater impact force is seen compared with a punch despite the forearm accelerations being similar (6). This can be attributed to the greater effective mass within the palm strike; the many joints within the hand are likely to absorb the force by decompression during the punch. This is similar to what is seen through increased activation of the musculature surrounding the striking limb.

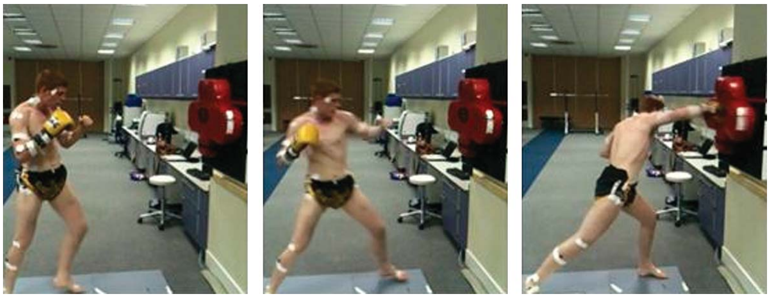

Figure 1. The athlete begins the punch by stepping forward while rotating the pelvis and shoulder away from the target. This rotation away preloads the trunk musculature to use a stretch-shortening contraction, which increases force development. Triple extension of the rear leg finalizes the movement.

In summary, the puncher will be able to increase his/her RHP striking force through a movement initiating at the feet, employing a front foot lift and rear leg drive. This is added to by increasing the breaking impulse of the front leg and the use of the SSC within the trunk musculature. Stiffening of the system before contact will increase the effective mass and thus the impulse imparted at impact. If hand velocity can be increased (before the stiffening of the system), then the impact force of the punch will be greater still. This can be shown theoretically using the impulse-momentum relationship. An increase in velocity will cause an increase in momentum (mass × velocity), which will then result in a greater force (impulse = force × time). Furthermore, although velocity decreases moments before impact, this drop is supercompensated for by an increase in effective mass, thus resulting in a potentially greater momentum at impact.

STRENGTH AND CONDITIONING CONCEPTS TO OPTIMISE THE REAR HAND PUNCH

The kinetic and kinematic analysis above revealed several possible variables that may increase the impact force of the RHP. These are identified below and briefly discussed in turn:

A. Increase rear leg drive
B. Following the step forward, land with a rigid leg to increase breaking and transmission of forces
C. Increase the SSC action of the trunk musculature
D. Increase the velocity of the punch
E. Increase the effective mass

A. INCREASE REAR LEG DRIVE

This is likely best achieved through exercises that use triple extension such as squats, deadlifts, weightlifting techniques (e.g., the clean), and plyometrics (e.g., box jumps). The former 2 are regarded as strength exercises and the latter 2 are regarded as power (ballistic) exercise and thus affect different regions of the force-time (*f-t*) curve and force-velocity (*f-v*) curve (Figures 2 and 3, respectively). Because punches are generally delivered within 0.3 seconds (2,38), ballistic training, which increases the rate of force development (RFD), is considered fundamental. However, because strength and power are highly correlated (3), strength training is also paramount. Although ballistic exercises should be performed with variable loads to cover the full spectrum of the *f-v* curve (35), strength training should be undertaken using heavy loads (>80% 1 repetition [1RM]) to enable the transition of Type IIx to Type IIa (1). Although the disappearance of Type IIx may seem disadvantageous (given that they can generate greater shortening speeds and power than Type IIa), this is more than outweighed when looking at it from a functional, whole-muscle point of view versus an individual fiber comparison; increases in contractile strength, power, and RFD are noted in strength-trained muscles (1).

As a word of caution, strength and conditioning coaches should be aware of the detriment caused by long, slow-distance running on force (Figure 4) and power (Figure 5) production (mainly because of a decrease in the volume percentage of Type II fibers and their transition toward endurance-based qualities) (14). If the strength and conditioning coach deems a high aerobic capacity as a necessary attribute to the combat athlete, then they should consider developing it via high-intensity intervals, thereby negating the negative effects (14).

B. FOLLOWING THE STEP FORWARD, LAND WITH A RIGID LEG TO INCREASE BREAKING AND TRANSMISSION OF FORCES

The ability to maintain a stiff leg at landing, which would increase the breaking force and reduce braking time, is likely to be governed by the muscles' ability to resist lengthening under contraction. The Golgi tendon organ (GTO) is designed to protect a tendon by limiting the muscle's maximal, and rate of, contraction strength (20). At landing, this would be evidenced by the presence of knee flexion, which would allow the dissipation of force and thus reduce the

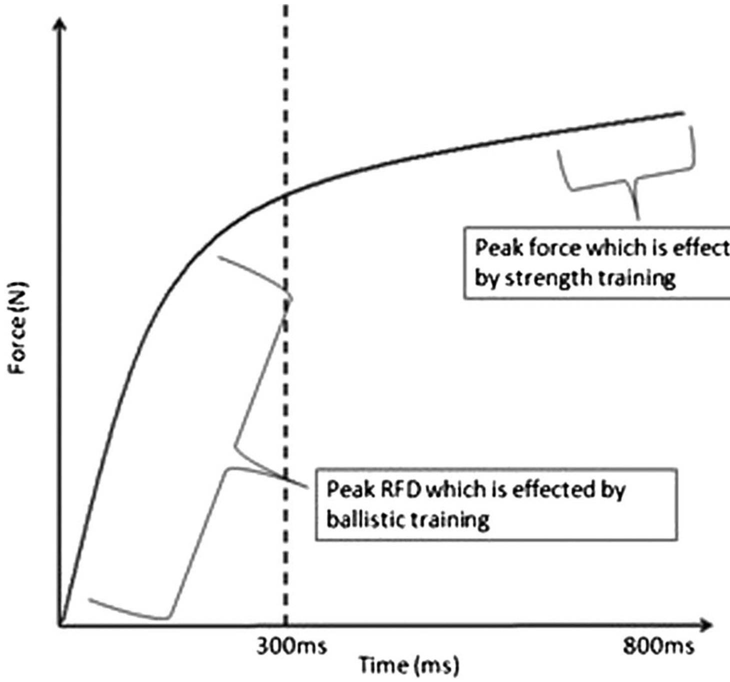

Figure 2. The force-time (*f-t*) curve. Ballistics train rate of force development (RFD) and thus improve the initial slope of the *f-t* curve. Strength training improves the final height of the *f-t* curve.

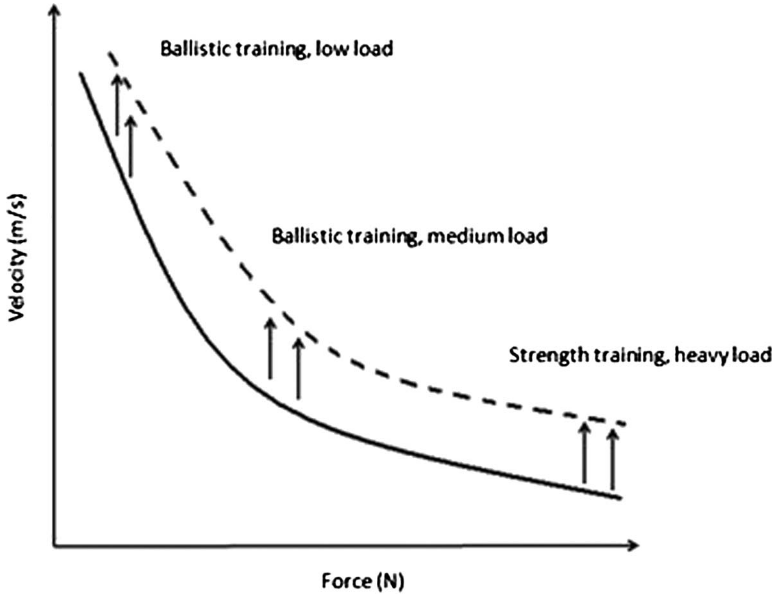

Figure 3. The force-velocity curve. Ballistics train the high-velocity, low-force end of the curve, whereas strength training improves the low-velocity, high-force end of the curve.

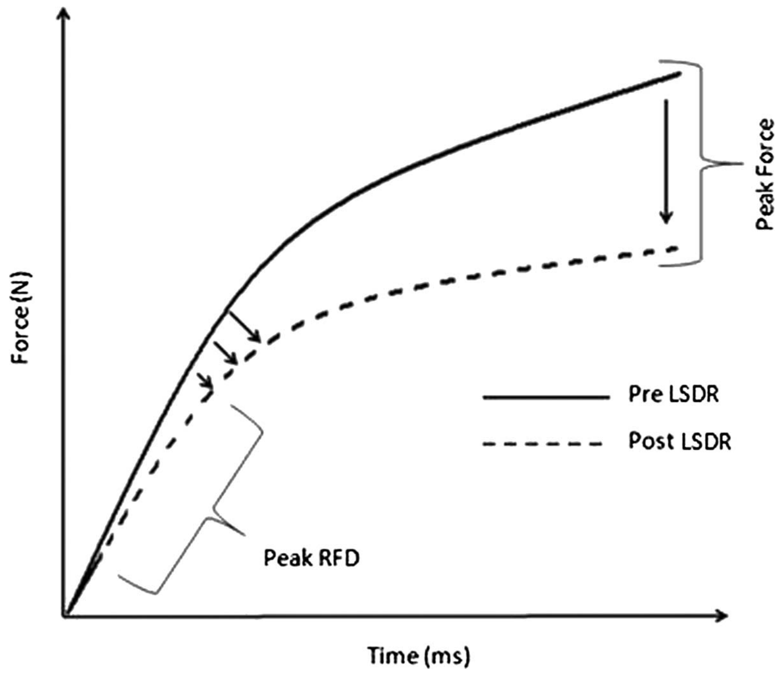

Figure 4. Changes to the force-time curve consequent to long slow-distance running (LSDR). Adapted from Bompa and Haff (7). RFD, rate of force development.

transmission of force up the kinetic chain. To maintain a stiff leg at landing, plyometrics, emphasizing the landing element (e.g., drop lands) may prove beneficial. These would gradually accommodate the leg musculature to high landing forces, thereby gradually disinhibiting the GTO (this is concomitant to increases in muscle and connective tissue strength, thus mitigating injury risk) (23). The same may be said for the landing phase of weightlifting lifts.

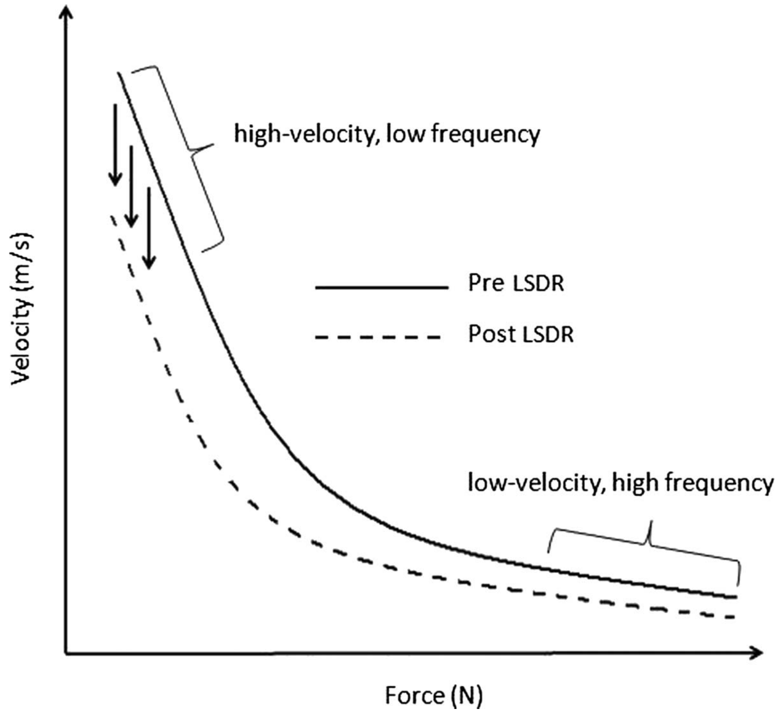

Figure 5. Changes to the force-velocity curve consequent to long slow-distance running (LSDR).

C. INCREASE THE STRETCH-SHORTENING CYCLE ACTION OF THE TRUNK MUSCULATURE

Medicine ball throws (another form of ballistic training) can be an effective training tool for athletes concerned with developing rotational power (34) such as that demonstrated in the RHP. Medicine ball training can allow a high degree of sport specificity through mimicking both range (34) and velocity (11) of motion. For example, ensuring the feet stay in contact with the ground, a proximal to distal development of force, emphasizing a ground-up approach, can be ensured. It is recommended that these exercises be performed standing to make use of simultaneous internal and external rotation about the hips; seated torso twisting relies more on rotation developed at the lumbar spine. A variety of medicine ball weights should be used to ensure full coverage of the *f-v* curve. Cable machines can also be used to enable rotation training at higher loads; however, the correct movement pattern (and muscle recruitment) should not be compromised by load.

D. INCREASE THE VELOCITY OF THE PUNCH

The velocity of the punch may be best increased through exercises that target the initial slope of the *f-t* curve (Figure 4) and is thus concerned with ballistic exercises that target the enhancement of RFD (e.g., plyometrics including medicine ball throws and weight lifts and their derivatives); ballistics are recommended because they ensure maximal acceleration through the entire movement. Also, by using light to moderate loads, the object can be propelled quicker thus training the velocity component of the power (P) equation ($P = f \times v$). Ensuring exercises are sport specific (as described in Table 2) further

Table 2
Strength and conditioning program designed to increase the impact force of the rear hand punch

Strength and power (2 example sessions of each)			
Strength session 1	**Strength session 2**	**Power session 1**	**Power session 2**
Squat snatch (3 × 2 × variable load)	Squat clean and split jerk (3 × 2 ×variable load)	Deadlift (3 × 2 × 3RM)	Front squats (3 × 2 × 3RM)
Bench press (4 × 4 × 4–5RM)	Overhand chin-ups (4 × 4 × 4–5RM)	Power snatch (3 ×3 × variable load)	Bench press throw (5 × 3 × variable load)
Back squats (4 × 4 × 4–5RM)	Split squats (4 × 4 ×4–5RM)	Power split snatch (3 × 3 ×variable load)	Power clean (5 ×3 × variable load)
Bent over row (4 × 4 × 4–5RM)	Stiff leg deadlift (4 × 4 ×4–5RM)	Nordics (4 × 4 × 4–5RM)	Split jerk (5 × 3 × variable load)
Complex training: Plyometrics or pad/bag work performed during the rest period (1 × 3 = strength phase; 3 × 3 = power phase). The drill should be determined by ability (see below for example drills) with adequate rest between sets and reps to maintain an ethos of quality over quantity.			
Plyometric (SSC) and pad/bag work drills			
Lower-body SSC (1 × 3):			
Ankling → Jump up to box (gradually increase the height) → drop lands (gradually increase the height) → drop jumps (gradually increase the height) → consecutive jumps (e.g., drop jump followed by jump over 3 × hurdles) → lateral jumps → single-leg variants of above			
Upper-body SSC (1 × 3):			
Medicine ball throws, for example, in sports stance and mimicking punching techniques, rotational throws and slams → push-up claps			
Pad/bag work drills (1 ×3/per limb):			
RHP. If this is progressed to be preceded by a jab or hook or any other relevant combination, then emphasis must remain on the RHP only			
The taper (example strength and power sessions)			
Strength session 1	**Strength session 2**	**Power session 1**	**Power session 2**
Back squats (3 × 3 × 3RM)	Deadlift (3 × 3 × 3RM)	Power split snatch (3 × 2 × variable load)	Power clean (3 ×2 × variable load)
Bent over row (3 × 2 × 3RM)	Stiff leg deadlift (3 × 2 × 3RM)	Plyometrics or pad/bag work (1 × 3) (see Table 1 above)	Split jerk(3 × 2 × variable load)

Loadings to elicit strength and power gains are based on the works of Aagaard (1) and Turner (36), whereby intensity needs to be sufficient enough to recruit and transform Type IIx to the more useable Type IIa fast-twitch muscle fiber. "Variable load" refers to the necessity to alter the loadings used (between sessions) to ensure full coverage of the power curve (see Turner (36)). Exercises are "complexed" for time efficiency (12,19) and to induce a potentiating effect (5,31). → = progress to (sets × reps × load).

rep = repetition; RHP = rear hand punch; RM = repetition; SSC = stretch-shortening cycle.

ensures RFD is trained across relevant movement patterns.

Knowledge that impact strikes occur in <0.3 seconds (2,38) and induce a double peak in muscle activation, with the phase of muscle relaxation between these pulses allowing for greater limb velocity (26), may add further weight to this argument. Because this relaxation phase appears involuntary (and presumably outweighs continuous contraction), the time over which force (and therefore velocity) can be developed is actually less than total punch time. The ability to generate a high RFD therefore gains added significance. McGill et al. (26) also noted a distinct double pulse in the vocal grunts of the athletes known as "kiai" or an "energy shout" in Japanese martial arts when striking. This grunt may facilitate the RFD and the onset of muscle relaxation, and its purposeful use may accentuate both the impact force and speed of delivery. It is interesting to speculate as to whether the addition of a 2-phase vocal grunt during ballistic exercises would facilitate gains/carry-over further.

E. INCREASE THE EFFECTIVE MASS

This may be best developed through pad/bag work, because it is logical to assume that system stiffening is consequential to impact. For example, Netto et al. (28) showed greater activation, and an increase in agonist muscle activity, in the brachioradialis (stabilizing muscle) when comparing contact with noncontact punching. Combining this with the "energy shout" may accentuate gains. It is also reasonable to speculate that system stiffening would be better developed through pad/bag work when compared with sparring, because the latter would require some level of deceleration and therefore a reduction in effective mass to soften impacts.

STRENGTH AND CONDITIONING PROGRAMMING: THE APPLICATION OF THEORY

Table 2 details a strength and conditioning program to meet the goals identified above. This is preceded by a rationale for the program's structure.

The traditional periodization strategy (36) should be adopted for combat athletes preparing for competition, because they normally need only peak for a single event at a time, with plenty of notice before subsequent fights. Because strength can only be maintained for 2 weeks (18) and because strength is highly correlated to power (3), strength training is included throughout the periodized program, albeit with a reduced frequency and volume. Adequate rest between sets and even repetitions (reps; i.e, cluster training) should be employed to maintain the quality of rep (and maximize force output) and reduce the accumulation of lactate. Lactate has been correlated with growth hormone release (17) and subsequent muscle hypertrophy; this is often an unwanted response in athletes of weight-classed sports. Of course, as the competition approaches, coaches are likely to use drills that increase the power endurance of their athlete and thus target the lactate system. Although large amounts of lactate will be produced here, they are done so through the use of volume loads that are unlikely to stimulate an anabolic response (i.e., volume is too high and intensity/load is too low) (21).

The progressive increases in the volume load of periodized strength and conditioning programs (and actual sports practice) are likely to accumulate excessive fatigue and overstress the neuroendocrine system, thus reducing the body's adaptive responses (16). Therefore, a taper should be employed to dissipate the accumulated fatigue and enable performance-enhancing adaptations to become apparent (27). The optimal manipulation of training variables for the purpose of tapering may be best evidenced from the meta-analysis conducted by Bosquet et al. (8); it is 2 weeks in duration and consists of exponentially reducing the volume of training by 41–61%, while maintaining both the intensity and frequency of sessions.

The use of complex training is advised including the inclusion of the RHP within the strength and conditioning session itself. Complex training involves the coupling of kinematically similar high-load and high-velocity exercises in a set for set combination to induce a postactivation potentiation (PAP) response (32). For example, the pairing of a strength-based triple-extension exercise with the RHP will, in theory, evoke a PAP response that will increase RFD and impact force (32) of the RHP. The program below (Table 2) advises the use of plyometrics and combat strikes during the rest period for these reasons.

This form of training has shown beneficial results in both upper- and lower-body power (4,5,9), including in younger athletes (31). In general, a low volume at high intensity (e.g., 3 reps using 3–4RM loads) separated by rest periods in excess of 4 minutes have shown a potentiating effect to subsequent low load (<50% 1RM)/body weight, high-velocity movements of kinematic similarity. Examples include squats followed by box jumps (for the lower body) or bench press followed by bench press throws using a Smith machine (for the upper body). Where complex training does not stimulate a potentiated response (12,19), possibly because the athletes are not accustomed to strength training, do not have a sufficient strength base (10), or more commonly, because fatigue cannot be sufficiently dissipated (5), it is not reported to be detrimental and may facilitate training efficiency to coaches who are limited to 1 or 2 sessions per week (12,19). This form of training may also assist in facilitating the cognitive and motor transfer of gym-based exercises to sport-specific movements.

HOW APPLICABLE IS THIS PROGRAM TO OTHER FORMS OF STRIKING?

Although this article concerns the RHP, the author proposes that these training methods will offer some functional carryover to other strikes used by boxers and martial artists. That is, jabs, hooks, and upper cuts, for example, still rely on speed of delivery, impact force, and trunk potentiation. Each strike is likely to be preceded by a phase of muscle relaxation and an increase in effective mass. Furthermore, when stepping forward to attack or delivering a flurry of punches, SSC augmentation becomes paramount as the boxer shifts his CM while coiling to store and use elastic energy. SSC is also important to footwork. There is no reason to assume that these training methods would not also facilitate the efficacy of kicks and knees. Here push kicks and round houses, for example, or plyometrics emphasizing hip flexion, can be "complexed" in place of the RHP. Finally, medicine ball drills can be adapted to replicate the kinematics of each punch.

CONCLUSION

The impact force of the RHP is subject to 5 trainable qualities. These and their respective training interventions are

Table 3
Variables affecting the impact force of the rear hand punch and their associated training intervention

No.	Variable	Training intervention
1	Increase rear leg drive	Develop strength and RFD through triple-extension–based exercises such as squats, weightlifting lifts, and plyometrics
2	Increase the SSC action of the trunk musculature	Use medicine ball exercise where force is initiated from the ground
3	Following the step forward, land with a rigid leg to increase breaking and transmission of forces	Use plyometrics that emphasize the landing element.
4	Increase the velocity of the punch	Increase RFD (and muscle relaxation phase) through ballistic exercises.
5	Increase the effective mass	Use pad and bag work incorporating impact.

RFD = rate of force development; SSC = stretch-shortening cycle.

identified in Table 3. The traditional form of periodization should be used and athletes should be sure to taper in the weeks leading up to competition.

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