Strength Training Practices in Amateur and Professional Boxing

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ABSTRACT

Previous research has highlighted that force development are key contributors to punch impact force in boxing, however, the strength training practices within the sport remain unclear. Identifying such practices are an important first step in the development of accessible educational resources and recommendations to develop strength at all standards in boxing. The aim of this study was to investigate strength training practices in amateur and professional boxing. Seventy-two trainers or support staff working in amateur or professional boxing completed an online survey comprising of seven sections: Study Information and Informed Consent, Participant Information, Perceptions of Strength Training, Strength Training Characteristics, Power Training Characteristics, and Strength and Power Assessment. Frequency analysis was used to report responses to fixed-response questions, and thematic analysis was applied to one open-ended question. The main findings of this study demonstrate that the majority of practitioners (i) implemented strength training to improve 'punching power,' muscular endurance and reduce the likelihood of injury (72 – 88%); (ii) utilised punch-specific and reactive-strength training the most in programming (93%); (iii) acknowledged that maximal strength training improves 'punching-power' (84%), yet programmed it the least in training; and (iv) highlighted that there was a fear in boxing that maximum-strength training may lead to unwanted increases in muscle-mass and cited a lack of resources as a reason for maximal strength training not being utilised. As there is a large contingent of volunteer practitioners in boxing without professional S&C or sport science accreditations (78%), it is recommended that national governing bodies provide adequate training and education to practitioners.

Key Words: combat sport, punch impact force, programming, maximal-strength, explosive-strength, special-strength

INTRODUCTION

Boxing is one of the oldest and most popular combat sports in the world (21); two formats exist, amateur and professional. In amateur boxing, male bouts consist of up to 5 but typically 3, 3-minute rounds, whereas female bouts consist of 4, 2-minute rounds, during single- or multi-day competitions. A professional bout can include up to 12, 3-minute rounds for males, and 10, 2-minute rounds for females. Regardless of the format, the main aim of boxing is to succeed in delivering a clean punch to the opponent and evade punches in return (i.e. to score a point, control the bout, knock-down, or knock-out the opponent) (21). To succeed in delivering precise and forceful punches, boxers require a well-developed cardiovascular and neuromuscular system (4).

The cardiovascular characteristics of elite boxers (35), and the physiological demands of simulated competition (i.e. $\dot{V}O_{2max}$, heart rate, blood lactate) (8,16), have been previously investigated. For example, during simulated amateur boxing, intensity can be 85 - 90% of $\dot{V}O_{2max}$, corresponding to 90 – 95% HR_{max} (8) and blood lactate concentrations greater than 12 $mmol \cdot L^{-1}$ (35). Consequently, elite boxers can have $\dot{V}O_{2max}$ values greater than 65 $mL \cdot kg \cdot min^{-1}$ up to middleweight, and greater than 50 $mL \cdot kg \cdot min^{-1}$ up to heavyweight (31). Due to this physiological requirement, the sport has traditionally placed a heavy emphasis on aerobic training, with boxers performing high volumes of steady-state road running and high-intensity intervals to physically prepare for a bout. However, punching (e.g. straights, hooks and uppercuts) is a high-force whole-body movement (10). Whilst technique is likely to play a major role in a boxer's punching ability, the force production capabilities of the neuromuscular system may be a limiting factor (i.e. rate of force development [RFD]).

'Punching power' is a colloquial term often utilised within the sport to refer to the impact force of a punch. Strength qualities of elite amateur boxers are largely associated with punch impact

force (11,27,28) and improving a boxer's neuromuscular function using strength training is recommended (44). Although scientific literature may highlight 'research-informed' practice for improving strength and RFD for athletes, it does not suitably encompass the context-specific and nuanced aspects of applied practice in boxing. An insight into the knowledge of practitioners (e.g. trainers, S&C coaches, physiotherapists) working with amateur and professional boxers would improve the understanding of applied practice and provide a basis for comparisons between best-practice and applied practice. This approach would be practically significant since it would 1) contribute to the knowledge of strength training, and 2) enable convergence of practices leading to optimised training recommendations. Strength training practices have been widely investigated in a wide range of sports such as athletics (1,19), swimming (7), soccer (29), rugby union (20), wrestling (22) and judo (42). Even though there are recommendations on strength training methods to improve punch impact force in combats sport athletes (33,37,39), to the author's knowledge, the actual strength training practices utilised in striking combat sports is unknown. Therefore, the aim of this novel study was to investigate strength training practices in amateur and professional boxing.

METHODS

Experimental Approach to the Problem

An online survey was designed to assess the strength training practices in amateur and professional boxing. The survey was administered online through Microsoft Forms (Microsoft, Washington, USA) cloud-based software and consisted of a total of 48 questions. Specifically, there were 44 closed questions (providing participants with predetermined answers with a comment box often included if relevant) and four open-ended questions that allowed the

participant to share any information or opinions in relation to strength training methods utilised in boxing that they did not have the opportunity to input in the survey.

Subjects

Seventy-two trainers or support staff working in amateur or professional boxing participated in the study. Ethical approval for the study (#20200603) was obtained from the Research Ethics Committee at the XXXXX. All procedures were conducted in accordance with the Declaration of Helsinki. Before providing informed consent, all participants were informed of the risks and benefits, and acknowledged that their participation was voluntary. All participants were required to complete a pre-survey screening questionnaire to ensure eligibility (i.e. over 18 years of age, and currently working as a trainer, coach, or in a support staff role [S&C coach, physiotherapist, sport scientist etc] within senior amateur or professional boxing). Further, all completed surveys were also screened by the lead author. Due to incomplete or incoherent survey responses, five participants were removed from the survey. The remaining sixty-seven survey responses were collated and analysed (n = 58 male; n = 9 female). Participants included boxing trainers or coaches (n = 46), S&C coaches (n = 14), sport scientists (n = 4) and physiotherapists (n = 2). Participants had 13.5 ± 9.5 years of experience working in amateur (n = 53) and/or professional boxing (n = 14), and were based in Europe (n = 45), Australia (n = 10), North America (n = 9), Asia (n = 2), and South America (n = 1).

Procedures

The survey was designed by the two authors. The survey structure and questions were developed from previous surveys investigating the physical preparation practices of athletes in other sports (7,18,19,23,24). The original version of the survey consisted of sixty-one questions split into seven main sections: (i) Study Information & Informed Consent, (ii) Participant

Information, (iii) Perceptions of Strength Training, (iv) Strength Training Characteristics (Session Frequency), (v) Strength Training Characteristics (Exercises), (vi) Power Training Characteristics (Exercises), and (vii) Strength & Power Assessment. The survey was evaluated for content validity and pilot tested with an expert advisory panel (n = 6). The expert advisory panel consisted of three experienced S&C coaches working in elite amateur boxing at a national amateur boxing federation, and three academics experienced in combat sport research. Each member of the expert advisory panel evaluated and scored each survey question on its relevance to the study aim using a 1 – 10-point Likert scale (1 = no relevance; 10 = highly relevant). Depending on the average rating from the expert panel, each question was either accepted (average score > 7) or rejected (average score ≤ 7) for the final version of the survey. There was also an opportunity at the end of the review for each member of the advisory panel to comment on how to improve the survey (e.g. clarity, comprehensiveness, readability etc) in relation to relevance to the study aim. As a result of the responses from the expert advisory panel, a revision of the survey was made on three areas: (i) removal of questions with an average rating of ≤ 7 for relevance to the study aim (thirteen questions were removed, resulting in forty-eight questions remaining), (ii) improving terminology, and (iii) rephrasing of questions.

The final version of the survey was sent via email to all national amateur boxing federations from each main continent (i.e. Europe, North America, South America, Australia, Asia, Africa). Each national federation email address was obtained online from the International Boxing Association (IBA) website (45). Each email included a brief background and aim of the study, time commitment, notifying anonymity of participants, and a request that the survey web link be sent to all clubs, trainers, coaches and support staff within the national federation. Further, to gather as many participants as possible, the survey was advertised through social

media (i.e. X) and utilised snowball sampling. The survey responses were collected from July 2021 to November 2021.

Statistical Analyses

The survey responses were extracted from Microsoft Forms and analysed using Microsoft Excel (365, Microsoft; Washington, USA). Responses to closed-ended questions were analysed by the authors using frequency analysis and presented as absolute frequencies and/or percentages.

Thematic analysis was applied by the lead author to question 16 using the six-phase guidelines set out by Braun and Clarke (2,3). To increase validity, each step of the thematic analysis was underpinned by the guidelines described by Yardley (43): sensitivity to context; commitment and rigour; transparency and coherence; impact and importance. Yardley (43) suggested that the guidelines are not necessarily rigid rules or prescriptions, but are open to flexible interpretation. The thematic analysis phases included: (a) familiarization with the data – the lead author read each of the participant's responses multiple times to become familiar with the data, (b) generating initial codes – participant's responses were then reviewed and a meaning was interpreted from each, (c) searching for themes - a list of all codes were gathered from the responses and the lead author explored a shared meaning across code labels (i.e. "fear of increasing muscle mass," "lack of resources", etc), (d) reviewing themes - where a meaning was shared (i.e. "lack of resources"), sub-themes were then created and grouped (i.e. "facilities & finances," "education," "expertise," etc), (e) defining and naming themes - six themes including five sub-themes were then defined and named, and (f) producing the report. Thematic analysis has been used in previous studies investigating S&C practices in a various sports (7,18,24).

RESULTS

Characteristics of Survey Respondents

A total of sixty-seven practitioners (male = 87%; female = 13%), with 13.5 ± 9.5 years' experience working in boxing, completed the survey. The most common practitioner was a trainer or coach (69%), followed by S&C coach (21%), with the remainder being either sport scientists (6%) or physiotherapist (3%). The majority of trainers or support staff (i.e. S&C coach, physiotherapy, etc) in boxing work in a voluntary or part-time capacity (64%), with the rest working in full-time (25%), consultancy (7%) or self-employed (3%) roles. Seventy-two percent of practitioners had third-level education (Bachelors, masters, or doctoral-level degree), with 22% having a professional S&C or sport science accreditation (i.e. United Kingdom Strength and Conditioning Association [UKSCA], British Association of Sport and Exercise Sciences [BASES] etc). Seventy-one percent of practitioners worked in amateur boxing, of which 22% worked at Olympic-, World-, or European-standard. Nineteen percent of practitioners worked in professional boxing, of which only 4 % worked with a current or former IBF, WBA, WBC or WBO belt holder (e.g. International, 'Regular,' or World-Champion).

Engagement with Strength Training

All practitioners utilised one or more strength training methods (i.e. maximal-, explosive-, reactive-, special-strength, or strength-endurance training) with their boxers. Strength training was programmed for 2.3 ± 0.9 sessions/week 'out of camp', 2.4 ± 1.0 sessions/week 'in-camp', and 1.0 ± 1.2 sessions/week during 'fight week.' Practitioners deemed explosive-strength, strength-endurance, and maximal-strength training as the three most important strength training methods for boxing performance. The rationale for utilising strength training for physically preparing boxers are presented in Figure 1. The most popular strength training

methods utilised are presented in Figure 2 - maximal-strength training was utilised the least amongst practitioners. Fear of increasing muscle mass (sub-themes: 'detrimental to making weight' and 'restricting speed and endurance') and lack of resources (sub-themes: 'lack of facilities', 'finances', 'education', and 'expertise') were the main themes reported on why amateur and professional boxers may not utilise maximum-strength training for physical preparation. In addition, other themes such as maximal-strength being detrimental to speed and mobility, traditional training methods, and fear of injury were also identified (see Table 1).

FIGURE 1 HERE

FIGURE 2 HERE

TABLE 1 HERE

Strength Training and Punching Capability

The practitioner's level of agreement that maximal-strength training and punch-specific strength training improves punch power, and the importance of upper-body strength, abdominal strength and leg strength for punch power in boxing are presented in Figure 3 and Figure 4.

FIGURE 3 HERE

FIGURE 4 HERE

Strength Training and Performance Related Factors

The practitioner's view on the importance of strength and power for amateur and professional boxing performance is presented in Figure 5.

FIGURE 5 HERE

Strength Training and Assessment Strategies in Boxing

The most common exercises to develop reactive-strength and special-strength capabilities, explosive-strength capabilities of the lower-body and upper-body, strength capabilities of the lower-body, upper-body and core in amateur and professional boxing, are all presented in Table 2. The most common tests utilised to assess strength capabilities in amateur and professional boxing are presented in Table 2.

TABLE 2 HERE

DISCUSSION

The aim of this study was to investigate strength training practices in amateur and professional boxing. To the author's knowledge, this study is original in that it is the first of its kind to investigate the strength training methods utilised in boxing. The recruitment of a relatively large sample size for this sector and validation of our survey by experienced practitioners ensured methodological rigour, whilst our findings provide the potential for significant impact in the provision of strength and conditioning for boxers. The main findings of this study demonstrate that 1) improving 'punching power', muscular endurance and reducing the likelihood of injury were key reasons for strength training; 2) punch-specific training was utilised the most in training along with reactive-strength training; 3) practitioners acknowledged that maximal strength training improves 'punching-power', yet is was programmed the least in training; 4) practitioners highlighted that there was a fear in boxing that maximum-strength training might lead to unwanted increases in muscle-mass and cited a lack of resources as a reason for not implementing maximal strength training.

Practitioners working in amateur and professional boxing viewed that improving punch 'power' as a key driver for the inclusion of strength training, along with improving muscular endurance and reducing the risk of injury. Punching is an explosive whole-body and multi-planar muscular movement that accelerates the fist towards a target (25). Although technique plays a major role in a boxer's punching ability, the rate of force development (RFD), and capability of the neuromuscular system may also be a limiting factor (11). Explosive-strength is the ability of the musculature to exert high-force in minimal time (44). Therefore, the assertion that utilising strength training to improve the musculature's RFD and consequent improvements in so called 'punch-power' provides content and face validity to support strength training. Indeed, research in elite amateur boxing has demonstrated that the explosive-strength

qualities of both the upper- (27,28) and lower-body (11,28) are *largely* associated with punch impact force, and suggests that improving RFD would improve 'punching-power'.

In this survey, explosive-strength was deemed to be the most important strength quality for boxing performance, with the majority (84%) programming explosive-strength training methods. The most prevalent exercises utilised by practitioners to develop explosive-strength in the lower-body of boxers were medicine ball throws, box jumps, and jump-squats. In the upper-body, medicine ball slams, explosive or plyometric press ups, and seated or lying medicine ball throws was the most common exercises used. Even though these explosive-strength exercises are similar to what is recommended by world-leading practitioners and researchers to increase punch impact force in combat sport athletes (26,37,39), it's important to note that there has been no experimental research investigating the effect of explosive-strength training on punch impact force in boxing.

Knowledge of the upper- and lower-body's contribution to punching 'power' is important in order to provide evidenced-based guidance for designing and directing boxing-specific strength programmes. Due to weight classifications in boxing, practitioners should be cautious when programming strength exercises that may implement a hypertrophic stimulus on muscles that are not important in contributing to punching 'power' – especially during the 'off-season' when the boxer may in a calorific surplus out of camp. In this study, nearly all trainers and support staff (94%) deemed leg strength and abdominal strength as important or very important for punching 'power.' In contrast, only 67% of practitioners deemed upper-body strength as important or very important for punching 'power.' This view is supported by research in the area of punch kinetics. For example, early work by Smith et al (36) observed that elite boxers produce larger punch impact forces than novice boxers, attributing to greater leg drive and larger rotational force production capabilities of the torso. Further, recent work from Lenetsky et al (25) highlighted that straight and hook punches are full body rotations, initiated by the

legs, sequentially producing torque through the hips and torso musculature, to maximize fist velocity and stiffness during impact. The research group (25) highlighted that, during a punch, the leg contralateral to the punching arm may counteract, or 'block,' force away from the target. This counterforce, similar to a 'block' movement seen in throwing sports (30), is theorised to increase hip rotation velocity, converting linear to angular momentum, therefore increasing impact force during a punch. Additionally, Lenetsky et al also suggested that the latissimus dorsi muscle group may also have a key role in rotation and stiffening during a punch (25). Interestingly, in this survey, the exercise that practitioners utilised the most (85%) to develop upper-body strength was the pull-up or chin-up - which is a key exercise for latissimus dorsi development (9).

After improving punching power, the most prevalent rationale as to why practitioners programme strength training sessions within their boxer's physical preparation programme is to improve muscular endurance and fatigue resistance. Strength-endurance is defined as the ability to produce a high level of muscular activation under work conditions of long duration (40). In boxing, punching is an explosive movement that takes place intermittently over the course of a 9 (amateur) to 36-minute bout (professional) (32). Therefore, like many sports, boxing specifically involves 'explosive' strength-endurance – which is repetitively performing explosive actions over a prolonged period (41). Based on this rationale, it is possible to identify why strength endurance was deemed the second most important strength quality for boxing performance, and why the majority (76%) programmed strength-endurance training methods. However, to date, there has been no experimental research demonstrating that improvements in strength-endurance lead to improvements in punch related characteristics.

The principle of specificity states that training adaptations are specific to the stimulus applied (40). Special-strength training applies the principle of specificity to strength training by utilising exercises that have similar motor patterns and neuromuscular characteristics to the

'competition movement' (e.g. punching) (40). Reactive-strength, which is the most specific of the 'general' strength qualities, is the capacity to bear a stretch load and rapidly switch between eccentric and concentric muscle actions (i.e. the stretch-shortening cycle [SSC]) (32). Both special- ('punch-specific') and reactive-strength strength training were the most popular strength training methods utilised for physical preparation in boxing (93%). Further, 88% of practitioners agreed or strongly agreed that punch-specific strength training improves punching power, with only 3% disagreeing. The most prevalent punch-specific strength exercises used by practitioners were medicine ball punch throws, medicine ball rotational throws, punches with weights, landmine punches, and heavy punch bag pushes. These exercises align with research-informed guidance for punch-specific training in boxers (33). However, given their similarities in physiological, neuromuscular, morphological and biomechanical qualities appear valid, at present, it is unclear whether these exercises transfer to punching capability due to the absence of scientific evidence within this area.

For punch-specific strength assessment, the most common test utilised by practitioners is the MB punch throw. In a controlled laboratory setting, Dunn et al (12) and Finlay et al (17) have highlighted that vertically mounted force platform dynamometry is a reliable and sensitive tool to monitor punch impact force of elite amateur boxers. However, as mentioned earlier, due to a lack of finances and facilities, access to punch dynamometry is limited. Therefore, even though medicine ball assessments (e.g. medicine ball punch throw for distance) may not be as ecologically valid, they provide a cost-effective, reliable and sport-specific alternative for boxing gyms (33).

Maximal-strength is the ability to voluntarily generate maximum force without a time constraint (44). Although maximum-strength, or peak force, is rarely expressed in striking combat sports such as boxing, maximal-strength is a foundational component of explosive-strength and 'power' (6,38). For example, there is a strong relationship between maximal-

strength (i.e. peak force) and explosive-strength (i.e. RFD) (1). Further, the neuromuscular adaptations from maximal-strength training can also improve explosive-strength in athletes who may be relatively weak or who have a limited strength training age (5). Specific to boxing, Dunn et al (11) observed that, in a controlled laboratory setting, the maximum-strength capability of the lower-body explains 46% of the variation in elite male amateur's punch impact force (r = 0.68). Also, the research group demonstrated that elite amateur boxers who punch with 'high' impact forces have significantly greater lower-body maximal-strength (and explosive-strength) when compared with elite amateurs who punch with less impact forces (11).

In this survey, 84% of boxing trainers and support staff agreed or strongly agreed that maximal-strength training improves punching power. However, maximum-strength was implemented the least in the physical preparation programmes of boxers. Practitioners highlighted that fear of increasing muscle mass (i.e. detrimental to making weight & restricting speed and endurance) was the main reason why amateur and professional boxers may not utilise maximum-strength training for physical preparation. This theme was encapsulated by practitioner #46 and #56 stating that boxers and trainers are "*afraid of building too much muscle mass in order to fit in a weight category,*" and are in "*fear [of] getting bigger and slower*." A secondary theme highlighted was that lack of resources (i.e. lack of facilities, finances, education, and expertise) restricted the utilisation of maximum-strength training within boxing. Practitioners #7, #10 and, #48 explained that there were "*limited facilities, [and] financial elements*" in the sport, and that boxers and trainers were "*uneducated on [the] benefits and [on] how to structure strength training*," with a "*lack of technical knowledge to perform [the] lifts safely and with correct technique.*" In addition, other tertiary themes were identified such as the belief that maximum-strength training caused injury and that it was detrimental to speed and mobility. However, no empirical evidence exists to support the belief that maximum-

strength training causes injury and is detrimental to a boxer's speed, endurance, and mobility. For those practitioners that programmed strength training, the most prevalent exercises utilised for the lower-body were lunges, back squats, and trap-bar deadlifts. Also, the most popular exercises utilised to develop upper-body strength were chin ups or pull-ups, press ups and bench press (barbell or dumbbell). Interestingly, for the core, medicine ball rotational throws, overhead throws or slams, which are explosive-type exercises and side planks, which are isometric, were the most popular choices to improve maximal strength of the core. These lower and upper-body exercises are similar to those recommended by world-leading practitioners and researchers to increase punch impact force in combats sport athletes (26,33,37,39).

It is important to highlight that, in this study, the majority of trainers or support staff (i.e. S&C coach, physiotherapy, etc) in boxing work in a voluntary or part-time capacity (64%), with the remainder working in full-time or consultancy roles. Considering that 78% of survey participants work in amateur boxing, it could be speculated that the sport is mainly led by part-time or voluntary practitioners. Further, the majority of practitioners working in amateur and professional boxing do not have a professional S&C or sport science accreditation (e.g. UKSCA, BASES, etc). However, this may be due to the fact that trainers do not require a professional S&C or sport science accreditation to coach the sport. Also, it is important to note that 13% of trainers or support staff were female, potentially highlighting a practitioner gender imbalance in amateur and professional boxing. Considering the physiological stress boxers may experience during a training camp (e.g. cutting weight, brain and musculoskeletal injury from sparring etc), there is an ethical duty for practitioners within the sport to have an adequate level of scientific knowledge to utilise 'research-informed' training methodologies and safeguard that boxers are in 'optimal' physical condition to defend themselves during a bout (and limit the likelihood of repeated punch impact forces to the head or body). Therefore, it is recommended that NGBs around the world provide clubs and their coaches with adequate sport

science education and resources (e.g. qualified S&C support, equipment, funding etc) to ensure the required physical development of their boxers.

Due to the topic of the survey, there was a risk of self-selection bias as coaches and support staff that implement strength training with their boxers may have been more likely to participate, and subsequently increase the risk of confirmation bias, inflating the importance of strength training for boxing performance. The final version of the survey was sent via email to all national amateur boxing federations from each main continent (i.e. Europe, North America, South America, Australia, Asia, Africa), however, we acknowledge the risk of coverage bias given the respondents were required to complete the survey in English, restricting a potentially large population from completing the survey. Further, as the majority of the participants in this study worked in amateur boxing (78%), the results may not give a true reflection of the strength training practices in professional boxing. Also, there may have been a risk of gender bias given only 13% of participants were female. Nonetheless, given that this is the first study of its kind in boxing, the findings may provide a basis for more comprehensive research in both amateur and professional codes (e.g. interviews, focus groups, etc).

The main findings of this study were that practitioners include strength training in amateur and professional boxer's physical preparation programme to improve punching power, muscular endurance and reducing the likelihood of injury. Specifically, punch-specific and reactive-strength training was utilised the most in training. Trainers and support staff (e.g. S&C coaches, physiotherapists, etc) acknowledged that maximal strength training improves 'punching-power', but it was programmed the least due to a lack of resources (i.e. facilities, finances, education, and expertise) and fear of increasing unwanted muscle-mass.

PRACTICAL APPLICATIONS

The results from this study are important for practitioners working in boxing to give them a better understanding of 'current' strength training practices. Considering that a boxer's physical preparation for competition is arduous (i.e. sparring, calorific deficit, weight cut, etc), it is imperative that trainers and support staff have a sound rationale and professional knowledge on 'why' (i.e. improve punching power, muscular endurance, and reduce injury likelihood) and 'how to' (i.e. target explosive- and maximal-strength development, utilise key exercises) programme for strength development. It is recommended that national governing bodies (NGBs) within amateur boxing provide adequate training and education (e.g. via workshops, integrating within coaching awards, etc) in basic S&C, particularly in the areas highlighted in our main findings. For example, coach education workshops could be provided on maximal strength training because it improves 'punching-power', but is programmed the least by coaches and practitioners. Further, these workshops could address (i) coach and athlete concerns that maximum-strength training leads to unwanted increases in muscle-mass, and (ii) demonstrate how to implement maximal strength training with limited resources. As there in no NGBs within professional boxing, it is therefore important that boxers and managers employ support staff that have appropriate qualifications, education, and experience.

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Appendix

Survey Title: Strength Training Practices of Amateur and Professional Boxers

XXX Ethics Application Number: 20200603

I Participant Information & Informed Consent

1. Please indicate whether you would like to participate in this research study. If you agree to participate please sign the consent form below:
   - I have read and understand the information above
   - I agree that research data collected from this study may be published
   - I am over 18 years of age
   - I currently work as a trainer, coach, or in a support staff role (e.g. S&C coach, sport scientist, physiotherapist, nutritionist etc) within senior amateur or professional boxing
     - I agree to participate in this study

II Participant Information

2. What is your gender?
   - Male
   - Female
   - Other (Enter your answer)

3. What country are you currently based in?
   - (Enter your answer)

4. What is your main role within boxing?
    - Trainer or Coach
    - Strength & Conditioning Coach
    - Sport Scientist
    - Physiotherapist
    - Nutritionist
    - Other (Enter your answer)

5. In what capacity do you work within boxing?
    - Full-time (paid) contract
    - Part-time (paid) contract
    - Voluntary
    - Consultancy
    - Other (Enter your answer)

6. How many years of coaching (or support work) do you have in boxing?
    - (Enter your answer)

7. What is the gender of the boxers that you currently work with?
    - Male only
    - Female only
    - Both male and female

8. What is the highest level of boxers that you are currently working with?

- Amateur (County or Local level); Amateur (Provincial or State level); Amateur (National level); Amateur (International level); Amateur (Olympic, European or World level); Amateur (Current or Former 'Olympic, European or World' medallist); Professional; Professional (Current or Former 'National belt holder'); Professional (Current or Former 'Continental belt holder'); Professional (Current or former 'IBF, WBA, WBC or WBO belt challenger'); Professional (Current or former 'IBF, WBA, WBC or WBO belt holder'); Professional (Current or former 'Unified' Champion); or Professional (Current or former 'Undisputed' Champion)

9. What is your highest level of education qualification attained?
    - Secondary school / High school
    - Bachelor's degree
    - Master's degree
    - Doctorate
    - Other

10. Do you hold a national Strength & Conditioning or Sport Scientist accreditation (e.g. UKSCA, BASES, CSCS, ASCA, ASpS)?
    - Yes
    - No

11. What national Strength & Conditioning or Sport Scientist accreditation do you hold?
    - UKSCA - UK Strength & Conditioning Association Accreditation
    - CSCS - USA Certified Strength and Conditioning Specialist

- ASCA - Australian Strength and Conditioning Association Accreditation
- BASES - British Sport and Exercise Scientist Accreditation
- ASpS - Australian Sports Scientist Accreditation
- Other (Enter answer here)

III Perceptions of Strength Training

12. Do your boxers strength train?
    - Yes
    - No

13. In your opinion, why do your boxers not utilise any strength training methods? (If answer in question 12 is No)
    - (Enter your answer)

13.What type of strength training method(s) do your boxers utilise? (If answer in question 12 is Yes)

- **Power or explosive-strength training** (e.g. box jumps, medicine ball throws, vertical jumps, standing long jumps, power cleans, barbell jump squats, bench press throws etc)
- **Strength-endurance training** (e.g. low load, high-repetition body weight exercises such as circuit-type exercises: press ups, lunges, squats, sit-ups, crunches, burpees etc)
- They don't utilise any of these methods
- **Maximal-strength training** (e.g. moderate-to-heavy load [> 80% 1RM] squats, lunges, deadlifts, bench press, shoulder presses, chin ups etc)

- **Plyometric or reactive-strength training** (e.g. skipping, hurdle jumps, hops, bounds, depth jumps, sprinting etc)
- **Punch-specific or special-strength training** (e.g. medicine ball punch throws, landmine punch throws, weighted punches etc)
- Other

14. In your opinion, why do your boxers participate in strength training?

- To reduce injury
- To improve punching 'power'
- To improve hand speed
- To improve footwork and evasion
- To improve their muscular endurance and fatigue resistance
- To improve defence (e.g. clinching, parrying etc)
- I don't know
- Other

15. .In your opinion, what do you think is the most important strength training method for boxing performance?

- **Power or explosive-strength training** (e.g. box jumps, medicine ball throws, vertical jumps, standing long jumps, power cleans, barbell jump squats, bench press throws etc)
- **Strength-endurance training** (e.g. low load, high-repetition body weight exercises such as circuit-type exercises: press ups, lunges, squats, sit-ups, crunches, burpees etc)
- They don't utilise any of these methods

- **Maximal-strength training** (e.g. moderate-to-heavy load [> 80% 1RM] squats, lunges, deadlifts, bench press, shoulder presses, chin ups etc)
- **Plyometric or reactive-strength training** (e.g. skipping, hurdle jumps, hops, bounds, depth jumps, sprinting etc)
- **Punch-specific or special-strength training** (e.g. medicine ball punch throws, landmine punch throws, weighted punches etc)
- Other

16. In your opinion, why do you think some boxers DO NOT utilise maximum-strength training?
    - Enter your answer
17. Please answer each of these questions regarding the importance of 'strength' in boxing

	Unimportant	Of little importance	Moderately important	Important	Very Important
(i) How important is strength and power for amateur boxing performance?	◉	○	○	○	○
(ii) How important is strength and power for professional boxing performance?	○	○	○	○	○
(iii) How important is upper body strength (e.g. chest, shoulder & arm strength) for punching 'power'?	○	○	○	○	○
(iv) How important is abdominal or trunk strength (e.g. 'ab' strength) for punching 'power'?	○	○	○	○	○
(v) How important is leg strength for punching 'power'?	○	○	○	○	○
(vi) How important is strength training for defence in boxing (e.g. footwork / evasion, clinching, parrying etc)?	○	○	○	○	○
(vii) How important is strength training for reducing injury in boxing (e.g. grip & wrist strength, posterior shoulder strength etc)?	○	○	○	○	○

18. Below are a number of statements regarding attitudes to strength training in boxing. Please read each one and indicate to what extent you agree or disagree with each statement

	Strongly disagree	Disagree	No opinion	Agree	Strongly agree
(i) Maximal-strength training (e.g. moderate-to-heavy load exercises) makes boxers slow	◯	◯	◯	◯	◯
(ii) Maximal-strength training makes boxers big and bulky	◯	◯	◯	◯	◯
(iii) Maximal-strength training hinders the ability of boxers to make weight	◯	◯	◯	◯	◯
(iv) Maximal-strength training improves punching 'power'	◯	◯	◯	◯	◯
(v) Strength training helps to retain muscle during a weight cut	◯	◯	◯	◯	◯
(vi) Punch-specific strength training (e.g. med ball punch throws, landmine barbell punch throws etc) improves punching 'power'	◯	◯	◯	◯	◯

IV Strength Training Characteristics (Session Frequency)

19. On average, how many weeks are your boxers in camp (or in full-time training) leading up to a fight or tournament?
    - Option of 1 – 20

20. On average, how many strength training sessions do your boxers complete (per week) when they are in camp (or in full-time training)?
    - Option of 1 – 7

21. On average, how many strength training sessions do your boxers complete during fight week (i.e. the week leading up to a fight or tournament)?
    - Option of 1 – 7

22. Do your boxers strength train when they are NOT in camp or in full-time training (i.e. during their off-season)?
    - Yes
    - No

23. On average, how many strength training sessions do your boxers complete (per week) when they are NOT in camp or in full-time training (i.e. during their off-season)? (If yes was selected in question 22)
    - Option of 1 – 7

V Strength Training Characteristics (Exercises, Intensity & Volume)

23.What type of exercises do your boxers utilise to increase the 'strength' capabilities of their legs? (If no was selected in question 22)
- Landmine squat
- Deadlift (conventional / straight bar)
- Back squat
- Lunges
- Goblet squat
- Leg Press
- Split-squats
- Front squat
- Trap-bar deadlift / Hex-bar deadlift
- Single-leg squats (e.g. pistol squats)
- Bulgarian split-squats / Rear-foot elevated split-squats (RFESS)
- They don't utilise any of these exercises
- Romanian deadlift (RDL)
- Other

24. How many sets and repetitions do your boxers complete to increase the 'strength' capabilities of their legs?
    - (Enter your answer)

25. What type of exercises do your boxers utilise to increase the strength capabilities of their 'core' (e.g. abdominals, lower back, glutes etc)?
    - Back extensions
    - Glute Bridges, hip thrusts
    - Medicine Ball Rotational Throws
    - They don't utilise any of these exercises
    - Roll outs (Ab wheel, Barbell, Swiss ball, TRX etc)
    - Front planks
    - Reverse crunches, leg raises
    - Sky divers / Supermans
    - Cable-pulley Rotations, Landmine Rotations

- Side planks
- Unilateral Farmer Walks
- Pallof Presses
- Medicine Ball Overhead Throws / Slams
- Sit-ups, Crunches
- Other

26. What type of exercises do your boxers utilise to increase the 'strength' capabilities of their upper body (e.g. chest, shoulders, arms, back)?
    - Rows (i.e. barbell row, dumbell row, TRX row, bench row etc)
    - Press ups
    - Shoulder press (i.e. dumbell press, military press, kettlebell press etc)
    - Bench press (barbell or dumbell)
    - They don't utilise any of these exercises
    - Chin ups / pull ups
    - Dips
    - Landmine press
    - Floor press (dumbell or barbell)
    - Other

VI Power Training Characteristics (Exercises, Intensity & Volume)

27. What type of exercises do your boxers utilise to increase the 'power' of their lower body?
    - Medicine ball throws
    - Box jumps
    - Broad jumps / standing long jumps
    - Lateral jumps / Skater Jumps (jumping laterally from one leg to the other)
    - Squat-jumps with weight (jumps with barbell or trap-bar from a static start position)
    - They don't utilise any of these exercises
    - Kettlebell swings
    - Squat-jumps (jumps with from a static start position)
    - Power cleans
    - Jump-squats with weight (e.g. barbell or trap-bar jumps)
    - Jump-squats / Countermovement Jumps
    - Other

28. What type of exercises do your boxers utilise to increase the 'power' of their upper body?
    - Landmine press throw (without using legs)
    - Medicine Ball Slams

- Seating or lying medicine ball throw (without using legs)
- They don't utilise any of these exercises
- Battle ropes
- Bench press throw
- Explosive or 'clap' press ups
- Other

29. What type of plyometric (i.e. reactive-strength) exercises do your boxers utilise?
    - They don't utilise any of these exercises
    - Skipping (with jump rope) for maximal height
    - Drop-jumps
    - Bounding (jumping forward from one leg to another)
    - Hops (jumping vertically with maximal height and minimal ground contact)
    - Depth Jumps
    - Hurdle hops
    - Sprints (i.e. 0 - 40m, maximal effort)
    - Other

30. What type of 'punch specific' strength exercises do your boxers utilise?
    - Medicine ball 'punch' throw
    - Medicine ball 'rotational' throw
    - Punches with weights (e.g. light dumbbells)
    - They don't utilise any of these exercises
    - Heavy punch bag push
    - Landmine (barbell) punch
    - Other

VII Strength & Power Assessment

31. Do you test the 'strength' or 'power' of your boxers?
    - Yes
    - No

32. What method do you utilise to assess the 'strength' of your boxers?
    - Load-velocity tests (e.g. Gym Aware, Push band, Output Sports, GymAware, Tendo etc)
    - Isometric tests with a force platform (e.g. Isometric mid-thigh pull or squat)
    - Repetition maximum (RM) tests (i.e. 1-5 RMs)
    - Other

33. What 'strength' assessments do you use with your boxers?
    - Trap-bar deadlift
    - Isometric mid-thigh pull (IMTP)
    - Bench press
    - Landmine press
    - Isometric bench press
    - Back squat
    - Isometric squat
    - They don't utilise any of these tests
    - Single-leg squat (e.g. Bulgarian split-squat)
    - Other

34. What 'power' or 'plyometric' assessments do you use with your boxers?
    - Bench press throw
    - Power clean
    - Standing long jump / broad jump
    - They don't utilise any of these tests
    - Depth-jump
    - Medicine ball rotational throw
    - Squat jump (from static start position)
    - Drop-jump
    - Medicine ball overhead throw
    - Medicine ball 'dive' throw (horizontal)
    - Countermovement jump (CMJ)
    - Other

35. What 'punch-specific' strength assessments do you use with your boxers?
    - Medicine ball rotational throw
    - Medicine ball 'punch' throw
    - They don't utilise any of these tests
    - Punch dynomometer
    - Landmine (barbell) punch throw
    - Other

36. Do you have any 'standards' for your strength and power assessments?
    - Yes
    - No

37. If so, what are your strength and power 'standards'?
    - (Enter your answer)

Figure 1

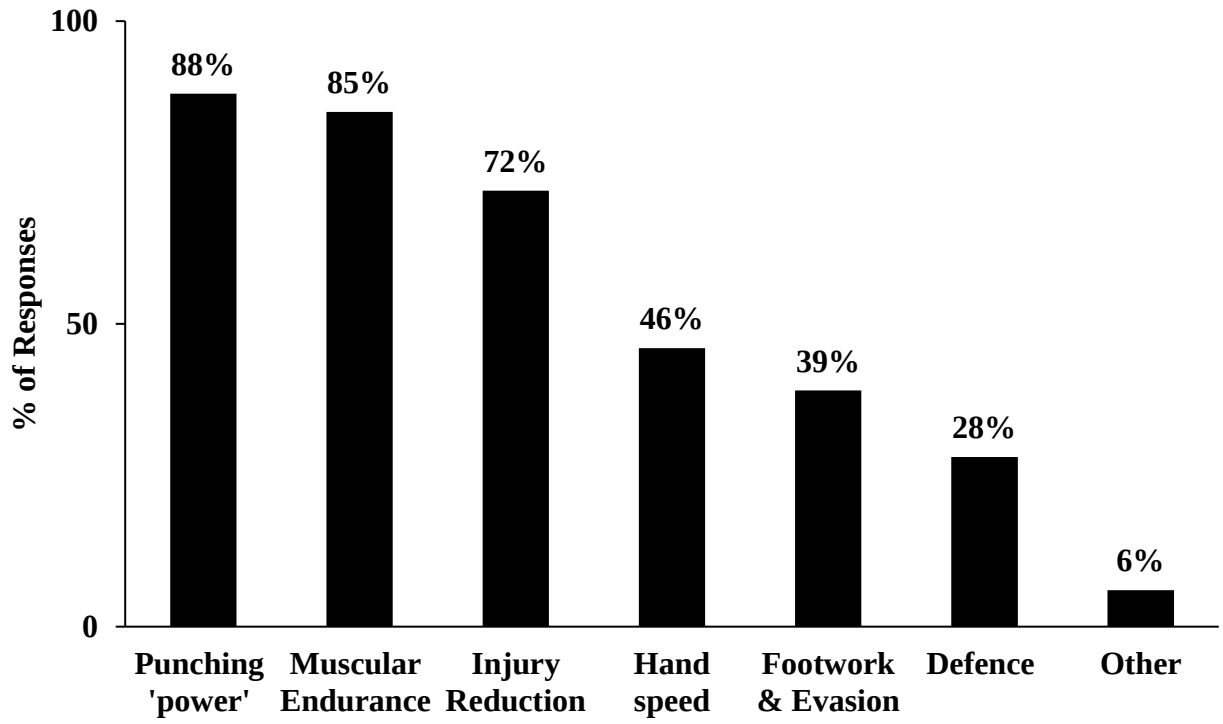

Figure 1. Practitioner's rationale for utilising strength training methods in Amateur and Professional Boxing (n = 67). N.B. percentages do not sum to 100% due to practitioners having the option to select multiple answers.

Figure 2

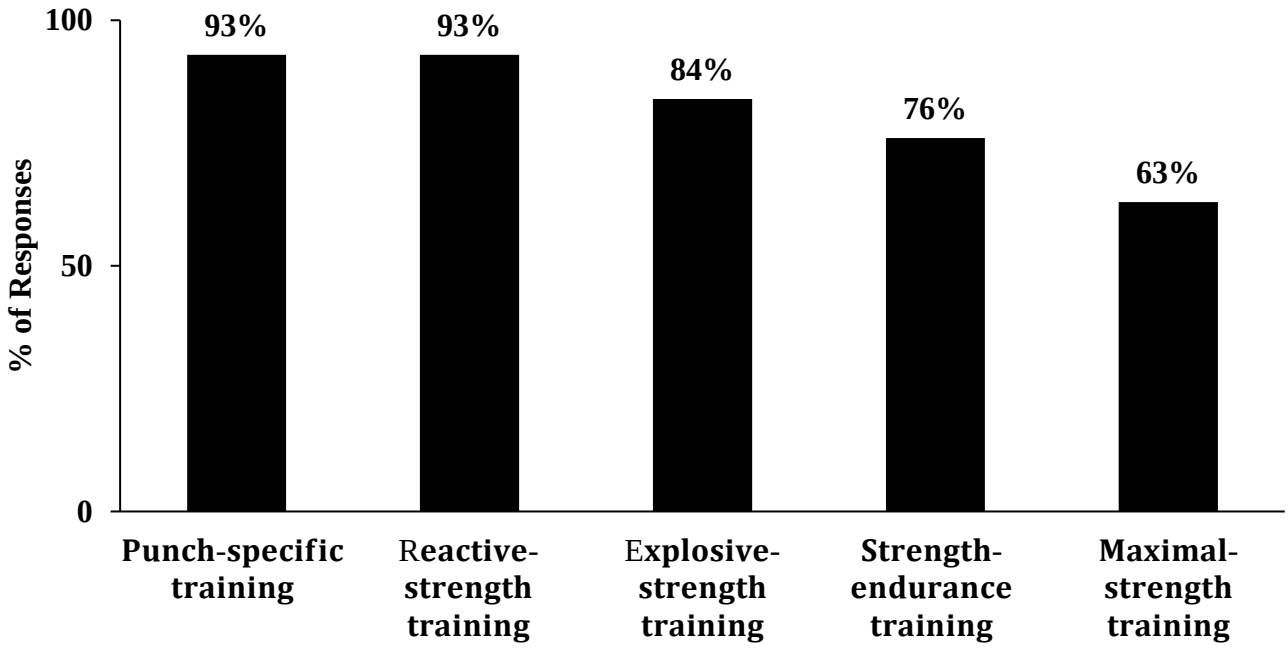

Figure 2. Strength training methods utilised in Amateur and Professional Boxing (n = 67). N.B. percentages do not sum to 100% due to practitioners having the option to select multiple answers.

Figure 3

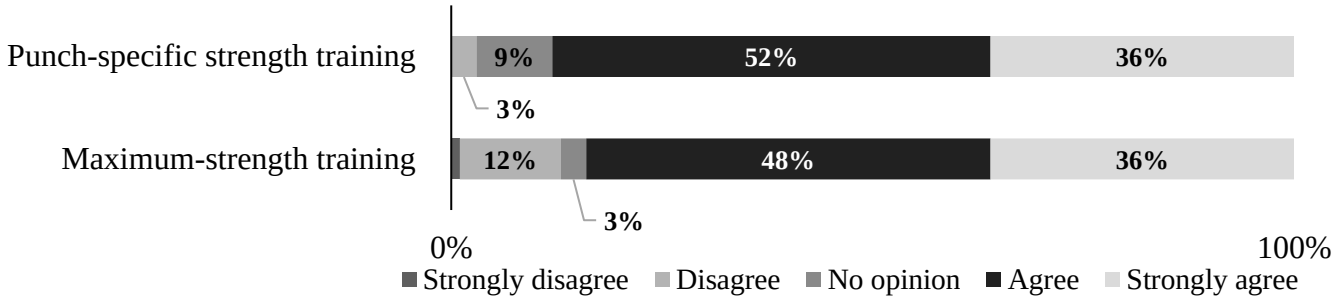

Figure 3. Frequency distributions (%) of the practitioner's level of agreement that maximal-strength training and punch specific strength training improve punch power in boxing

Figure 4

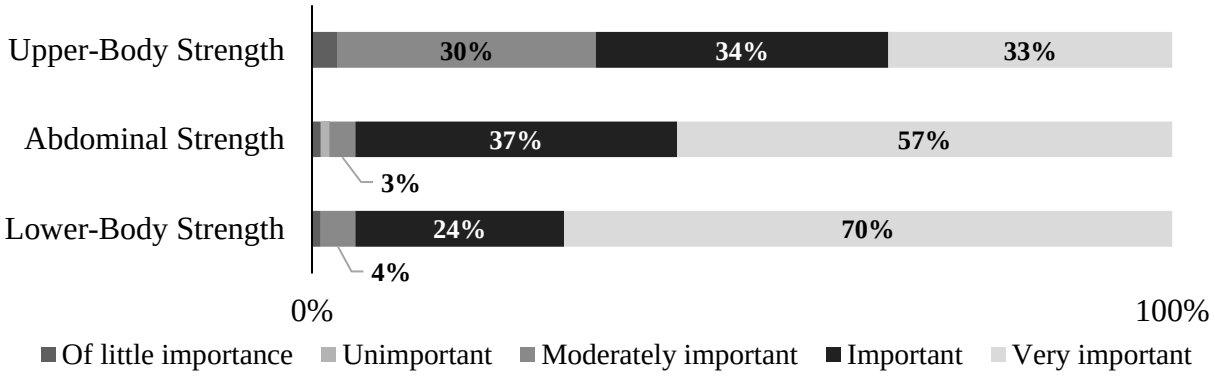

Figure 4. Frequency distributions (%) of the practitioner's view on the importance of upper-body strength, abdominal strength and leg strength for punch power (n = 67).

Figure 5

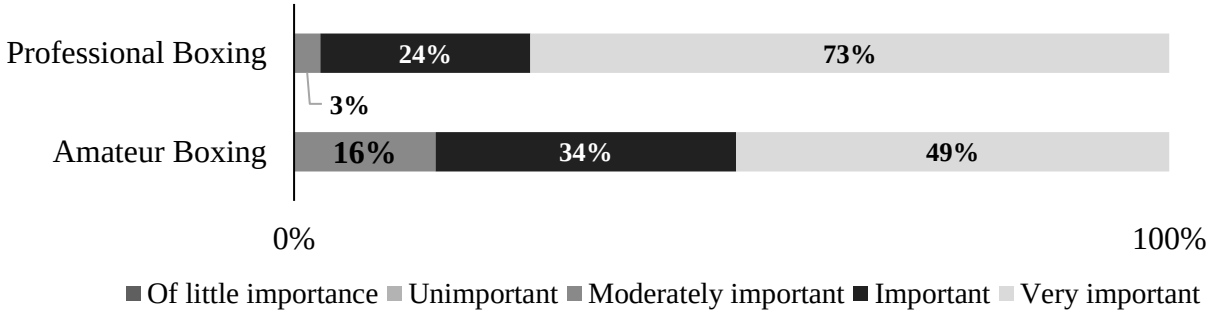

Figure 5. Frequency distributions (%) of the practitioner's view on the importance of strength and power for amateur and professional boxing performance

Table 1. Higher-order themes identified from practitioners on why amateur and professional boxers may not utilise maximum-strength training for physical preparation

Theme		*Representative Quotes*	*Participant ID*
1	**Fear of increasing muscle mass**		
	Making weight	*"Afraid of building too much muscle mass in order to fit in a weight category" "Some don't want to have big muscles because it means more weight" "Increased muscle size can hamper weight making"*	#46, #28, #17
	Restricting speed & endurance	*"Fear getting bigger and slower" "extra muscle will reduce their endurance and reactions responses" "boxers and their coaches think this will impede on their speed and agility, making them too heavy to move quickly" "They feel that extra muscle will reduce their endurance and reactions responses" "adding too much muscle mass and as a result a loss of speed"*	#56, #62, #22, #39
2	**Lack of resources**		
	Facilities & Finances	*"limited facilities, financial elements" "My boxing gym does not have any heavy weights" "additional time and cost involved. This is ok for full time athletes who are funded and have the resources and training centres equipped with adequate facilities and equipment"*	#7, #31, #38
	Education	*"Lack of knowledge in S&C benefits" "Lack of knowing why... don't know how it links to fighting" "uneducated on benefits and how to structure strength training" "a lack of [S&C] knowledge by older coaches" "lack of [S&C] education in the sport"*	#3, #5, #10, #1, #16
	Expertise	*"No one to teach them [S&C exercises]" "lack of technical knowledge to perform [the] lifts safely and with correct technique" "[lack of S&C] guidance from a competent coach"*	#29, #48, #4
3	**Detrimental to Speed**	*"Some coaches believe the heavier lifting could compromise the speed and agility of a boxer" "maximum-strength training will slow down their athlete" "Old stereotype, that barbell, strength work makes boxer slower"*	#44, #63, #42
4	**Traditional Training Methods**	*"training methods can get stuck in the past...There are still many dogmatic coaches" "old school mentality" "old-fashioned training methods"*	#11, #5, #36
5	**Detrimental to Mobility**	*"reduction in mobility" "In fear of...shortening of the muscle" "muscle stiffness"*	#43, #60, #40
6	**Fear of Injury**	*"fear of injury" "bone growth plates affected"*	#49, #18

Table 2

Table 2. Frequency of practitioner's exercise selection (%) (i) to develop reactive-strength and special-strength capabilities in amateur and professional boxing, (ii) to develop explosive-strength capabilities of the lower-body and upper-body, (iii) develop strength capabilities of the lower-body, upper-body and core, and (iv) assessment selection to monitor strength, explosive-strength and special-strength in amateur and professional boxing

(i)	***Reactive-Strength Exercises***	***Special-Strength Exercises***
1	Sprints (i.e. 0-40m, max. effort) (78%)	MB Punch Throw (84%)
2	Skipping (with rope, for max. height) (66%)	MB Rotational Throw (73%)
3	Hops (57%)	Punches with weights (58%)
4	Drop-jumps (49%)	Landmine (barbell) Punch (52%)
5	Bounding (46%)	Heavy Punch Bag Push (48%)
(ii)	**Explosive-Strength Exercises**	
	Lower-Body	**Upper-Body**
1	MB Throws (78%)	MB Slams (85%)
2	Box Jumps (72%)	Explosive / 'Clap' Press-ups (64%)
3	Jump-squats / CMJs (69%)	Seated / Lying MB Throw (55%)
4	Squat-jumps (63%)	Battle Ropes (49%)
5	Broad jumps / Standing Long Jumps & Lateral / Skater Jumps (60%)	Landmine Throw (seated) (45%)
(iii)	**Strength Exercises**	
	Lower-Body	**Core**	**Upper-Body**
1	Lunges (81%)	MB Rotational Throws (81%)	Chin-ups / Pull-ups (85%)
2	Back Squat (67%)	MB Overhead Throws / Slams (76%)	Press-ups (70%)
3	Trap-bar Deadlift (51%)	Side Planks (75%)	Bench Press (barbell or dumbbell) (70%)
4	Split-squats (51%)	Front Planks (72%)	Rows (e.g. barbell or dumbbell) (64%)
5	Deadlift (conventional) (51%)	Sit-ups / Crunches (66%)	Shoulder Press (63%)
(iv)	**Assessment**		
	Strength	**Explosive-Strength**	**Special-Strength**
1	Bench Press (61%)	Squat-jump (57%)	MB Punch Throw (54%)
2	Back Squat (59%)	Countermovement jump (54%)	Punch Dynamometer (35%)
3	Trap-bar Deadlift (43%)	Broad Jump / Standing Long Jump (39%)	MB Rotational Throw (35%)
4	Isometric Mid-thigh Pull (22%)	MB Rotational Throw (39%)	Landmine Punch Throw (26%)
5	Single-leg Squat (20%)	MB Overhead Throw (35%)	None of these tests (20%)

MB = medicine ball; CMJ = countermovement jump; max = maximum