

The effect of a high load resistance priming intervention on perceptual, physiological and performance markers in female rugby union players

## ABSTRACT

This study investigated the effects of a high load resistance priming session on perceptual, physiological and performance responses in female rugby athletes. Using a randomized counter-balanced crossover design, ten highly trained female rugby players (mean  $\pm$  standard deviation: age  $23.4 \pm 3.7$  years; height  $172.1 \pm 4.7$  cm; mass  $86.7 \pm 13.9$  kg) completed a resistance priming session and control condition. Perceptual and physiological variables were collected at baseline (PRE), immediately post (POST), and 120 minutes post (POST120) intervention, with performance compared between conditions at POST120. Data were analyzed using linear mixed models within the Bayesian framework. Compared to PRE, the priming protocol had a larger increase in physical readiness (Maximum a posteriori [MAP] = 14.6, 95% high-density intervals [HDI] = -3.4 – 30.4, PD % = 94, % in region of practical equivalence [ROPE] = 9.9) at POST than the control with no differences between conditions at POST120. There were no meaningful differences between the priming and control conditions for salivary testosterone, cortisol or the testosterone to cortisol ratio at any timepoints. Priming led to a lower countermovement jump (CMJ) relative peak power output MAP = -3.2, 95% HDI = -6.7 – -0.2, % in ROPE = 3.9) when compared to the control condition at POST120. There were no meaningful differences in CMJ height, isometric mid-thigh pull relative or absolute force, or 5 m, 10 m or 20 m sprint times between the priming and control condition at POST120. These findings suggest that high load resistance training may not be an effective strategy to improve performance and readiness two hours later in female rugby players.

**KEY WORDS**

exercise, strength, power, speed, testosterone, cortisol, readiness

## INTRODUCTION

Rugby union is a high-intensity, intermittent team-sport, with players requiring high levels of muscular strength and power, the ability to sprint and rapidly change direction, and well developed aerobic fitness to repeatedly perform high-intensity tasks for an extended duration (13,27,50). To prepare athletes to meet the demands of rugby, sport performance practitioners implement a combination of interventions leading into competition to improve key athletic performance markers and an athlete's readiness to perform (48). Long term training strategies (e.g. strength training, metabolic conditioning) are often applied over successive training blocks or seasons, and target neuromuscular, musculoskeletal and cardiovascular adaptations using progressive and systematic loading approaches (30,41,50). In comparison, acute strategies (e.g. warm-ups, priming) are implemented in the minutes, hours or days prior to competition with the aim of realising the full potential of chronic training adaptations (2,36).

An acute preparation strategy supported by emerging evidence, and often applied within rugby codes is 'game day priming' (12,23,35). This term commonly refers to exercise interventions applied in the 1-12 hours prior to competition, with recent reviews reporting mixed outcomes across populations (e.g. males vs females), exercise modalities (e.g. strength vs. endurance interventions), and rest periods (e.g. 2-6 hours) (22,32). In male rugby union players, resistance training at low volumes using heavy loads (>80% one repetition maximum [1RM]), and high velocity movements (i.e. banded bench press) have shown to improve speed, strength and power performance following a ~2-6 hour recovery (33,47). The performance improvements observed in priming studies have been reported

alongside changes in hormonal profiles, with the notion that an increase in testosterone, a decrease in cortisol, and a higher testosterone to cortisol (T:C) ratio (12,47), may be linked with improvements in athletic performance (e.g. squatting, sprinting), arousal levels and athlete readiness respectively (19,25,48). Despite this, inter- and intra-individual hormonal responses to priming vary across the literature (12,21,47,48), and causal relationships between hormonal profiles and priming outcomes are yet to be determined (12,28).

While these findings provide insight into the responses to priming exercises in males, priming research in females athletes is limited (34,51) with only one known study investigating the effects of prior exercise in a priming context exclusively with a female population (34). Woolstenhulme et al. (51) investigated the effects of morning resistance training on afternoon vertical jump, shooting accuracy and Wingate performance in female collegiate basketball players, finding no differences in performance between the strength training and a no exercise group following a 6-hour rest period. It is worth noting, this study was conducted to see if negative effects of prior exercise were evident as opposed to determining if resistance exercise could be used to prepare participants for afternoon performance (51). More recently, Mason et al. (34) investigated the use of a field-based priming intervention consisting of 6 x 40 m repeat shuttle sprints and a rugby specific drill on testosterone and cortisol responses, perceptual readiness and CMJ height and peak power in highly trained female rugby sevens players. No meaningful changes were reported at any timepoint for CMJ measures or hormonal markers, however perceived mental and physical readiness was increased at 30 minutes post exercise before returning to baseline values after 2 hours (34).

The lack of female specific priming research may lead to the application of evidence underpinned by research conducted with males. This approach may be erroneous noting the differences that exist between male and female athletes, which may contribute to a priming response, including the underpinning hormonal differences between the sexes. For example, the absolute lower-body strength of females is markedly lower than that of males (46,49), and circulating testosterone is 15 times greater in males when compared to females (19). Noting the physiological differences between males and females, alongside the positive correlations between absolute strength levels (17), testosterone concentrations (12), and improvements in performance outcomes post priming, further exploration into priming responses in females is warranted. Therefore, the aim of this study was to investigate the influence of a high load, low volume resistance training priming session on perceptual, physiological and performance markers in highly trained female rugby union players. A secondary aim of this study was to determine if there is a relationship between changes in hormone responses and performance variables following resistance training priming compared to a control condition.

## **METHODS**

### **Experimental Approach to the Problem**

Using a randomized counter-balanced crossover design, participants completed two conditions: a resistance training priming intervention; and a control condition, separated by 7 days. Participants arrived at the testing facility at the same time each day (6:45am) in a fasted state, before baseline (PRE) perceptual (rating of perceived exertion [RPE], perceived athlete readiness [READ]) and physiological (blood lactate [BLa], salivary

testosterone [Sal-T] and salivary cortisol [Sal-C]) measures were collected. Upon completion of baseline measures, participants undertaking the priming condition completed a 20-minute resistance training session, while those in the control condition remained in a restful state undertaking minimal activity as illustrated in Figure 1. Immediately post the priming and control conditions, all participants completed the same perceptual and physiological measures (POST) before undertaking a passive 2-hour recovery in preparation for subsequent performance testing. As participants arrived for testing in a fasted state, a standardized snack was provided 15 minutes after POST measures were taken (see Figure 1). The snack (i.e. muesli bar) contained ~26g carbohydrates, ~4g protein, and ~7g fat, and was provided to ensure participants had adequate energy for POST120 testing and to standardize nutritional intake between sessions. At 09:10am, perceptual and physiological markers were assessed (POST120), before participants completed a 10-minute warm-up followed by speed (20 m sprint), power (counter-movement jumps [CMJ]), and strength (isometric mid-thigh pull [IMTP]) testing. An overview of the study design is outlined in Figure 1.

*FIGURE 1 ABOUT HERE*

### **Subjects**

Ten highly trained (37) female rugby union players (mean  $\pm$  standard deviation: age 23.4  $\pm$  3.7 years; height 172.1  $\pm$  4.7 cm; mass 86.7  $\pm$  13.9 kg; body fat 30.4  $\pm$  6.4 %; lean body mass 57.5  $\pm$  6.5 kg; 3RM trap bar deadlift 105.6  $\pm$  25.5 kg), were recruited via convenience sampling and volunteered to participate in this study. All participants competed in a National rugby competition; had >2 years of resistance training experience; completed a 6-

week training block immediately prior to this study; and were free from injury and illness. Participants verbally provided their menstrual cycle history, inclusive of the first day of their last menstrual period, contraceptive use and contraceptive type based on recommendations by Noordhof et al. (44). Six participants were naturally menstruating, and four were using hormonal contraceptives (three using combined levonorgestrel and ethinylestradiol contraceptive pill; one using levonorgestrel contraceptive pill). Ethical approval was provided by the University of Canberra Human Ethics Committee (Project ID: 13292) and all participants provided written informed consent prior to their participation in this study.

## **Procedures**

### *Perceptual measures*

To determine participants' RPE pre- and post-intervention, the Borg 6–20 point scale (4) was used with a score of '6' indicating 'no exertion at all' and '20' indicating 'maximal exertion'. Subjective athlete readiness was assessed at PRE, POST and POST120 using an athlete readiness questionnaire. This questionnaire has been utilized effectively in previous research (34) and was used to assess 'fatigue', 'muscle soreness', 'stress', 'physical readiness' and 'mental readiness' using a 100-point visual analog scale (VAS) (34). The terms 'physical readiness' and 'mental readiness' were presented in the context of each players perception of readiness to perform in a rugby match at the POST120 timepoint.

### *Physiological measures*

To assess changes in Sal-T, Sal-C and the T:C ratio, samples were collected at PRE, POST and POST120 for each condition. Samples were collected via unstimulated, passive drool using protocols previously outlined (34). Participants received training in the saliva collection procedure and adhered as closely as possible to standardized collection guidelines (38,39), with all samples were stored at -80 °C until analysis. Samples were analyzed for Sal-T and Sal-C in duplicate using enzyme immunoassay kits according to the manufacturer's instructions (Salimetrics, LLC, State College, PA). The results are expressed as pg/mL for Sal-T and µg/dL for Sal-C. To reduce between-person variability, samples from the same participant were tested using the same analysis kit. The coefficients of variation (CV) were <5% for intra-assay variability and <10% for inter-assay variability. Blood lactate concentrations were assessed via capillary blood taken from a finger prick at PRE, POST, and POST120 for both conditions. Samples were collected at rest under the same environmental conditions and analyzed using the Edge handheld lactate analyzer (Transatlantic Science, USA). This device has shown low error rates, low bias and good reliability at both low and high lactate concentrations (3).

#### *Resistance Training Priming Intervention*

During the priming condition, participants completed a 20-minute resistance priming session. The session commenced with a warm-up which included dynamic stretching and mobility; activation exercises targeting the musculature of the lower-body and back; and a single set of five repetitions of unloaded CMJs. Each participant then completed one set of four repetitions of a trap bar deadlift at 50%, 70%, and 80% of their predetermined 1RM, followed by three sets of four repetitions at 85% 1RM with a 2-min rest between sets (45).

Participants were instructed to complete each of the three working sets at maximal intensity with verbal encouragement provided throughout. To determine the trap bar deadlift loads applied in this study, participants completed a 1RM testing protocol in the 7-14 days prior to the first trial. The trap bar deadlift was selected as it is a multi-joint lower-body exercise that participants were familiar with, and one which could be performed with maximal concentric force development and minimal eccentric loading. While participants in the priming condition completed the exercise intervention, participants undertaking the control condition were instructed to remain seated, to avoid using their mobile devices, and to perform minimal activity only as required. Following both conditions, participants remained in a restful state for 2 hours before completing follow up physiological and perceptual assessments and undergoing performance testing.

#### *Performance measures*

Lower-body power was assessed using the CMJ with all jumps performed on dual force plates sampling at 1000Hz (ForceDecks Max, VALD, Brisbane, Australia) with force-time data analyzed using proprietary software. After completing an initial 1s weighing period (40), participants were instructed to start in a tall standing position with feet hip width apart and hands on hips. Two warm-up jumps were performed at 50% and 75% of perceived maximal effort using a self-selected dip, followed by three maximal effort CMJs each interspersed with a 20-second rest (20). Participants were provided a countdown of “3,2,1, jump” and were instructed to “jump as high as possible” for each repetition (20). The jump height (m) (Typical Error [TE] % = 3.29, Intraclass Correlation Coefficient [ICC] = 0.93) and relative peak power (W/kg) (TE % = 2.33, ICC = 0.93) of the best of the three CMJs,

as determined by jump height using the impulse-moment method (40), was included in the analysis. The best repetition for each performance test was analyzed as it represented the participant's maximal performance potential and is consistent with previous priming research (14,33,34).

Following jump testing, each participant completed a speed assessment with times recorded at 5 m (TE % = 4.04, ICC = 0.38), 10 m (TE % = 2.37, ICC = 0.66), and 20 m (TE % = 3.16, ICC = 0.70) using electronic timing gates (Fusion Sport, Brisbane, QLD, Australia). Participants were instructed to commence each repetition in a standing 2-point start, 30 cm behind the first gate as per manufacturers recommendations. Each participant completed two warm up repetitions at 50% and 75% of maximal effort, followed by three maximal effort 20 m sprints with approximately 1-minute rest between each repetition. Speed testing was completed in football boots on a grass surface to maintain ecological validity in accordance with National testing protocols. The best sprints, determined by fastest time to complete 5 m, 10 m and 20 m, were included in the analysis.

Finally, to assess maximal strength an isometric mid-thigh pull was performed on dual force plates (ForceDecks Max) using a purpose-built IMTP rack. During the familiarization session, a bar height that allowed the participant to maintain an upright torso, and optimal knee (125-145°) and hip angles (140-150°) was selected and used throughout the study (10). Once the bar was set at the pre-determined height, participants were instructed to stand on the force plates with feet hip width apart and centered under the bar (10). Wearing athletic footwear (runners) and using a double overhand grip with added straps to reduce

grip strength as a limiting factor (10), participants performed two warm up repetitions at 50% and 75% of maximal effort, before completing two maximal effort IMTPs separated by a 3-min rest. Participants were instructed to ‘push their feet into the ground and pull upwards on the bar as hard and as fast as possible’ for 3-seconds or until there was a visible decline in force output (10,18), with the highest peak force (N) value of the two repetitions included in the analysis.

### **Statistical Analyses**

Bayesian Gaussian mixed models with a random intercept for each participant were constructed to address the study aims. Bayesian was selected over frequentist statistical methods due to better efficiency with smaller sample sizes and a more intuitive interpretation. Random intercepts were applied over fixed intercepts to account for individual differences between participants at baseline. To examine the influence of the priming intervention on hormonal and perceptual responses, separate models with a condition x timepoint interaction term were created for each response variable. To evaluate the effectiveness of the priming intervention on sprint, jump and IMTP performance, separate models were specified with condition as the independent variable and each sprint, jump and IMTP variable as the response variable. To assess the association between hormonal responses and sprint, jump and IMTP performance, an interaction term between the change in T:C ratio from PRE to POST120 (centered and scaled) and condition was included, with each sprint, jump and IMTP variable specified as the response variable in separate models. The posterior distributions of the marginal effects (i.e., slope coefficients) are described using the maximum a posteriori (MAP) and 95% high-density intervals

(HDI), probability of direction (PD), and the percentage of the 95% HDI within the region of practical equivalence (ROPE)(31). A smaller percentage of the 95% HDI within a ROPE indicated a more practically meaningful effect. The ROPE for the marginal effects for each model was calculated as  $\pm 0.2$  times the standard deviation of the response variable, so that values outside the ROPE could be considered at least small effects, according to Cohen (1988) (8,31) Analysis was conducted using R (version 4.4.0) in RStudio (version 2024.04.2+764) (Posit Software, PBC, <https://posit.co/products/open-source/rstudio/>). The R packages ‘*brms*’ (5) and ‘*bayestestR*’ (31) were used to create and describe the gaussian mixed models.

## RESULTS

An RPE of  $6 \pm 0$  (mean  $\pm$  SD) was reported at PRE, POST and POST120 for the control condition. For the priming intervention, an RPE of  $6 \pm 0$  was reported at PRE,  $14.1 \pm 1.85$  at POST, and  $6 \pm 0$  at POST120. Changes in self-perceived fatigue, stress, muscle soreness and mental readiness to perform were negligible at POST and POST120 in both conditions when compared to PRE. When compared to the control, there was a meaningful increase in self-perceived physical readiness to perform (MAP = 14.6, 95% HDI = -3.4 – 30.4, PD% = 94, % in ROPE = 9.9) at POST following the priming intervention, however there were no differences between conditions at POST120. Changes in readiness to perform scores following the priming and control conditions are presented in Figure 2.

*FIGURE 2 ABOUT HERE*

Changes in physiological variables are presented in Figure 3. An increase in blood lactate was observed POST priming (MAP = 0.7, 95% HDI = -0.0 – 0.7, PD% = 96, % in ROPE = 5.2), but not the control. There were no meaningful changes in blood lactate at POST120. There were no differences in Sal-T, Sal-C or T:C ratio between the priming and control condition at POST120. Compared to PRE, there were no meaningful changes in Sal-T, Sal-C, or T:C ratio at POST when data were pooled, however there were declines in Sal-T (MAP = -37.3, 95% HDI = -55.3 – -18.4, PD% = 100, % in ROPE = 0) and Sal-C (MAP = -0.3, 95% HDI = -0.4 – -0.2, PD% = 100, % in ROPE = 0), and an increase in T:C ratio (MAP = 1.5, 95% HDI = 0.6 – 2.2, PD% = 100, % in ROPE = 0) at POST120.

*FIGURE 3 ABOUT HERE*

Differences in CMJ and IMTP metrics between the priming and control conditions at POST120 are shown in Figure 4. CMJ relative peak power was lower at POST120 following priming when compared to the control (MAP = -3.2, 95% HDI = -6.7 – -0.2, PD% = 97, % in ROPE = 3.9). No meaningful differences in CMJ height, IMTP peak force or IMTP relative peak force were observed between the priming and control condition at POST120. Similarly, there were no meaningful differences in 5 m, 10 m, and 20 m sprint times between the priming and control conditions at POST120 as outlined in Figure 5. There were no meaningful relationships between changes in T:C ratio and CMJ height, CMJ relative peak power or IMTP as outlined in Figure 6. Similarly, there were no notable relationships between changes in the T:C ratio and sprint times across 5 m, 10 m or 20 m as shown in Figure 7.

*FIGURE 4 ABOUT HERE*

*FIGURE 5 ABOUT HERE*

*FIGURE 6 ABOUT HERE*

*FIGURE 7 ABOUT HERE*

## **DISCUSSION**

The aim of this study was to determine the effects of a resistance priming intervention on perceptual, physiological and performance measures in female rugby union athletes. The findings show no change in IMTP metrics or 5, 10 or 20 m sprint times, however there was a reduction in CMJ relative peak power following priming when compared to the control condition. Changes in Sal-T and Sal-C followed similar patterns throughout the priming and control trials, with the highest concentrations observed at PRE, before steadily declining across POST and POST120 timepoints. There were no relationships observed between hormonal responses and changes in performance nor with perceptual readiness to perform variables.

The lack of performance changes observed in the present study are similar to those reported previously when implementing priming 2 hours prior to subsequent performance with female athletes (34). Mason et al. (34) reported no change in CMJ height or peak power 2 hours after a 20-minute priming session including repeat shuttle sprints and a rugby specific drill, and it was suggested that the priming stimulus may have been insufficient to stimulate a response (34). This was on the basis that the priming intervention only included 120 m

of sprint volume ( $>6 \text{ m}\cdot\text{s}^{-1}$ ) in a population highly trained in repeat sprints, and who regularly exceed the sprint dosages in the study in training sessions and matches (34). Based on the suggestion to increase load put forward by Mason et al. (34), the present study implemented a strength stimulus, using loads relative to each participants individual strength levels (3 x 4 repetitions with 85% of trap bar deadlift 1RM). This protocol has been used in previous research (45) in which the priming intervention led to improvements in CMJ height, and an  $\sim 18 \text{ m}$  out and back shuttle sprint, when compared with a control condition, although this was after a 5.5 hour rest period with professional male cricketers. The findings from this study differ from those presented by Nutt et al. (45), with no differences in sprint times or strength outcomes, and a reduction in CMJ relative peak power when compared to the control condition. The reduction in CMJ relative peak power could be indicative of acute neuromuscular fatigue (7) caused by the intensity of the priming stimulus being too high, the rest period (2 hours) being too short, or a combination of these factors. However, it is important to note that while a reduction in CMJ relative peak power was observed at a group level following the priming intervention, some participants observed improvements in performance. This finding suggests that responses to priming are highly individualized, and as reported by Nishioka et al. (43), may be influenced by training status.

The contrasting outcomes observed between studies with male and female participants may also be due physiological differences (1,46), more specifically, hormone responses to exercise (19). Investigation of the hormone responses in the present study found there were no meaningful differences in Sal-T or Sal-C levels between the priming and control

conditions at PRE, POST or POST120. This contrasts with previous findings which observed higher Sal-T and Sal-C concentrations 6 hours post a high load resistance training (12), and 5 hours post moderate load upper-body resistance training (47) in professional male rugby union players when compared to control conditions. Russell et al. (47) also reported an increase in Sal-T 5 hours post 6 x 40 m shuttle sprints, however Mason et al. (34) found no change in Sal-T concentrations 2 hours post a priming intervention consisting of 6 x 40 m shuttle sprints in female rugby sevens players. It has been reported that circulating testosterone is 15 times greater in young men than in age-matched women, with a reference range of 7.7 nmol/L to 29.4 nmol/L for young males compared to 0 nmol/L to 1.7 nmol/L in women of under 40 years old (19). Whilst a high correlation has been shown between Sal-T and serum free testosterone in both males and females (15), it has been indicated that Sal-T is not directly comparable to serum free testosterone due to testosterone binding to saliva proteins, which substantially affects the low Sal-T found in females (15). Noting this, and given the positive relationship reported between testosterone and athletic performance (12,19,48), and competitive behaviour (11), it is to be expected that increased testosterone concentrations may have a greater impact on priming responses in males compared to females. When interpreting testosterone and cortisol responses following priming exercise it is important to consider clinically meaningful changes (i.e. critical difference) (26) Critical difference values for testosterone and cortisol have been reported as 90% and 148%, respectively, highlighting the magnitude of change required for meaningful biological outcomes to occur (24,26). While beyond the scope of the present study, it is important to note that female hormone profiles vary based on the menstrual cycle phases (6,16). Evidence linking cycle phases to objective performance outcomes is

inconclusive (6,9,42), however, menstruation has been linked to a perceived reduction in training capacity, nausea, cramps and abdominal pain, which may indirectly influence outcomes (16).

There was an increase in the T:C ratio at POST120 in both conditions when compared to PRE, however there were no meaningful differences between conditions. The changes in T:C ratio in the present study were not associated with any changes in performance in the control or priming condition. The change in T:C ratio in this study is similar to that reported by Harrison et al. (21) who found a moderate and large effect at 8 hours post high load resistance training and a control, respectively. Interestingly, the increases in T:C ratio observed in the study by Harrison et al. (21) were accompanied by increases in squat jump (SJ) and CMJ height at 8 hours following high load priming, but not the control. When investigating perceptual readiness, there were no differences in stress, muscle soreness, fatigue, mental readiness or physical readiness between groups at POST120 compared to PRE. Studies previously assessing perceptual readiness to perform have reported increases in mood (33) and aggression (45) subscales 2 hours and 5.5 hours post priming interventions, respectively. It is difficult to make direct comparisons between these studies based on the questionnaires used. Mason et al. (33) and Nutt et al. (45) assessed readiness to perform using 5-point Likert scales whereas the present study used a 100 mm VAS scale with different subscales. These are two examples of a range of subjective questionnaires implemented across priming studies. To improve the reporting of perceptual readiness to perform, a uniform and validated scale is needed to provide consistency with reporting within the literature. Furthermore, determination of construct validity of novel items in the

subjective readiness questionnaire (i.e. mental readiness, physical readiness) is required. This will improve the validity and reliability of the questionnaire implemented in the present study for future applications (29).

This study is one of only two that have investigated priming interventions in female athletes, with a key limitation being the small sample size. The study aimed to explore the priming response in highly trained female rugby union players, with the participants competing in a national level competition. While a larger sample size may have been beneficial in providing certainty to outcome measures, recruiting athletes from outside of this cohort would have increased participant heterogeneity, potentially impacting the applicability of findings to the highly trained female rugby union population. To account for the small sample size, a repeated measures crossover design was implemented based on suggestions by Mason et al. (34) and analyzed using a Bayesian approach. It must also be acknowledged that this study was conducted with a single cohort, using a single intervention and a single rest period. Before decisions regarding the implementation of priming strategies with female athletes can be made with confidence, more research is needed to develop a larger evidence base. Researchers are encouraged to contribute to this evidence base through unbiased publishing, including reporting of negative and equivocal findings, to determine the efficacy of priming exercise. Future studies should consider implementing a variety of exercise modalities across a range of rest periods in a bid to identify strategies and timelines that may contribute to positive outcomes. In addition, exploring the responses to these priming strategies prior to a competitive match, as opposed to training or research settings, would add ecological validity to the use of priming as an

acute preparation strategy. Finally, given the individual variability in responses between the participants in the present study, future research should aim to determine individual characteristics that may be indicative of responders and non-responders to priming interventions.

In conclusion, the findings from this study highlight there were no positive outcomes associated with a resistance priming intervention compared with no exercise on performance, physiological responses and perceived readiness to perform 2 hours later in this specific population of female rugby players. This may have been due to the training status of the participants, overall exercise volume, exercise intensity, and/or the duration of the rest period applied in this study. These findings highlight the need for further exploration into the configuration and application of priming interventions to determine the best approach to stimulate positive outcomes. Based on the findings of the present study, alongside the competing priorities on the day of competition and the often-limited facilities and resources, there appears to be limited value in implementing the resistance priming intervention used in this study in the hours prior to competition.

### **PRACTICAL APPLICATIONS**

Performing 3 sets of 4 trap bar deadlifts with 85% of 1RM provided no benefit to perceptual, physiological or performance outcomes following a 2-hour recovery for the female rugby union players in this study. The literature to support the application of priming in female athletes is limited, making it difficult to implement priming interventions with a high level of confidence. As outlined in this study, caution should also be taken

when applying research findings with male participants to female populations. Therefore, it is recommended that coaches and athletes trial a range of exercise modalities, volumes, intensities and rest periods in a training environment to determine the effectiveness of different priming strategies. By better understanding an individual's response to priming, coaches and athletes can make informed decisions regarding its use as strategy to improve sport performance on the day of competition.

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## Figures

Figure 1: Overview of study protocol. RPE = rating of perceived exertion; READ-Q = readiness to perform questionnaire; CMJ = counter-movement jump; COG = Flanker task; LACT = blood lactate; T = testosterone; C = cortisol;  = passive recovery; PRE = baseline measures, POST = immediately post intervention measures; POST120 = 120 minutes post intervention measures.

Figure 2: Boxplots presenting perceptual readiness to perform variables. The points show the observed values for individual participants within a condition and timepoint.

Figure 3: Boxplots presenting physiological variables. The points show the observed values for individual participants within a condition and timepoint. T:C = testosterone to cortisol.

Figure 4: Boxplots presenting lower-body power and isometric strength variables. The points show the observed values for individual participants in the control and priming conditions. CMJ = countermovement jump, IMTP = isometric mid-thigh pull.

Figure 5: Boxplots presenting sprint variables. The points show the observed values for individual participants in the control and priming conditions.

Figure 6: Scatterplots showing relationships between changes in testosterone to cortisol ratios from pre to post intervention, and lower-body power and isometric strength variables. The lower-body power and isometrics strength points show the observed values for individual participants at POST120 within each condition. CMJ = countermovement jump, IMTP = isometric mid-thigh pull.

Figure 7: Scatterplots showing relationships between changes in testosterone to cortisol ratios from pre to post intervention, and sprint variables. The sprint variable points show the observed values for individual participants at POST120 within each condition. T:C = testosterone to cortisol.