The Back Squat and the Power Clean: Elicitation of Different Degrees of Potentiation

Laurent B. Seitz, Gabriel S. Trajano, and G. Gregory Haff

**Purpose:** To compare the acute effects of back squats and power cleans on sprint performance. **Methods:** Thirteen elite junior rugby league players performed 20-m linear sprints before and 7 min after 2 different conditioning activities or 1 control condition. The conditioning activities included 1 set of 3 back squats or power cleans at 90% 1-repetition maximum. A 2 × 2 repeated-measures ANOVA was used to compare preconditioning and postconditioning changes in sprint performance. **Results:** Both the back-squat and power-clean conditioning activities demonstrated a potentiation effect as indicated by improved sprint time (P = .001, ES = -0.66; power cleans: P = .001, ES = -0.92), velocity (back squat: P = .001, ES = 0.63; power cleans: P = .001, ES = 0.84), and average acceleration over 20 m (back squat: P = .001, ES = 0.70; power cleans: P = .001, ES = 1.00). No potentiation effect was observed after the control condition. Overall, the power clean induced a greater improvement in sprint time (P = .042, ES = 0.83), velocity (P = .047, ES = 1.17), and average acceleration (P = .05, ES = 0.87) than the back squat. **Conclusions:** Back-squat and power-clean conditioning activities both induced improvements in sprint performance when included as part of a potentiation protocol. However, the magnitude of improvement was greater after the power cleans. From a practical perspective, strength and conditioning coaches should consider using power cleans rather than back squats to maximize the performance effects of potentiation complexes targeting the development of sprint performance.

**Keywords:** potentiating stimulus, conditioning activity, strength-power-potentiating complex, sprint, rugby league

There is a growing body of evidence advocating contrast training methods where there is a pairing of a heavy-load resistance exercise (eg, conditioning activity) with a biomechanically similar plyometric exercise. It has been suggested that the performance of the heavy-load resistance exercise increases the strength/power production in the subsequent plyometric exercise. The neuromuscular rationale underpinning this phenomenon has been referred to as postactivation potentiation (PAP). The majority of studies examining PAP have used a back-squat conditioning activity to induce a PAP response during a vertical jump or sprint performance test. The power clean has also been used as a conditioning activity to improve vertical jump and sprint performance. Conversely, there are a limited number of studies directly comparing the PAP responses of different types of conditioning activities.

McBride et al observed an improvement in 40-m-sprint time after the performance of 1 set of 3 back squats at 90% 1-repetition maximum (1RM), whereas performance was unchanged after 1 set of 3 jump squats performed at 30% of 1RM. Conversely, McCann and Flanagan report that the performance of 1 set of 5RM of either the back squat or the power clean induced similar PAP response during a vertical jump. Finally, Yetter and Moir found that the average speed over 10-m sprint was unchanged after the performance of 3 sets of either back squats or front squats at 30% to 70% 1RM, but a greater improvement in the average speed during the 30- to 40-m interval was found after the sets of back squats. Therefore, the influence of different types of conditioning activity on PAP responses remains unclear, especially when examining sprint activities. Ultimately, to the best of our knowledge, no studies have compared the acute effects of the back squat and the power clean on the PAP response during a sprint performance.

Considerable literature reports strong correlations between the back squat and sprint performance, but only a limited number of studies have investigated the relationship between the power clean and sprint performance. A significant correlation (r = -0.69, P ≤ 0.01) between the ratio of power clean to body mass and 36.6-m-sprint time was found among college American football players. In addition, similar findings were observed among semiprofessional Australian Rules football players, with the relative power clean being correlated (r = -0.57, P ≤ 0.01) with 20-m-sprint performance. The relationship between power clean and sprint performance might be explained by the fact that they exhibit similar biomechanical profiles, as they both involve extension at the hip, extension at the knee, and plantar flexion. As a consequence, the power clean is thought to closely simulate the movement patterns of the lower limb that occur during sprinting. When comparing 2 resistance-training exercises commonly used by practitioners to improve strength and power of their athletes, Brechue et al report a very large correlation (r = -0.69, P ≤ 0.01) between the relative power clean and 36.6-m-sprint performance, while the relative back squat exhibited a large correlation (r = -0.53, P ≤ 0.01) with 36.6-m-sprint performance. A possible explanation might be that the sprint start is highly dependent on "speed strength" and maximal power production, and the power clean allows for the production of high forces at high velocities, resulting in higher power outputs. Conversely, the back squat allows the production of high forces at low velocities, resulting in lower power outputs. Consequently, the power clean might allow athletes to better accelerate from the starting position than would the back squat. From a PAP perspective, based on the similarities between the power clean, the sprint start, and sprint kinematics, the use of a power-clean conditioning activity may result in the production of a greater acute adaptation.
and therefore a greater acute PAP response during a subsequent sprint performance than a back-squat conditioning activity. To the best of our knowledge no studies to date have directly compared the PAP effects of these 2 exercises on sprint performance. Therefore, the purpose of the current study was to compare the acute effects of the back squat and the power clean on the PAP response during a subsequent sprint test.

Methods

Design

The current study required the participants to complete 1 familiarization and 3 experimental sessions to compare the acute effects of the back squat and the power clean on PAP responses during a sprint test (Figure 1). During the familiarization session, anthropometric characteristics were measured and the subject 1RM in the power clean and back squat were determined. The participants were then familiarized with the experimental procedures. The 3 experimental testing sessions were then completed in a randomized order, at the same time of day over a 2-week period. During the experimental sessions, the participants were required to perform 20-m sprints before and 7 minutes after 1 of the 2 conditioning activities (1 set of 3 back squats at 90% 1RM or 1 set of 3 power cleans at 90% of 1RM) or after a control condition.

Participants

Thirteen elite junior rugby league participants, whose characteristics are presented in Table 1, took part in this investigation. All participants were recruited from the French Rugby League Academy on the basis that they were engaged in a regular training program that used combined maximal strength and power training for at least 1 year and were able to squat a minimum of 1.5 times their body mass. This cutoff was used as a marker of required strength since athletes who can squat at least 1.5 times body mass are able to express a greater degree of PAP.23,24 This investigation was conducted in accordance with the Declaration of Helsinki and approved by the ethics committee of Edith Cowan University, Joondalup, Australia.

Table 1 — Participants’ Anthropometric and Physical Characteristics (N = 13)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Measure, Mean ± SD</th>
</tr>
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<tbody>
<tr>
<td>Weight (kg)</td>
<td>77.1 ± 7.4</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>178.4 ± 5.5</td>
</tr>
<tr>
<td>Age (y)</td>
<td>18.8 ± 0.9</td>
</tr>
<tr>
<td>1RM back squat (kg)</td>
<td>154.3 ± 12.8</td>
</tr>
<tr>
<td>Relative 1RM back squat (kg/kg)</td>
<td>2.02 ± 0.12</td>
</tr>
<tr>
<td>1RM power clean (kg)</td>
<td>91.6 ± 12.8</td>
</tr>
<tr>
<td>Relative 1RM power clean (kg/kg)</td>
<td>1.17 ± 0.15</td>
</tr>
<tr>
<td>Back squat/power clean (kg/kg)</td>
<td>1.74 ± 0.18</td>
</tr>
</tbody>
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Abbreviations: RM indicates repetition maximum.

Familiarization Session

The familiarization session included anthropometric measurements, determination of the participants’ 1RM in the power clean and back squat, and familiarization with the experimental procedures. Height and body mass were measured using a calibrated Tanita stadiometer (model HR-200, Japan) and a Tanita scale (model BC-418MA, Japan), respectively. The average of 2 measures was calculated for both height and body mass and selected for further analysis. The intraclass correlation (ICC) values for height and body-mass measurements were .96 and .99, respectively. Thereafter, the participants were familiarized with the experimental procedures by completing in a randomized order the 2 potentiation protocols and the control protocol. A 10-minute passive recovery period was accorded between the protocols.

Experimental Sessions

Baseline Assessments

On arrival, the participants performed a standardized warm-up including 3 minutes of athletic drills (eg, internal-external hip rotation, cariocas, lateral shuffles, high knees, heel kicks, lunges, etc.)

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Abbreviations: RM indicates repetition maximum.
and straight-leg march) and 2 minutes of dynamic stretching. They were then required to complete 5 bursts of progressive accelerations over a 20-m distance and 2 maximal sprints over 20 m with 2 minutes recovery between sprints. This warm-up procedure was developed based on previously published research. Two minutes after the end of the warm-up, the participants completed two 20-m sprints interspersed with 2 minutes of recovery. The fastest sprint represented the baseline performance.

Speed was measured in an indoor environment using electronic timing gates (Brower Timing Systems, Draper, UT) positioned 20 m from the start line. All participants initiated the sprint in their own time from a 3-point stance with the fingers of their dominant hand on a small touch pad. The timer started when the participant released his fingers from the pad. This starting position has been previously used to assess sprint performance and has been shown to be highly reliable (ICC = .92). The participants received verbal encouragement during each sprint to promote maximal effort. The encouragement during each sprint to promote maximal effort. The timing gates (Brower Timing Systems, Draper, UT) positioned 20 m from the start line. All participants initiated the sprint in their own time from a 3-point stance with the fingers of their dominant hand on a small touch pad. The timer started when the participant released his fingers from the pad. This starting position has been previously used to assess sprint performance and has been shown to be highly reliable (ICC = .92). The participants received verbal encouragement during each sprint to promote maximal effort.

**Potentiation and Control Protocols**

Two minutes after the determination of the baseline sprint, the participants performed 1 of the following activities: 1 set of 3 back squats at 90% 1RM, 1 set of 3 power cleans at 90% 1RM, or a control condition (one 20-m sprint). After a 7-minute recovery period, the postmeasurement 20-m sprint was performed. One set of 3 at 90% 1RM was chosen based on previous studies reporting PAP effects after the performance of this conditioning activity. A 7-minute recovery period was selected based on the work of Wilson et al., who showed that subjects display the greatest potentiation response at 7 minutes after the conditioning activity.

### Statistical Analysis

Two-way (time × condition) repeated-measures ANOVAs were performed to compare changes in sprint performance before and 7 minutes after the 2 conditioning activities and the control condition. Pairwise comparisons with Bonferroni corrections were performed when significant interaction effects were detected. Pearson product–moment correlations were calculated to determine relationships between variables. Strength of relationship was assessed using the following criteria: trivial, $r < .1$; small, $r = .1-.3$; moderate, $r = .3-.5$; large, $r = .5-.7$; very large, $r = .7-.9$; and nearly perfect, $r > .9$. The magnitudes of the ESs were considered trivial, <0.20; small, 0.20–0.50; medium, 0.5–0.8; large, 0.8–1.30; or very large, >1.30.

For all statistical analyses, the level of significance was set at $P = .05$.

### Results

As shown in Table 2, there was a significant interaction (time × condition) effect for PAP during the sprint test ($P < .05$). Post hoc analyses revealed a significant improvement in 20-m-sprint time, velocity, and average acceleration after both the set of back squats and the set of power cleans, with no significant changes observed after the control condition.

The set of power cleans induced a significantly ($P = .042$, ES = 0.83) greater improvement in 20-m-sprint time (3.05% ± 1.08%) than did the set of back squats (2.16% ± 1.07%; Figure 2[A]). Similarly, the improvement in velocity was significantly greater ($P = .047$, ES = 1.17) after the set of power cleans (3.22% ± 1.15%) than after the set of back squats (2.25% ± 1.11%; Figure 2[B]). The improvement in average acceleration was also significantly greater ($P = .05$, ES = 0.87) after the set of power cleans (6.61% ± 2.36%) than after the set of back squats (4.59% ± 2.26%; Figure 2[C]).

The percentage improvement in 20-m-sprint time (ie, PAP) had a large correlation with relative 1RM back squat ($r = .56$, $P = .04$; Figure 3[A]) and relative 1RM power clean ($r = .63$, $P = .02$; Figure 3[B]). Conversely, absolute 1RM back squat ($r = .49$, $P = .09$) and absolute 1RM power clean ($r = .54$, $P = .06$) were not significantly correlated with the improvement in 20-m-sprint time.

In addition, 20-m-sprint time displayed a large correlation with relative power-clean strength ($r = -.64$, $P = .02$; Figure 4[A]) and relative power-clean strength ($r = -.64$, $P = .02$; Figure 4[A]) and

### Table 2 20-m-Sprint Performance Before and 7 Minutes After the 2 Conditioning Activities and the Control Condition

<table>
<thead>
<tr>
<th>20-m-sprint characteristic</th>
<th>Protocol</th>
<th>Baseline</th>
<th>7 min after</th>
<th>$P$</th>
<th>Effect size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time (s)</td>
<td>Back squats</td>
<td>3.28 ± 0.11</td>
<td>3.21 ± 0.12</td>
<td>.001</td>
<td>-0.66</td>
</tr>
<tr>
<td></td>
<td>Power cleans</td>
<td>3.26 ± 0.11</td>
<td>3.16 ± 0.14</td>
<td>.001</td>
<td>-0.92</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>3.31 ± 0.11</td>
<td>3.30 ± 0.13</td>
<td>.528</td>
<td>-0.06</td>
</tr>
<tr>
<td>Velocity (m/s)</td>
<td>Back squats</td>
<td>6.11 ± 0.20</td>
<td>6.25 ± 0.24</td>
<td>.001</td>
<td>0.63</td>
</tr>
<tr>
<td></td>
<td>Power cleans</td>
<td>6.13 ± 0.20</td>
<td>6.33 ± 0.27</td>
<td>.001</td>
<td>0.84</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>6.05 ± 0.21</td>
<td>6.06 ± 0.24</td>
<td>.436</td>
<td>0.07</td>
</tr>
<tr>
<td>Average acceleration (m/s²)</td>
<td>Back squats</td>
<td>1.87 ± 0.12</td>
<td>1.95 ± 0.15</td>
<td>.001</td>
<td>0.70</td>
</tr>
<tr>
<td></td>
<td>Power cleans</td>
<td>1.88 ± 0.12</td>
<td>2.11 ± 0.17</td>
<td>.001</td>
<td>1.00</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>1.83 ± 0.12</td>
<td>1.84 ± 0.15</td>
<td>.393</td>
<td>0.08</td>
</tr>
</tbody>
</table>
Discussion

The purpose of the current study was to compare the effects of a back-squat and a power-clean conditioning activity on the occurrence of PAP during a sprint test. Both the back squats and power cleans resulted in a significant PAP effect during a 20-m-sprint performance test. In addition, the magnitude of PAP response was significantly greater after the power-clean conditioning activity.

The improvement in 20-m-sprint time after the back squats and the power cleans is in agreement with the findings of previous studies investigating the effect of a conditioning activity on PAP responses during a sprint test. McBride et al\textsuperscript{6} also used 1 set of 3 back squats at 90% IRM as a conditioning activity and observed a significant improvement of 1.39% in 10-m-sprint time 4 minutes after conditioning activity. Similarly, the 5- and 10-m-sprint performance of professional male rugby players was improved by 5% and 8%, respectively, after 1 set of 3 back squats at 91% IRM.\textsuperscript{9} In another study, Matthews et al\textsuperscript{8} observed findings similar to those of the current study, with a 3.3% improvement in 20-m-sprint time 10 minutes after the completion of 1 set of 5RM back squats. Conversely, Guggenheimer et al\textsuperscript{10} failed to demonstrate any improvement in 20-m-sprint time 3 minutes after 1 set of 3 power cleans at 90%
1RM. Despite using the same type of conditioning activity as Guggenheimer et al., there was a significant improvement in sprint time after the back-squat (+21.6%) conditioning activity in the current study. The contradictory findings between the current study and that of Guggenheimer et al. could be partially explained by the different (ie, 3 vs 7 min) recovery intervals used between the conditioning activity and the sprint test. Indeed, a recent meta-analysis on PAP reported that the greatest PAP response occurs somewhere between 7 and 10 minutes (ES= 0.7) after the completion of a conditioning activity. Therefore, it is possible that Guggenheimer et al. could have observed a greater improvement in PAP with a longer recovery duration. Another possible explanation might be due to the difference in participants’ strength levels between the current study and that of Guggenheimer et al. Indeed, it has been shown that stronger individuals (1RM back squat >2 × body mass) produce significantly greater degrees of potentiation than their weaker counterparts. The average ratio of 1RM back squat to body mass of the participants of the current study was 2.02 ± 0.12. Unfortunately, the strength level of the participants was not reported in the study of Guggenheimer et al., making it difficult to verify this hypothesis.

The current study also suggests that the type of conditioning activity influences the magnitude of PAP induced during a sprint test. This finding is in agreement with the findings of McBride et al., who observed a PAP effect during sprinting after 1 set of 3 back squats at 90% 1RM. Conversely, sprint performance was unchanged after 1 set of 3 jump squats performed at 30% 1RM. However, because these 2 conditioning activities displayed different intensities it is difficult to determine if lack of a PAP response occurred because of the intensity or type of conditioning activity used. Therefore, to our knowledge the current study is the first to demonstrate that the type of conditioning activity influences the PAP response during a sprint test. In addition, 1 set of 3 power cleans performed at 90% 1RM resulted in a significantly (P = .042, ES= 0.83) greater PAP response (3.05% ± 1.08%) than the PAP response (2.16% ± 1.07%) to 3 back squats performed at 90% 1RM.

The fact that the magnitude of PAP during a 20-m sprint was greater after the set of power cleans than the set of back squats may potentially be explained by the sprint start used in the current study and the kinematics associated with sprinting. First, the sprint start is thought to be highly dependent on “speed strength” and maximal power production, and the power clean allows for the production of high forces at high velocities, resulting in higher power outputs. Conversely, the back squat allows the production of high forces at low velocities, resulting in lower power outputs. Therefore, the execution of the set of power cleans might have allowed the participants to acutely produce a better acceleration than after the set of back squats, allowing them to run the 20-m distance quicker. The current data support this hypothesis, as a statistically significantly greater average acceleration was observed after the set of power cleans than after the set of back squats (Table 2). In addition, this hypothesis might explain why the 20-m-sprint time was more correlated to the relative strength in the power clean (r = -.64; P = .02) than back squat (r = -.57; P = .04), which is in agreement with previously published scientific literature. However, the relatively small number of participants (ie, 13) must be taken into consideration when interpreting these correlations. Second, it
has been shown that higher peak ground-reaction forces, impulses, and rates of force development during each foot strike while running significantly affect an athlete's overall speed performance. Because Olympic-style lifts produce greater power outputs than traditional lifts such as the back squat, it can be speculated that the participants of the current study might have produced a more efficient foot strike after the set of power cleans, allowing them to better improve their sprint performance. However, further research comparing the kinematics and kinetics of sprinting before and after power-clean and back-squat conditioning activities would be needed to elucidate this hypothesis.

**Practical Applications**

Strength and conditioning professionals should consider the type of conditioning activity when designing sprint PAP protocols, as the power clean appears to maximize the performance effects of a potentiation complex to a greater extent than the back squat. In addition, given the results of the current study and those of previous research, a 7- to 10-minute recovery duration after conditioning activity may be necessary to induce greater PAP responses during sprint performances.

**Conclusions**

In conclusion, 20-m-sprint performance can be improved if 1 set of 3 back squats or power cleans performed at 90% 1RM is performed 7 minutes before a maximal 20-m-sprint effort. In addition, the magnitude of improvement is greater after a set of power cleans than after a set of back squats.

**References**


