RESISTANCE TRAINING PRIMING ACTIVITY IMPROVES UPPER-BODY POWER OUTPUT IN RUGBY PLAYERS: IMPLICATIONS FOR GAME DAY PERFORMANCE

BILLY R.J. MASON,[1,2] **CHRISTOS K. ARGUS,**[2,3] **BEN NORCOTT,**[3] **AND NICK B. BALL**[1,2]

[1]Faculty of Health, Discipline of Sport and Exercise Science, University of Canberra, Bruce, ACT, Australia; [2]Research Institute for Sport and Exercise Science, University of Canberra, Bruce, ACT, Australia; and [3]Brumbies Rugby, Bruce, ACT, Australia

ABSTRACT

Mason, BRJ, Argus, CK, Norcott, B, and Ball, NB. Resistance training priming activity improves upper-body power output in rugby players: implications for game day performance. *J Strength Cond Res* 31(4): 913–920, 2017—"Priming" or preactivation strategies performed in the hours leading into competition have been suggested to improve game day performance. Therefore, this study assessed the effectiveness of a resistance training priming activity on eliciting changes in lower- and upper-body power output, along with perceptual measures. To assess these changes, 13 state-level rugby players (aged 18.5 ± 0.5 years) completed a test–retest protocol using a counterbalanced crossover design. Perceptual (readiness to perform questionnaire) and performance measures (20-kg countermovement jump [CMJ], 20-kg bench throw) were completed before either a control (rest) or priming activity (4 sets of 3 banded back squats and banded bench press). After a 1-hour and 45-minute recovery period, perceptual and performance measures were repeated. Readiness to perform showed no meaningful differences pre- and postintervention. Bench throw peak power (8.5 ± 5.8%, 90% confidence limit; $p \leq 0.05$) improved after the priming activity when compared with the control trial. Countermovement jump peak power (3.4 ± 4.9%; $p > 0.05$) had a small decrease after the priming activity when compared with the control trial. Therefore, completing a priming activity 1 hour and 45 minutes before competition is recommended to improve upper-body power output. However, further research into lower-body priming protocols should be conducted before implementing a lower-body priming activity before competition.

KEY WORDS countermovement jump, bench throw, squat, bench press

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Address correspondence to Billy R. J. Mason, billy.mason@live.com.au.

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INTRODUCTION

To optimize physical performance in team sport athletes, a considered balance of work to rest in the training week leading into competition is required (31). Furthermore, preactivation strategies or "priming activities" performed in the hours leading into competition have been suggested to further improve performance on the day of a match. (11,27). Kilduff et al. (27) recently reviewed preconditioning strategies (warm-ups, passive heat maintenance, postactivation potentiation [PAP], hormonal priming, remote ischemic preconditioning, and morning resistance training) and their contribution in improving performance on the day of the competition (27). Of the preactivation strategies reviewed (27), 5 of the 6 were suggested to have the greatest effect when implemented within 1 hour of competition, with the only exception being the use of morning resistance training, which improved performance when implemented 6 hours before competition (11,16,27,33).

Although morning resistance training extends outside of the implementation timelines seen with more acute preactivation strategies (i.e., those implemented <1 hour before competition), research suggests that a bout of morning resistance training leads to improvements in lifting, jumping, and maximal sprints that are performed later in the day (11,16,33). Cook et al. (11) assessed the effects of 2 different morning exercise protocols (resistance training or sprint training) on afternoon performance. Using 18 male semiprofessional rugby players, Cook et al. (11) found that when compared with sprint and control trials, a morning resistance training session comprising a 3-repetition maximum (RM) back squat and bench press led to greater improvements in afternoon performance; more specifically, improvements in countermovement jump (CMJ) peak power, 40-m sprint time, and 3RM bench press and back squat (11). It was also reported that morning resistance training attenuated the decline of salivary testosterone concentrations (11), which because of the link between testosterone levels and athletic performance (9,13), may be associated with the improvements in performance later in the day. The findings from Cook et al. (11) support previous research by Ekstrand et al. (16), who reported that throwing performance in shot putters improved in the 4–6 hours after the implementation of morning resistance training (16). Using 14 subjects (7 male and 7 female subjects) with greater than 4 years throwing experience, Ekstrand et al. (16) observed significant increases in the backwards overhead shot throw after a bout of morning resistance training, comprising 1RM back squats and 4RM power cleans, when compared with a control trial (16).

Considerable research has looked at the effect a priming activity implemented 1 hour before competition has on subsequent performance (7,14,22,26,27), with research also reporting improvements in performance 6 hours after a priming activity (11,16,33,37). Still, there is limited research assessing the influence of priming activities on match performance when implemented in the 1- to 6-hour period before the start of competition (16). Therefore, the purpose of this study was to assess if the priming effects of a resistance training priming activity were evident after a recovery period of 1 hour and 45 minutes. This timeframe provides a practical application for club- and state-level rugby union players who typically assemble 2 to 3 hours before competition. A secondary aim for this study was to assess perceptual responses after a priming activity and the relationship between these responses and variations in performance. It was hypothesized that improvements in performance, more specifically lower- and upper-body power output, would be seen after a priming activity. Additionally, because of hormonal variations (11) and an anecdotally reported "feel good" response after resistance training (20), it was further hypothesized that there would be positive changes in perceptual responses after a priming activity.

METHODS

Experimental Approach to the Problem

Figure 1 provides an overview of the testing procedure. Using a test–retest protocol with a counterbalance crossover design, a group of state-level rugby players were assessed for changes in lower- and upper-body power output and changes in perceptual responses after a priming activity. Each subject was required to complete a control and priming activity trial, which was separated by a 7-day period. Before both the trials, subjects completed a readiness to perform questionnaire to assess perceptual responses, followed by 2 maximal-effort 20-kg CMJs and 2 maximal-effort 20-kg bench throws, which were used to measure lower- and upper-body power output. Once initial measures were collected, the control group performed light activities typical to the morning of a match (i.e., sitting, standing, minimal walking), whereas the experimental group performed a 30-minute priming activity consisting of 4 sets of 3 banded back squats, followed by 4 sets of 3 banded bench presses. Resistance bands were selected as a loading mechanism for this study based on practicality for travelling teams, who otherwise may not have access to additional gym facilities or equipment. Upon the completion of the priming activity, the experimental group also performed light activities typical of the morning of a match. Two and a half hours after initial measures were collected (1 hour and 45 minutes after the conclusion of the priming activity), subjects completed a secondary readiness to perform questionnaire before repeating the CMJ and bench throw assessments.

Subjects

Thirteen state-level rugby players (mean ± *SD*; age, 18.5 ± 0.5 years [range, 18–20 years]; height, 181.7 ± 6.8 cm; mass 98.2 ± 16.9 kg) with greater than 1 year resistance training experience competing in a national under-20's competition provided signed informed consent documents prior to participation in this study, which was approved by the University's institutional review board. This study was conducted during the preseason phase of the season. All subjects were free from injury and presented with no preexisting conditions that would influence the results of this research.

Procedures

Testing. ***Readiness to Perform.*** Subjects arrived at the testing facility 3 hours before a hypothetical match, at which time their height and weight were recorded and

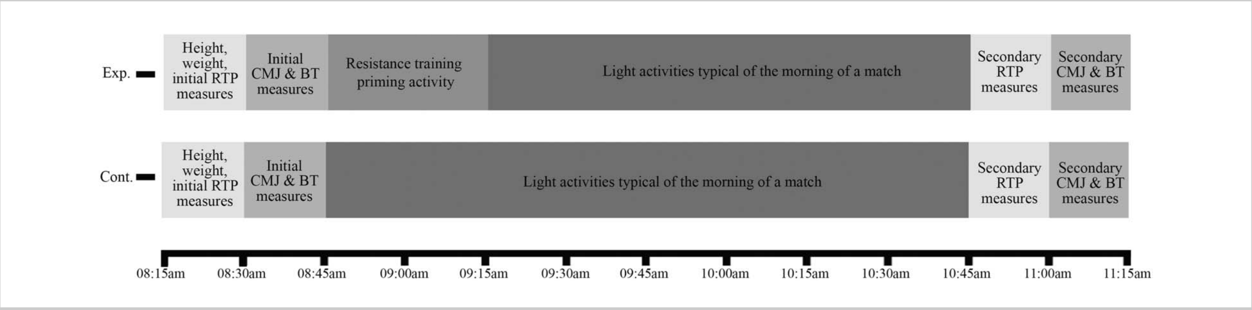

Figure 1. Overview of experimental protocol. RTP, readiness to perform; CMJ, countermovement jump; BT, bench throw.

Figure 2. Band set up for back squat; top position (A) and bottom position (B) of squat.

a readiness to perform questionnaire was completed. The readiness to perform questionnaire was developed in consultation with high-performance coaching staff and was based off of variables used by McLean et al. (30) using recommendations from Hooper et al. (23). The questionnaire assessed fatigue, muscle soreness, levels of aggression and mood on a 5-point Likert scale (scores of 1–5; with 1-point increments). The overall readiness to perform score was determined by totaling the 4 individual scores together (30), with a higher score more favorable.

Countermovement Jumps. Two hours and 30 minutes before the hypothetical match, lower-body power output was assessed during 2 maximal-effort CMJs, with concentric force (Newton), velocity (meter per second), and power (Watts) measured using a GymAware PowerTool (50-Hz sample period with no data smoothing or filtering; Kinetic Performance Technology, Canberra, Australia), which was attached to the sleeve of the barbell. The CMJs were performed using a standard 20-kg Olympic barbell placed on the participant's upper back between their shoulders as outlined in previous research (5). The 20-kg load was selected for the CMJ based on findings from Lopez-Segovia et al. (29), who reported that the highest correlation between performance measures was with the 20-kg CMJ when compared with greater loads (29). The CMJ has also been shown to be a highly repeatable assessment of lower-body power with a test–retest correlation of 0.97 (32). A warm-up consisting of 2 submaximal CMJs using a self-selected foot position and dipping to a self-selected depth was performed at 80 and 90% of perceived maximal effort (5). After the warm-up, subjects then completed 2 maximal-effort CMJs with a 30-second rest between each repetition. During the maximal-effort CMJs, subjects were encouraged to jump vertically to achieve maximum height (5). All measures collected during the CMJs were calculated using system load (i.e., subject's bodyweight plus the 20-kg barbell) (15). The best of the 2 peak measures were collected and used in the analysis.

Figure 3. Band set up for bench press; top position (A) and bottom position (B) of bench press.

Bench Throws. After the CMJs, upper-body power output was assessed during 2

TABLE 1. Changes in bench throw measures (mean ± *SD*) in rugby players after a control trial and a resistance training priming activity.

	Pre (mean ± *SD*)	Post (mean ± *SD*)	Change (mean ± *SD*)
Control			
Peak velocity ($m\cdot s^{-1}$)	3.0 ± 0.2	3.0 ± 0.2	−0.1 ± 0.1
Peak force (N)	916 ± 218	872 ± 220	−45 ± 71
Peak power (W)	1,074 ± 139	1,022 ± 131	−52 ± 65
Priming activity			
Peak velocity ($m\cdot s^{-1}$)	3.0 ± 0.1	3.1 ± 0.2	0.1 ± 0.1
Peak force (N)	902 ± 203	967 ± 199	65 ± 108*
Peak power (W)	1,027 ± 80	1,064 ± 120	37 ± 102*

*$p \leq 0.05$ when compared with the control trial.

maximal-effort bench throws performed in a Smith machine (Integrity Strength Systems, Queensland, Australia). Concentric force (Newton), velocity (meter per second), and power (Watts) measures were collected using the GymAware PowerTool, which was attached to the sleeve of the Smith machine barbell. The bench throws were performed with a weight of 20 kg (including bar weight) using a self-selected hand position and by lowering the bar to a self-selected depth as outlined previously (4). The 20-kg load was selected for the bench throws based on research by Ostrowski et al. (32), who also showed the 20-kg bench throw to be a reliable measure of upper-body power with a test–retest correlation of 0.85 (32). A warm-up consisting of 2 submaximal bench throws at 20 kg were performed at 80 and 90% of perceived maximal effort. After the warm-up, subjects completed 2 maximal-effort bench throws with a 30-second rest between each repetition. Each repetition began with an eccentric phase followed immediately by an explosive concentric contraction to vertically throw the bar with the aim of reaching maximal height (4). The best of the 2 peak measures were collected and used in the analysis.

Two hours and 15 minutes before the start of the hypothetical match, after measuring the CMJ and bench throw values, the control group performed light activities typical of the morning of a match (i.e., sitting, standing, minimal walking), whereas the experimental group commenced a priming activity.

Priming Activity. ***Back Squat.*** The back squat was performed with a standard 20-kg Olympic barbell with the addition of variable resistance in the form of elastic bands (Power Bands, 41″ Power bands; Iron Edge, Melbourne, Australia). The power bands were attached to the lowest point on each side of the squat rack, with the opposite end of each band then hooked over the barbell sleeves (Figure 2). The power bands provided an additional 46.8 kg (±5.3 kg) tension to the 20-kg barbell when subjects were in an upright standing position (36). The additional tension was measured by weighing each subject with the loaded barbell in place in an upright standing position and then subtracting the subject's body weight and barbell weight (20 kg). With the barbell positioned across the subjects back on the trapezius, just slightly above the posterior portion of the deltoids as defined in previous research (21), subjects used a self-selected stance to perform 4 sets of 3 consecutive back squats. The back squats were performed using a controlled eccentric contraction followed by an explosive concentric contraction with no pause between the 2 phases of the lift. Subjects were required to accelerate the bar maximally during the concentric portion of each repetition and, if capable, were encouraged to leave the ground at the top of the lift. A 3-minute rest period was allocated between each set, with all subjects taking a 5-minute recovery between the conclusion of the back squats and the beginning of the bench press.

TABLE 2. Changes in CMJ measures (mean ± *SD*) in rugby players after a control trial and a resistance training priming activity.

	Pre (mean ± *SD*)	Post (mean ± *SD*)	Change (mean ± *SD*)
Control			
Peak velocity ($m\cdot s^{-1}$)	2.7 ± 0.2	2.8 ± 0.2	0.2 ± 0.2
Peak force (N)	2,964 ± 529	3,128 ± 582	165 ± 227
Peak power (W)	5,329 ± 5,902	5,902 ± 1,088	573 ± 489
Priming activity			
Peak velocity ($m\cdot s^{-1}$)	2.7 ± 0.2	2.8 ± 0.2	0.1 ± 0.1
Peak force (N)	3,155 ± 827	3,215 ± 635	60 ± 355
Peak power (W)	5,346 ± 777	5,722 ± 968	376 ± 313

Bench Press. The bench press was performed using a standard 20-kg barbell with power bands attached. The resistance bands were attached to the lowest rung of the squat rack using a doubled-over

Table 3. Changes in readiness to perform scores (mean ± *SD*) in rugby players after a control trial and a resistance training priming activity.

	Pre (mean ± *SD*)	Post (mean ± *SD*)	Change (mean ± *SD*)
Control			
Fatigue	3.2 ± 0.8	3.2 ± 0.4	−0.1 ± 0.9
Aggression	3.0 ± 0.9	3.4 ± 0.5	0.4 ± 0.9
Muscle soreness	3.0 ± 0.7	3.1 ± 0.5	0.1 ± 0.5
Mood	3.6 ± 0.5	3.5 ± 0.5	−0.1 ± 0.9
Total score	12.9 ± 2.4	13.2 ± 1.1	0.3 ± 2.0
Priming activity			
Fatigue	3.2 ± 0.6	3.4 ± 0.7	0.2 ± 1.0
Aggression	3.1 ± 0.9	3.5 ± 0.5	0.5 ± 0.8
Muscle soreness	3.2 ± 0.9	3.2 ± 0.8	0.0 ± 0.6
Mood	3.3 ± 0.4	3.8 ± 0.4	0.5 ± 0.5*
Total score	12.7 ± 1.8	13.9 ± 1.7	1.2 ± 1.7

*$p \leq 0.05$ when compared with the control trial.

approach (Figure 3) with both ends of the band then hooked over the barbell sleeve. The resistance bands provided an additional 46.8 kg (±2.9 kg) to the 20-kg barbell when subjects were lying in a supine position with the arms fully extended and elbows locked. To establish the additional tension provided by the bands, each subject pressed the bar until the arms were fully extended, and this point was then recorded. The additional tension was then measured by the lead researcher standing on scales and holding the bar at the appropriate height and recording the weight. The researchers' body weight and barbell weight (20 kg) were then subtracted to get the band tension. Using a self-selected hand position (4), and lowering the bar to their chest, subjects performed 4 sets of 3 consecutive bench presses. Each repetition began with a controlled eccentric contraction followed immediately by an explosive concentric contraction aimed at generating maximal velocity through the concentric phase of the lift. Subjects were encouraged to accelerate the bar maximally during the concentric portion of each repetition. A 3-minute rest period was also allocated between each set of bench press.

One hour and 45 minutes before the hypothetical match, the priming activity concluded and the experimental group commenced light activities typical of the morning of a match (i.e., sitting, standing, minimal walking). Fifteen minutes before the start of the hypothetical match, all subjects completed a secondary readiness to perform questionnaire before repeating CMJ and bench throw measures at what would be the start of the hypothetical match.

Statistical Analyses

To assess the effect of the priming activity on CMJ and bench throw peak force, velocity, and power outputs, performance data were log-transformed to reduce nonuniformity of error before being back-transformed to derive effects as a percentage of change (5). Standardized differences in the mean of each measure were calculated by dividing the changes by the appropriate between-subject *SD*. Standardized changes of 0.00–0.19, 0.20–0.59, 0.60–1.19, 1.20–1.99, and ≥2.0 were interpreted as trivial, small, moderate, large, and very large, respectively (3), with the smallest worthwhile change set at ≥0.2. To test for statistical significance, pre–post comparisons using a 1-way analysis of variance were performed, with a Bonferroni corrected post hoc analysis used in all comparisons. Data are presented as mean ± *SD* with statistical significance set at $p \leq 0.05$. Where significance is indicated, 90% confidence limits are presented for an estimate of the population mean difference. Within-subject reliability was calculated for each performance variable in this study using coefficient of variation (CV). Thresholds for acceptable reliability were set at <10% CV based on the work of Hopkins et al. (25).

To assess the relationships between intersubject and individual variations in performance measures, Pearson's product–moment correlation was performed, with Spearman's rank correlation used to assess the relationship between variations in performance measures and perceptual responses from the readiness to perform questionnaires. Correlation coefficients of 0.0–0.09, 0.10–0.29, 0.30–0.49, 0.50–0.69, and ≥0.70 were interpreted as trivial, small, moderate, large, or very large, respectively, and were used in all correlations (24). All statistical examinations were performed using Microsoft Excel (2013; Microsoft Corporation, Albuquerque, NM) and SPSS (Version 21; IBM, Armonk, NY) software packages.

RESULTS

Within-subject reliability analysis showed that all variables displayed acceptable CV (2.9–7.5%), with the exception of bench throw peak force which showed a 10.6% CV. When compared with the control trial, a moderate increase in bench throw peak power of 8.5 ± 5.8% ($p \leq 0.05$) was observed after the priming activity (Table 1). There was also a small increase in the bench throw peak velocity of 3.8 ± 1.9% ($p \leq 0.05$) after the priming activity when compared with the control trial (Table 1). Bench throw peak force produced a large increase of 13.9 ± 7.0% ($p \leq 0.05$) after the priming activity when compared with measures of the control trial (Table 1).

After the priming activity, there was a small decrease in CMJ peak power of 3.4 ± 4.9% ($p > 0.05$) when compared with the control trial (Table 2). The priming activity also led to a trivial decrease in CMJ peak velocity of 1.5 ± 2.9% ($p > 0.05$) relative to the control trial (Table 2). Countermovement jump peak force presented a small decrease in CMJ peak force of 2.3 ± 6.0% ($p > 0.05$) after the priming activity in comparison with the control trial (Table 2).

A large negative relationship was observed between initial bench throw peak force and the change in bench throw peak force after the priming activity ($r = -0.533$; $p \leq 0.05$). A very large positive relationship was found between the band tension at the top position of the back squat during the priming activity and changes in CMJ peak power ($r = 0.762$; $p \leq 0.05$) after the priming activity. There were no relationships found between bench throw power, force, or velocity outputs and the band tension in the top position of the bench press.

No relationships were observed between CMJ or bench throw measures collected after the priming activity and scores from the secondary readiness to perform questionnaire. Changes in the group means for readiness to perform scores after the control trial and priming activity can be seen in Table 3.

DISCUSSION

Findings from the present study show that a resistance training priming activity was effective in improving upper-body performance, but not lower-body performance when compared with the control trial. Indeed, the effects of the priming activity observed by Cook et al. (11) and Ekstrand et al. (16) after 6 hours were evident after 1 hour and 45 minutes in upper-body power output. However, trivial to small negative responses were seen in lower-body power output after the priming activity in comparison with the control trial. These findings outline that differences exist when comparing the priming effects observed in the upper body with those of the lower body.

Although no strength testing was performed, initial testing measures showed a substantially larger peak force output in the CMJ (Table 2) when compared with the force outputs of the bench throw (Table 1). These results highlight that the strength levels of the lower body were likely greater than those of the upper body for subjects in this study. The similar loads applied to the bench press and back squat during the priming activity (resistance bands adding approximately 47 kg to both lifts) may in part explain why there was no improvements in the lower body compared with the upper body. It may be that the external load was not great enough to elicit a potentiating effect for the lower body. Indeed, a very large positive relationship was observed between band tension in the back squat and changes in CMJ peak power ($r = 0.762$; $p \leq 0.05$) after the priming activity and suggests that increasing the force output required by increasing the load lifted (or band tension) in the lower body may lead to a greater priming response.

Previous research further supports the relationship observed between force output requirements and an increased priming effect (11). Cook et al. (11) found that a resistance training priming activity led to greater improvements in 3RM bench press and back squat, CMJ peak power, and 40-m sprint times when compared with a sprint-based priming activity (11). The observations from Cook et al. (11) not only highlight that force, as opposed to velocity, may elicit a greater priming response but also that specificity of movement during a priming activity may not contribute to improvements in performance as much as with other preactivation strategies (1,12).

Although the mechanisms behind the priming effect were not investigated, it is important to consider that other preactivation strategies may have contributed to the overall priming effect observed in this study. One strategy that is commonly implemented using resistance training to improve performance is PAP (1,12). The PAP phenomenon, which works on the principle that a muscle's response to a stimulus is based on the contractile history of that muscle (14,22,34), has been reported to increase when the initial stimulus is specific to the movement requirements of subsequent performance (12,17). Although movement specificity was present in this study (i.e., back squat to improve CMJ, bench press to improve bench throw), PAP has been observed to improve neuromuscular output for up to 24 minutes after the initial stimulus with little evidence supporting its effectiveness upward of this time period (2,18,19). These findings suggest that although PAP has been shown to improve power output (14,22,34), the 1-hour and 45-minute recovery period suggests PAP is unlikely to contribute to the priming effect observed in this study.

Another preactivation strategy that must be considered when investigating changes in performance 1 hour and 45 minutes after a priming activity is warm-ups (6,7,27). Previous research suggests that temperature-related mechanisms provide the greatest performance improvements from warm-ups, with a 4% increase in power output reported for every 1° C increase in muscle temperature (27). Bishop (6) reported that after the onset of moderate-intensity exercise (80–100% of lactate threshold), muscle temperatures increased rapidly from resting levels before reaching a temperature equilibrium after 10–20 minutes of exercise (6,27). At the completion of exercise, muscle temperature gradually returned to baseline levels across a period of up to 90 minutes (6). The timeline put forward by Bishop (6) suggests that regardless of whether muscle temperatures were elevated after 1 hour and 45 minutes as a result of the priming activity, the muscle temperatures would be only slightly higher than those of resting muscle temperatures and thus be insufficient to elicit a priming effect of the magnitude observed in this study.

It is possible that the priming effect observed in this study may be a because of an increase in testosterone levels or an attenuation of the circadian decline of testosterone, reported in previous research (11,35). Testosterone is reported to be one of the primary anabolic hormones released in response to resistance training, and it is suggested to play a major role in increasing muscle size and strength in male players (35). Additionally, the link between testosterone and athletic performance has previously been established (9,10,13), with strong positive correlations observed between levels of serum testosterone and both speed (i.e., sprinting) and explosive power (i.e., vertical jump performance) (8). These correlations suggest that the elevated testosterone levels reported 6 hours after morning resistance training (11) may lead to improvements in power output (8,9,11). However, it is unknown whether the attenuation of the circadian decline in testosterone levels observed by Cook et al. (11) was causal in improving power output or simply a reflective marker (11,27). Furthermore, a review conducted by Vingren et al. (35) suggests that circulating total testosterone and free testosterone typically peak immediately after a high-intensity resistance training before returning to baseline within 30 minutes (35). The findings from Vingren et al. (35) and Cook et al. (11) highlight that further investigation is necessary to determine whether a resistance training priming activity has any impact on testosterone levels after a 1-hour and 45-minute recovery period. If changes in testosterone levels are observed, research is required to establish whether these changes are indicative of changes in performance.

In addition to the improvements in power output after a priming activity, anecdotal evidence has suggested that implementing a priming activity leads to a "feel good" response later in the day (20). This suggestion led to the inclusion of a readiness to perform questionnaire in the present study to assess changes in perceptual responses 1 hour and 45 minutes after the priming activity. After the priming activity, unclear changes in fatigue, muscle soreness, and aggression scores on the readiness to perform questionnaire were observed. However, there was a significant increase in mood after the priming activity when compared with the control trial. This increase in mood confirms the "feel good" response anecdotally reported by Gill (20); yet, there was no meaningful relationship between mood and increases in performance variables. However, as stated by Lane et al. (28), mood is a construct of emotions including depression, tension, vigor, fatigue, anger, and confusion (28). Therefore, to gain further insight into the influence of mood on performance, a more in-depth analysis looking at the individual relationships between the above-mentioned emotions and performance measures would prove beneficial.

Although the mechanisms behind the priming effect were not investigated in this study, the results of this research highlight the need for further investigation into the use of a resistance training priming activity to improve performance. First, because of the relationship between force output requirements and an increase in the priming effect observed, it is suggested that individualizing loads between subjects by adding or removing resistance bands or using a percent of 1RM for the back squat and bench press loads may prove beneficial. It has also been put forward that the attenuation of testosterone after a priming activity may lead to improvements in subsequent performance; however, this does not explain the disparities between changes in lower- and upper-body power output observed in this study.

Furthermore, a typical match day routine includes many aspects aimed at improving on-field performance (i.e., warm-ups, tactical and technical skills, team talks). Before implementing a priming activity in a competitive setting, it is important to establish whether combining other match day routines with a priming activity leads to a positive or negative effect on performance. Lastly, although the 1-hour and 45-minute time period was selected for this study because of its practical application for club-level rugby, investigation into the length of time in which priming effects are evident, and optimal, after a priming activity (i.e., across a 24-hour period) may be advantageous.

To better understand changes in lower- and upper-body power output, 1 hour and 45 minutes after a priming activity, a more in-depth analysis of hormonal, physiological, and neuromuscular responses is needed. The extent of the priming effect will likely vary based on the different training intensities, volume, and exercise selection used during the priming activity. Based on research showing changes in performance 6 hours after a priming activity (11,16), it may be that the priming effect observed in the present study may have remained evident for a similar duration. However, as we did not measure changes at the 6-hour time point, we can only speculate.

PRACTICAL APPLICATIONS

Completing a priming activity 1 hour and 45 minutes before competition improves upper-body, but not lower-body, power output when compared with a control trial. Although the readiness to perform score for mood increased after the priming activity, no meaningful relationships were found between readiness to perform scores and changes in power output, suggesting the priming activity implemented in the present study had little, if any, influence on the subject's readiness to perform. As a result of this study, it is suggested that an upper-body priming activity be implemented to improve upper-body power output; however, further investigation into lower-body loading protocols is recommended before applying a priming activity to improve lower-body power output. Finally, it is suggested that before using a priming activity in a competitive setting, trials should be conducted to establish whether a priming activity, combined with other match day routines (i.e., warm-ups, tactical and technical skills, team talks), leads to a positive or negative effect on performance.

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