Original scientific research study

The Effects of Lower Core Resistance Training on Rear Hand Punching Performance in Professional Boxers.

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BLUF.

This investigation into core resistance training, using isometric strengthening and stabilising exercises, such as the plank, that utilised the entirety of the kinetic chain, has positively impacted rear hand punching performance by 24% in professional boxers.

Abstract.

This study aimed to investigate and identify if there was any impact on rear hand punching performance in professional boxers when trained using specific integrated core exercise modalities. Boxers use ballistic movements for striking performance; utilising the ground to potentiate ballistic force through the lower limbs, transferring through statically contracted hips and trunk before its released dynamically through the upper extremity of the striking hand. The experimental group carried out a six-week program that aimed to improve core stabilisation by using isometric and slowly controlled isotonic strengthening exercises such as the plank, bird bog, banded holds, side twists and pullovers, against a control group which used traditional methods such as sit-up. 20 male professional boxers from a U.K. boxing gym were recruited (24.2 $\pm$ 2.9 years; 176.7 $\pm$ 6.2cm; 76.5 $\pm$ 10kg), Pre- and post-intervention testing included rear hand punch strike power, measured using the PowerKube^{TM}. The experimental group significantly improved (p<0.001; g = 4.41) rear hand punch impact power (17781±1490 to 22014±1336 watts), compared with the control group (17326±1280 to 18152±1160 watts), demonstrating an extremely large effect size and a 24% improvement in power from pre- to post-test. A six-week training intervention using exercise modalities to strengthen and stabilise the core positively impacts punching power, supporting the value of the intervention as a suitable method for enhancing punching power when used with highly trained boxers. When aiming to improve punching power, it is advised that coaches who work with boxers should implement isometric and slowly controlled isotonic strengthening core exercises to improve the postural structure of the athlete, abstaining from forward trunk bending modalities such as the sit-up.

Keywords- Boxing, core, training, punching, power, combat sports.

INTRODUCTION.

Boxing is a combat sport, where two combatants attempt to stop one another by the use of forceful strikes from the upper extremities, where the point of impact results from the hands striking their opponent in any region above the waistline and restricted to the anterior portion of the head and body (30,31,37). Rules and regulations are designed to promote the health of the boxers, even though the goal is to incapacitate their opponent by causing trauma which may result in injury. With most injuries being minor, a sanctioned referee oversees the competition that regulates both fairness and safety, with medical professionals on standby; boxing is a relatively safe sport (11,12,16,23).

Boxing is both amateur and professional, with differences in duration of the fights being the most significant components that set them apart; physiological parameters and requirements of the boxers will be heavily dependent on how long the rounds are and how many rounds are in the fight (3). A boxing competition can range its timings from three rounds of two-minutes, up to twelve rounds of three-minutes depending on the experience of the fighters, however all bouts will have a one-minute restorative period in between rounds regardless of format, for the fighters to recover and receive instruction from their ringside coach (30).

Identifying the kinematic and kinetic demands of boxing is key to producing winning performances, and arguably, punching power output contributes to boxing success. Therefore, selecting the correct training modalities for the boxer is paramount for improving performance (3,31,37). Boxers use a variety of punches during competition, with the cross punch used up to 35% more in competitive boxing fights than the hook and up to 50% more than the uppercut (9, 29, 30, 35). Forceful strikes to the head using the cross punch are more predominantly used than strikes to the body, as they are more likely to cause a stoppage by knockout (12,36,37,40).

Boxers use dynamic and ballistic movements for striking performance; correct technique utilises the ground to potentiate force through the lower limbs, transferring through the trunk before being released through the upper extremity of the striking limb (5,6,20,23,26). The motion of the trunk when striking has been identified to be in alignment with the hips, therefore the torsional motion of the hips and trunk are in symmetry. This demonstrates that training modalities which promote forward trunk bending to improve punching performance may not be appropriate to the desired adaptations sought (33). Stanley et al. (32) identified the superior ground reaction forces produced from boxers' holding a rigid lead leg and is necessary to withstand the emitting force from the rear leg, through the hips, trunk and then through the upper limb to produce better performances, when vertical anterior-posterior braking forces are produced.

Forward trunk bending exercises such as sit-ups (Figure 1) and leg raises (Figure 2) contract the abdominals, moving the trunk through the sagittal plane, whilst activating the hip flexor muscle group (16, 6,11). Often labelled as an abdominal crunch (Figure 1), the variations of this exercise and others that employ forward bending motions of the trunk are heavily utilised in boxing training (16). However, research has shown that sit-ups can have a deleterious effect on the athlete and may impede athletic performance (19,20,24,39). Exercise modalities such as leg raises and sit-ups that direct shearing forces on the lumbar region can produce poor manoeuvrability of the torso, hindered locomotion and inferior biomechanics over time, emphasising the need to identify more specific training protocols (2,19,38). Training methods and modalities which target the core in a stable position could potentially be better suited, leading to greater improvements in athletic performance (24,42).

Myers et al. (26), described the core area as a muscular box that enables the body to generate force that transfers to the opposing limbs, through a kinetic chain (5,27). By increasing the body's core strength and stability through resistance and proprioceptive

training, improvements in athletic capability and decreased injury rates are seen (2,4,18,19,24,26,27,28). Chan et al. (8) stated, that reducing muscle asymmetries decreased the performance negating effects of lordosis, which affected optimal athletic performance by decreasing exercise economy with malalignment of the posterior oblique sling and posterior kinetic chain (17,19,20,22,24).

Core stability training is often focused on isometric muscle actions, such as the plank (figure 3), with Okada et al. (27) reporting that isometric exercises on their own may not significantly improve dynamic sporting performances, although more research is required. However, without core- targeted isometric exercises, core passive and active stiffness would be lost within the posterior oblique sling and muscular box (1,19,24). Core stability minimises passive joint movement and may decrease injury rates, particularly on the lumbar vertebrae segments, with an increase in strike performance via muscle stiffness (active stiffness) and osseous ligamentous structure improvement (passive stiffness) which is an essential factor to strike with more force and increased power output (2).

Improving the stability and strength of the muscular box aims to enhance athletic performance by increasing the range of movement and force transfer from the lower extremities through the core, terminating through the upper extremities, aiming to cause a forceful blow to an opponent (5,7,18, 19,26). Therefore, this study aims to identify the significance of specific integrated core resistance training modalities on punching power output in boxers by utilising a 6-week intervention programme.

Figure 1. The sit-up, at mid phase position, finishing with the torso fully vertical.

Figure 2. Leg raises, at near end phase.

METHODS.

Approach to the problem.

A repeated measures design was implemented to examine the impact of a 6-week core strengthening and stability training intervention on professional boxers' striking power potential. The subjects were randomised to either an experimental group or control group . The experimental group used the designed intervention programme as supplementation to their regular training and was carried out directly before their technical sparring days. The Control group were instructed to carry out their regular prescribed training protocol, with only sit-ups and leg raises that focused on their core training.

Subjects.

20 highly trained professional boxers from a U.K. boxing gym were recruited (20 male) (24.2 ± 2.9 years; 176.7 ± 6.2cm; 76.5 ± 10kg), with a minimum of 4 years amateur boxing and 2 years professional boxing experience and 2 years resistance training. Subjects were randomly assigned and coded to the control group (n=10) with a mean of 12 (SD ± 4) professional bouts and experimental group (n=10) with a mean of 11 (SD ± 5) professional bouts. All subjects were six months clear from injury and in a healthy state, all subjects completed the participation questionnaire from the British Association of Sport and Exercise Sciences, and the experiment was explained before commencing (13). Ethical approval was granted by the University of East London School of Health, Sport and Bioscience Ethics committee before recruitment.

Procedures.

Pre- and post-intervention testing included rear hand punch strike power, measured using the PowerKube™ (Birmingham, U.K) (Figure 11), a dynamometer that accurately quantifies the measure of the subjects striking potential (10,12,34,36,40). The PowerKube™ was secured to a fixed steel support beam and adjusted to the subject's head height. Data from

Steinebronn et al. (36) reported a typical error of 1.8% for accurate strikes on the PowerKube™. At peak force, a boxer could sustain an injury if they were to strike the metal support beam, therefore a typical error of 1.8% for accurate strikes suggests the PowerKube™ is suitable for collecting safe and reliable data (34,36,40).

The subjects carried out familiarisation training with the PowerKube™ two days before pre-testing to give the most accurate and reliable score. Pre- and post-testing of the subjects in the experimental group and control group used a general warm-up of ten minutes of shadow boxing, whilst supervised by their boxing coach. The best of five strikes was recorded to measure their peak power output, with ten seconds between each strike to ensure that technique was repeated.

Each experimental training session was preceded with a light cycle for 10minutes to warm up; no dynamic stretching was carried out before the training due to the low impact and intensity of the exercises. A qualified strength and conditioning coach supervised all sessions to ensure correct technique and intensities. The exercises for the experimental group were identified as core stabilisation and strengthening to improve performance (19,24,26). Because of their multi-joint positioning and large moment arms, core stabilising muscles are responsible for maintaining posture and distributing and absorbing force in the body, while mobilising muscles contribute to rapid movement, force, and strength (14). This study was designed to identify the effects of isometric and slow moving core stabilising exercises on boxers punching performance that would transmit force through the core.

The training programme (Table 1) was carried out twice a week and reviewed after the completion of week 3, with the volume or intensity or both being increased, ensuring that all sets were completed with correct form. The control group were instructed by their boxing coach to only carry out sit-ups and leg raises, with eight sets of three minutes of each

exercise modality in total for three weeks, then increased their volumes to ten sets of three minutes to induce progression, similar to the experimental group.

Table 1 – The bi-weekly training session, that was carried out under supervision for six weeks, with a steady progression to ensure adaptability of the experimental group.
BW = body weight, RBS = rest between sets.

Exercise week 1-3	***Volume and Intensity***
Plank (figure 3)	5 sets of 1 min - BW – 30secs RBS
Side plank (figure 4)	3 sets both sides with 1min to hold -BW–30secs RBS
Single Leg Glute Bridge (figure 5)	4 sets of 20 reps – BW– 30secs RBS
Bird Dog (figure 6)	3 sets of 20 reps -BW– 30secs RBS
Side Twists (figure 7a & 7b)	3 sets 10 reps each side -BW– 30secs RBS
Pull overs (figure 8 & 9)	2 sets of 15 reps – 10kg– 30secs RBS
Banded holds (figure 10)	2 sets 30 seconds – Red bands– 30secs RBS
Exercise week 3-6	***Volume and Intensity***
Plank (figure 3)	3 sets of 3 min - BW– 30secs RBS
Side plank (figure 4)	2 sets both sides with 2mins hold -BW– 30secs RBS
Single Leg Glute Bridge (figure 5)	4 sets of 20 reps – 10kg plate– 30secs RBS
Bird Dog (figure 6)	3 sets of 20 reps – 5kg dumbbell – 30secs RBS
Side Twists (figure 7a & 7b)	3 sets 15 reps each side -BW– 30secs RBS
Pull overs (figure 8 & 9)	2 sets of 15 reps – 15kg– 30secs RBS
Banded holds (figure 10)	2 sets 30 seconds – black bands– 30secs RBS

Figure 3. Plank:

Figure 4. Side plank:

Figure 6. Bird dog end position.

Figure 5. Single leg glute bridge end position.

Figure 7. Side twists: Start position,

finish position

Figure 8. Pullovers: Start position,

Figure 9. Mid position

Figure 10. Banded holds.

Figure 11. Striking the PowerKube™ in the centre target

Statistical Analyses.

Descriptive statistics for all variables are expressed as a mean ± SD, and the level of statistical significance was set at $p \leq 0.05$ (SPSS Version 21.0; SPSS Inc., IL, USA). Shapiro-Wilk statistics showed the data to be not normally distributed, hence Mann Whitney U tests were used to determine statistical significance. Magnitude of differences was estimated from Hedges' *g* effect size, due to small sample size and evaluated based on Hopkins et al (15) (Magnitude of effect size = Trivial 0.0-0.2 – Small 0.2-0.6 – Moderate 0.6-1.2 – Large 1.2-2.0 – Very large 2.0-4.0 -Extremely large >4.0)

RESULTS.

Table 2 illustrates the pre- and post-intervention rear hand strike power of the experimental group and control group. At the end of the 6-week study, the results showed the experimental group significantly improved rear hand punch power, when compared with the control group, both within groups (p<0.001) and between groups (p<0.001).

Table 2: Mean power outputs following 6-week core resistance training intervention (n=20). Data presented as mean and SD

Group	Pre-Test (Watts)	Post-Test (Watts)	Difference	Hedge's *g* effect size
Experimental group (*n*=10)	17780.5 (±1490)	22013.5* (±1336)	4233* (±1509)	4.41
Control group (*n*=10)	17325.9 (±1280)	18151.8 (±1160)	825.9 (±792.6)	0.82

* denotes significant difference between groups (p<0.01)

DISCUSSION.

The purpose of the current study was to examine the effects of core resistance training on rear hand punch striking performance within professional boxers. From the results, it is seen that the subjects in the experimental group significantly improved punch striking power (p< 0.001, g = 4.41), supporting the value of the intervention as a suitable method for enhancing punching power. Boxing does involve other strikes, such as uppercuts and hooks; however, this study focused on the one variable due to the prevalence of rear hand cross punches used in competition over any other punch (9, 29, 30, 35).

Using core stability isometric exercises, such as the plank and side plank (figure 1&2), ameliorate joint strength and passive and active muscle stiffness (24), promoting the transition of transverse forces through the muscular box produced from the lower extremities to the upper limbs (1,2,3,5,7,40). The subjects in the experimental group were prescribed stability exercises targeting joint strength and active muscle stiffness, that were not present in the control group. Subjects in the control group were prescribed traditional training involving sit-ups and leg raises. Core exercises such as those in table 1, that invoke spinal stabilisation through the posterior oblique sling and passive stiffness of joints create superior performance outcomes (1,2,3,5,7,21,22,41), which was seen in the subjects within the experimental group, who demonstrated a 24% improvement in rear hand punch strike power. .

The subjects in this study demonstrated that the core resistance training exercises carried out over six weeks produced a significant ($p<0.001$) increase in punching power, with a large effect size demonstrated in the experimental group (g = 4.41). Future investigations into core resistance training should elicit measuring the effects, if any, of postural changes such as anterior pelvic tilt and lordosis and its direct effects on punching power output, which was beyond the scope of this study. However, there is a clear indication that exercises which promote forward lumbar flexion could be removed from boxing programmes, where integral

exercises such as planks, bird dog and pullovers would improve the entirety of the kinetic chain and possibly decrease lordosis improving structural posture, muscle stiffness and stability of the muscular box (18,19,20).

Core resistance training exercises should elicit modalities that train towards spinal stabilisation, effectively using the muscular box as a fulcrum to transmit force. Although forward trunk bending exercises are commonly used to target the boxers' athletic status, they are seen to be less effective on athletic performance, with literature supporting the use of core strengthening and stabilising exercises that use the entirety of the kinetic chain (24,27,28). The subjects in this study demonstrated the effectiveness of a six-week in line core resistance training programme that avoided trunk bending exercises. Although this study did not identify if this was due to muscle stiffness or increased stabilisation of joints in the posterior oblique sling and muscular box area, the subjects in the experimental group did exhibit significant positive changes to their punching power output which can be attributed to the different core resistance training modalities carried out in the intervention programme.

PRACTICAL APPLICATIONS.

From this study, it is advised that coaches who work with boxers should implement core exercises that improve the postural structure of the athlete, rather than forward trunk bending modalities, as these exercises demonstrated greater improvements in punching power output, which may improve the chances of winning. Many previous studies have focused on forward trunk bending, that may not be functional enough to elicit significant changes in performance. Forward trunk bending exercises are not specific to punching due to the statue and kinematic motion of the boxer whilst performing the strike; therefore, emphasis should be on training the entirety of the kinetic chain. Specifically, the posterior oblique sling and muscular box in a fixed position to allow more force generated from the lower extremities to transmit to the upper extremities more efficiently to produce a more powerful punch.

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