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ORIGINAL ARTICLE

Grunting increases power production and vertical jump height in experienced martial artists

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ABSTRACT

Muscular power is a critical determinant of performance in athletic competitions and thus identifying methods to maximize this attribute is imperative. Grunting (GR) may be an effective way to increase power during high-velocity, explosive movements. The purpose of the current investigation was to determine the effects of GR on muscular power output. Twenty-four subjects were recruited from a local martial arts academy. Each subject had a minimum of 2 years of martial arts experience. The performance measures included five maximal cross punches (CR) and roundhouse kicks (RH) to determine peak power output and three countermovement vertical jumps (CMJ) and seated landmine throws (SLT). In randomized order, subjects performed these tests under three breathing conditions which included held breath (HB), audible exhale (AE), and GR. When compared to AE and HB conditions, GR increased CR and RH power output and CMJ height but not SLT. Grunting is effective at increasing force production during striking in experienced martial artists.
Keywords: Performance analysis, Breathing, Kiap, Punch, Cross, Kick.

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INTRODUCTION

As the level of competition rises, the disparity between winning and subsequent positions decreases. During the 2020 Tokyo Olympics, in the men's 96 kg category of Olympic Weightlifting, the second and third-place finishers had the same total weight lifted; the difference between second and fourth place was 0.2% (IOC, n.d.). As such, athletes and coaches actively seek means to make even small performance improvements. Previous efforts to gain such marginal gains are seemingly unlimited, among them include nutritional supplementation (Schubert & Astorino, 2013), varying exercise programs (Cejuela & Sellés-Pérez, 2022), footwear (Sun et al., 2020) and equipment modification (Ahmad & Hussain, 2024). This becomes increasingly important when the athlete, rather than competing against a clock, is doing so against an opponent who is striving for marginal performance gains.

Muscular power, defined as the ability to exert force per unit of time, is an important factor in determining the performance of various athletic skills (Sapega & Drillings, 1983). Differences in muscular power output may, at least partially, explain the performance differences between elite, proficient, and novice athletes (Baker, 2001). For example, Baker (2001) determined that, despite no differences in individuals' height and mass between levels, national rugby players had greater upper body power compared to state- and city-league players. Professional cyclists display higher levels of lower leg power compared to amateur cyclists (Alejo et al., 2022) and lower body power is higher in elite soccer players compared to amateur players (Slimani & Nikolaidis, 2019). Elite national handball players exhibit great upper and lower body power during the bench press and half squat and throwing velocities compared to second-division national players (Gorostiaga et al., 2005). Due to the importance of muscular power in athletic performance, identifying strategies to maximize this physiological trait is critical.

Striking power is an important characteristic in determining competitive success in boxers (Chaabène et al., 2015; Lenetsky et al., 2013; Pierce et al., 2006). In a study of professional boxing matches, researchers (Pierce et al., 2006) determined that, when a winner was chosen via decision, the athlete that delivered more forceful strikes over the duration of the bout and the greater number of punches was victorious. In national-level boxers, athletes with greater lower body power displayed more effective strikes to the head and a reduction in stoppage time during bouts (Rimkus et al., 2019). These studies demonstrate the importance of striking force in an authentic environment.

Creating an audible noise, or vocal disinhibition, during explosive movements is a common technique used as an ergogenic aid to increase muscular power output and is used in throwing events, tennis, martial arts, and weightlifting (Callison et al., 2014). In traditional martial arts, the audible noise has varying names, including kia, kihap, kiap and, recently, is referred to as grunting (GR). Although research on the impact of grunting on muscular power output is limited, researchers have shown that grunting can enhance performance in several sports, including tennis (Callison et al., 2014; O'Connell et al., 2014, 2016) and baseball (Tammany et al., 2021). Specifically, GR increases tennis serve and pitch velocity (Callison et al., 2014; Tammany et al., 2021). In tennis, GR garnered ample attention as some competitors contend that it is cheating. During Wimbledon matches, complaints were levied against grunters, and in 2023, an opponent was given a point because of excessive GR (Kamal, 2023).

Morales (1999) examined the effects of GR on isometric deadlift strength and EMG activity of the biceps femoris and rectus femoris. The researchers (Morales et al., 1999) found no significant differences in strength output or EMG activity when GR versus not GR. Although there were no significant differences for these measures, Morales (1999) reported that grunting increased power output by 2.3% in athletes and 5% in nonathletes. The authors contend that these increases, although not significant, may be meaningful in determining the outcomes of athletic competitions.

In combat sports, there is a long-held belief that GR will increase force output and improve performance while striking (Welch & Tschampl, 2012), however, the supporting research is limited. Welch and Tschampl (2012) examined the effects of grunting on isometric handgrip strength in novice and expert martial artists. In this study, subjects performed three repetitions of maximal handgrip dynamometry while holding their breath or grunting. The researchers concluded that grunting increased handgrip strength in both novice and expert martial artists (Welch & Tschampl, 2012). Moreover, GR increases in Dolio-chagui kick power output in expert Taekwondo martial artists (Martins et al., 2014).

Because of the importance of optimizing muscular power output in combat sports and the potential benefit of GR in this pursuit, the purpose of the current study was to determine the effects of GR on performance in experienced martial artists employing dynamic tests. The tests used included a cross (CR), roundhouse kick (RH), countermovement jump (CMJ), and seated landline throw (SLT). The researchers hypothesized that GR would increase muscular power output compared to the held breath (HB) and audible exhale (AE) for all dependent variables.

METHODS

Twenty-four subjects participated in the research study including 10 males and 14 females. Inclusion criteria in the study included those subjects participated in martial arts classes for a minimum of the previous two years at least twice per week. Individuals were excluded from the study if they had preexisting cardiovascular disease.

Subjects were recruited from a local martial arts academy. After agreeing to participate in the study, subjects were asked to complete a health history questionnaire to determine if they met the inclusion criteria. Upon arriving at the testing facility and before any data collection commenced, subjects completed an informed consent. All methods were approved by the University Institutional Review Board (IRB) prior to the start of the research study.

Before testing, subjects completed a dynamic warm-up including jogging for three minutes, high knees, hamstring stretch, and lateral skips. This warm-up was designed to resemble a typical warm-up included in martial arts classes. In randomized order, subjects performed a dominant hand CR, dominant foot RH, CMJ, and SLT. Subjects performed each test under three breathing conditions which included HB, an AE, and GR. The breathing technique used during each test was randomized. For all tests, each repetition was separated by 30s and inter-set rest was 3 min.

Cross and roundhouse power

Each subject performed five repetitions of a dominant hand CR and dominant leg RH. In order to minimize fatigue, each repetition was separated by 30 seconds. CR and RH force were measured using a PowerKube® (Strike Research Ltd., England, UK.). Researchers (Del Vecchio et al., 2022) determined that the PowerKube® is highly reliable for measuring impact kinetics with a technical error of the measurement of 0.8% for straight strikes. During punch testing, the top of the pad adjusted to the level of the acromion process for each subject. During RH testing, the top of the pad was set at the level of the subject’s iliac crest.

During CR testing, subjects wore 453.59 g (16 oz) boxing gloves to minimize the risk of hand and wrist injuries.

Countermovement vertical jump

The subjects performed three CMJ with no arm swing for maximal height. CMJ height was measured using a JustJump! mat (Probotics, Inc., Huntsville, AL, USA) and rounded to the nearest cm.

Seated landmine throw

The methods for performing the SLT have been previously described by Omcirk (2024). Briefly, subjects gripped a barbell in their dominant hand with the hand close to the shoulder and elbow fully flexed. The research assistants provided a verbal signal for the subject to begin the throw. During this phase, the subject rotated their torso while simultaneously performing dynamic shoulder flexion and elbow extension to throw the barbell as forcefully as possible. In order to reduce the risk of injury, the research assistants caught the barbell at a maximum distance away from the subject and slowly lowered the barbell into the hand of the subject. In order to determine the power output during the SLT a Tendo unit (TENDO Sports Machines, Trencin, Slovak Republic) was attached to the end of the bar and recorded after each repetition.

Statistical analysis

An observational-descriptive study design was selected, utilizing counterbalanced repeated measures.

An a priori analysis was performed with available freeware (G*Power, v 3.1.9.6, Düsseldorf, Germany) to ensure we do not commit a beta error. Utilizing effect size values of GR on muscular output from a previous investigation (Welch & Tschampl, 2012), a sample size of 10 was needed to achieve a statistical power of at least .80.

From the associations that were statistically significant ($p \leq .05$), effect size calculations were generated post-hoc.

A repeated measures multivariate analysis of variance (RM-MANOVA) was used to test for significant differences in RH, CR, SLT, and CMJ by breathing conditioning (HB vs. AE vs. GR). Force was measured in watts for the CR, RH, and SLT, while CMJ was measured in cm. Once statistically significant differences were identified, a Cohen's *d* Effect size was calculated post-hoc for each relationship. All data were analysed using an alpha level of .05 utilizing SPSS v24 (IBM, NY).

RESULTS

The age range for the subjects was 19.69 to 52.65 YOA with a mean of 34.46 YOA. The mean mass of the subjects was 78.321 kg (± 17.054 kg) and the mean height was 166.342 cm (± 9.699 cm).

There was no statistically significant difference between HB and the AE for the peak power (Watts) in the RH (p = .234), CR (p = .858), or the CMJ in cm (p =.075).

There was a statistical difference between the GR condition and both the HB condition and the AE condition for five of the six mean group comparisons. Mean group difference for the GR conditioning was statistically significant when compared to HB in the RH (p = .017), and CR (p = .008) peak power output, but not the CMJ (p =.160). Mean group difference for GR was statistically significant when compared to AE in the RH (p = .034), CR (p = .002), and the CMJ in cm (p < .001).

There were no group significant mean differences for the SLT activity between any of the breathing conditions. Group Means and Standard Deviations for the RH, SLT, CR, and CMJ are noted in Table 1.

Table 1. Group means and standard deviations for dependent variables.

	Condition	Mean	Standard Deviation
RH (peak Watts)	HB	26124.696	10640.359
	AE	27503.652	11914.751
	GR	28851.739	12606.367
STL (peak Watts)	HB	493.348	201.871
	AE	470.334	193.906
	GR	485.927	191.305
CR (peak Watts)	HB	11028.130	6358.724
	AE	11081.522	6523.848
	GR	12131.652	6825.415
CMJ (cm)	HB	47.090	13.131
	AE	46.050	13.535
	GR	47.917	13.271

Note. HB = Held Breath; AE = Audible Exhalation; GR = Grunting.

The effect sizes were calculated as small-to-moderate for RH (Cohen's *d* = .234, grunt vs HB, Cohen's *d* = .11 grunt vs AE).

The effect sizes were calculated as small for CR (Cohen's *d* = .169, grunt vs HB, Cohen's *d* = .157 grunt vs AE).

The effect sizes were calculated as small for CMJ (Cohen's *d* = .063, grunt vs HB, Cohen's *d* = .139 grunt vs AE).

Percent differences for statistically significant results are presented in Table 2.

Table 2. Percent differences for independent variables upon statistically significant different outcomes.

	GR improvement versus HB	GR improvement versus AE
RH	10.44%*	4.90%*
CR	10.01%*	9.48%*
CMJ	1.76%	4.06% *

*Note. * Statistically Significant at p ≤ .05.*

DISCUSSION

The primary findings of the current research are that GR increases power output for the cross and RH compared to AE and HB conditions. GR had no effect on power output during a SLM throw but did increase vertical jump height when compared to an AE. The effect size for the grunt condition ranged from small to moderate for the different conditions. The key findings of the current research are that GR increased the power output of the CR by 10.01% compared to the HB condition and 9.48% compared to an AE. Furthermore, when compared to the HB condition, GR increased the peak force of the RH by 10.44% and by 4.90% compared to an AE.

Previous researchers have reported similar increases in power output while GR during sport-specific activities. In collegiate tennis players, GR increased ball velocity by 4.91% during a tennis serve and by 3.80% to 5.39% during ground strokes (Callison et al., 2014; O'Connell et al., 2014). Moreover, GR increased throw velocity by 3.60% in collegiate baseball pitchers (Tammany et al., 2021). Li and Rymer (2011) examined the effects of a forceful exhale on finger strength and determined that a forceful exhale increased finger flexion force. The researchers (Li & Rymer, 2011) attribute this increase in force to augmented corticospinal excitability. Given these results, it is possible that GR increases corticospinal excitability leading to greater force production during the CR, RH, and CMJ in the current study.

Punching is a complex motion that requires kinetic linking between the lower body, torso, and arms (Lenetsky et al., 2013). The components of a punch are typically described as leg push-off, trunk rotation, and arm extension (Filimonov et al., 1985). Forces must be effectively transferred from the ground, through the legs, torso, and finally the arms (Lenetsky et al., 2013). O'Connell (2016) determined that GR increased internal oblique EMG activity during a simulated tennis serve when compared to a Valsalva manoeuvre. Furthermore, isometric shoulder flexion peak torque improves with increased levels of rectus abdominis activation (Cacolice et al., 2021). Similarly, Maeo et al. (2013) reported an increase in internal oblique EMG activity during abdominal bracing compared to abdominal hollowing. A possible explanation for the increase in punch force while GR observed in the current study is that GR increased abdominal muscular recruitment leading to greater rotational power. Furthermore, force transfer between the lower body and arms may be improved due to increased thoraco-lumbo-pelvic stiffness while GR (Cacolice et al., 2021).

The research regarding the effects of GR on kick force is limited. Martins et al. (2014) examined the effects of GR on kicking performance in experienced Taekwondo practitioners. In order to determine kick performance, the researchers (Martins et al., 2014) attached an accelerometer to a punching bag and determined that GR increased bag acceleration when the subjects grunted. The reported improvement of GR on kick performance was approximately 10% and had a large effect size (Martins et al., 2014). The mechanisms for improvement of RH impact kinetics may be similar to those reported during punching including increased corticospinal excitability (Li & Rymer, 2011), rotational forces (O'Connell et al., 2016), and torso stiffness (Cacolice et al., 2021).

The improvements in CR and RH power output observed while GR is profound and equal to or greater than resistance training programs aimed at increasing punch power (Loturco et al., 2018, 2019). Loturco et al. (2019) examined the effects of a short-term (i.e. one-week) optimal power resistance training program on punch force in elite boxers. The researchers (Loturco et al., 2019) reported an increase in punch of 8% after the program. Similarly, after elite boxers participated in a 10-week resistance training program, upper body power output increased by 8% (Loturco et al., 2018). In comparison, subjects during the current study had a greater increase in CR power output when grunting compared to the HB or AE conditions.

To the best of our knowledge, this is the first study to examine the effects of GR on CMJ performance. Lenehan and Scott (2012) reported that GR increased standing long jump distance with a medium effect size. Interestingly, GR increased CMJ height more than AE but was not significantly different from the HB condition. The CMJs completed during this study were completed with no arm swing. GR may be more effective for full-body movement, where kinetic linking between the upper and lower body is important for performance. Additionally, these results may partially be explained by the subjects used during the study. While the subjects were all physically active and participating in martial arts classes, GR while jumping may have been novel.

GR had no effect on power output during the SLM compared to other breathing conditions. The SLM is a unique exercise, requiring specialized equipment, that the subjects may not have performed previously. Similar to GR while performing a CMJ, it is possible that the novelty of the movement led to the lack of significant differences. The position of the subjects during the SLM could also explain the lack of difference between breathing conditions. Subjects were seated during the SLM in order to limit lower body movement during the test. It may be that GR is more effective at increasing force output when the upper and lower body are free to move in unison.

While GR increased strike force, there may be additional competitive advantages to GR. Using video analysis, Sinnet et al. (2018) examined the ability of subjects to accurately predict the initiation of a kick and the trajectory of the kick while the performer grunted or remained silent. The researchers determined that when subjects viewed the video of individuals kicking while GR, the ability to accurately predict when the kick started and the trajectory of the kick decreased. Sinnet et al. (2018) attributed this higher error rate to distraction caused by the GR.

There are several limitations to the current investigation. Due to time constraints, there was no familiarization period for the SLM throw. While subjects were provided the opportunity to complete 3-5 warm-up repetitions with an unloaded barbell, this may not have been sufficient practice to optimize the movement. Another potential limitation is that distance from the Powerkube was not measured during the CR or RH. However, subjects remained in the same position throughout the testing when possible, although some subjects needed to change positions after kicking.

Future research should investigate the effects of GR on EMG activity of the abdominal musculature while striking. Furthermore, ground reaction forces could be measured while GR during striking. Finally, researchers should determine if GR increases corticospinal excitability more than a forceful exhale.

CONCLUSION

Muscular power output is an important quality for many athletes, and thus, determining ways to maximize this characteristic should be paramount for athletes and coaches alike. GR is an easy and cost-effective way of increasing power output during explosive movements including striking and jumping. GR seems to be more effective at increasing power output during activities that require kinetic linking between the upper and lower extremities.

AUTHOR CONTRIBUTIONS

The authors listed contributed to the research study conceptualization and data collection: Jason Sawyer, Michael Pepin, and Paul Higgins. Paul Cacolice curated and analysed the data. Jason Sawyer, Paul Cacolice, Paul Higgins, and Michael Pepin completed the writing, editing, and final draft preparation.

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DISCLOSURE STATEMENT

No potential conflict of interest was reported by the authors.

DATA AVAILABILITY STATEMENT

Anonymized datasets are available upon request.

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