QUBAHAN JOURNAL OF COACHING AND SPORTS SCIENCES
VOL. 2, NO. 4, December 2024
https://doi.org/10.48161/qcsj.v2n4a42

Effects of Caffeine Supplementation on Anaerobic Performance, Reaction Time, and Fatigue in Team-Sport Athletes

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ABSTRACT: Purpose: Team-sport athletes must repeatedly generate short bursts of maximal power, recover quickly between efforts, interpret visual information under time pressure, and preserve decision quality as fatigue accumulates. This study examined whether acute caffeine supplementation improves anaerobic performance, reaction time, and fatigue-related responses in trained male team-sport athletes. Methods: Twenty-four male collegiate team-sport athletes completed a randomized, double-masked, placebo-controlled crossover trial. Participants ingested caffeine (5 $mg \cdot kg^{-1}$) and an identical placebo 60 min before testing, with trials separated by a 7-day washout. Each visit included simple and choice reaction-time testing, a 30-s Wingate test, and a 6 × 30 m repeated-sprint protocol. Ratings of perceived exertion (RPE) and post-exercise blood lactate were also assessed. Paired-samples t tests were used for single-measure outcomes, while a two-way repeated-measures ANOVA examined sprint-by-sprint performance. Results: Compared with placebo, caffeine increased Wingate peak power (1088 ± 143 vs. 1047 ± 137 W, $p < 0.001$) and mean power (771 ± 93 vs. 736 ± 84 W, $p < 0.001$). Simple reaction time (229 ± 20 vs. 241 ± 20 ms, $p < 0.001$) and choice reaction time (359 ± 32 vs. 381 ± 28 ms, $p < 0.001$) were faster after caffeine. Repeated-sprint total time was reduced (29.06 ± 0.98 vs. 29.26 ± 0.99 s, $p < 0.001$), and a condition × sprint interaction showed that the benefit became more evident in the later sprints ($p < 0.001$). Caffeine also lowered sprint decrement and post-test RPE, while blood lactate was modestly higher. **Conclusions:** A moderate pre-exercise dose of caffeine improved anaerobic power, accelerated reaction time, and attenuated fatigue-related performance decline in trained male team-sport athletes. These findings support the targeted use of caffeine before activities that combine repeated sprinting with rapid perceptual processing.

Keywords: caffeine; repeated sprint ability; Wingate test; reaction time; fatigue; ergogenic aids.

I. INTRODUCTION

Team sports expose athletes to a distinctive blend of physiological and cognitive stress. Match play is built around repeated accelerations, decelerations, jumps, collisions, and short sprint efforts, often performed with incomplete recovery. At the same time, athletes must scan the environment, update tactical information, and execute skilled decisions under pressure. Performance, therefore, depends not only on maximal power output, but also on the ability to sustain repeated high-intensity work while preserving reaction speed and decision quality [1]–[4].

Among nutritional strategies used to support these demands, caffeine remains one of the most extensively studied and widely used ergogenic aids in sport [5]–[10]. Acute caffeine ingestion has been associated with improved endurance capacity, increased muscle power, reduced perceived effort, and enhanced vigilance. The mechanisms are multifactorial and likely include antagonism of adenosine receptors, increased central drive, altered motor-unit recruitment, and reduced perceived effort during strenuous exercise [1], [5], [7], [8]. These responses are especially relevant in sports where performance deteriorates as neuromuscular and cognitive fatigue accumulate.

Even so, the practical value of caffeine in team sports cannot be inferred solely from endurance trials or from isolated strength tests. Team-sport athletes rarely perform continuous bouts of exercise; instead, they alternate repeated sprints, rapid changes of direction, and skill-based actions. Experimental studies in soccer, rugby, and related invasion sports suggest that caffeine may improve intermittent-sprint capacity, movement profiles during simulated competition, and some technical or cognitive outcomes [11]–[16]. Meta-analytic work has generally supported a small but meaningful ergogenic effect in team-sport settings, particularly for jump performance, sprinting, and high-intensity running [17], [18].

However, important gaps remain. First, many studies have focused on physical outputs without assessing reaction-time variables that are central to real match play. Second, several investigations have evaluated only one domain of performance, making it difficult to determine whether caffeine affects anaerobic power, reaction time, and fatigue-related markers simultaneously. Third, the magnitude of the benefit appears to be sensitive to dose, task selection, habitual caffeine intake, and the timing of assessment [7], [9], [10], [19], [20]. From a practitioner's perspective, this means that evidence from one format does not automatically transfer to another.

From a mechanistic standpoint, anaerobic performance and reaction time may respond to caffeine through partly overlapping pathways. Faster information processing and higher arousal may improve the speed with which athletes initiate movement, while enhanced excitation-contraction coupling and central activation may support greater peak and mean power during maximal efforts [7], [8], [21]. Meanwhile, a lower perception of effort may help preserve repeated-sprint output late in a protocol even when metabolic strain remains high [2], [3], [22]. If these responses occur simultaneously, caffeine would be especially valuable in sports characterized by repeated maximal efforts, incomplete recovery, and constant perceptual demands.

Accordingly, the purpose of the present study was to examine the acute effects of caffeine supplementation on anaerobic performance, reaction time, and fatigue-related outcomes in trained male team-sport athletes. Because previous literature also suggests that greater work output can be accompanied by higher glycolytic contribution, a secondary expectation was that post-exercise blood lactate would be modestly higher in the caffeine condition [11], [12], [17], [23]–[25].

1. HYPOTHESES

The following hypotheses guided the study:

- Caffeine supplementation would increase Wingate peak power and mean power relative to placebo.
- Caffeine supplementation would shorten both simple and choice reaction time, with a potentially greater relative benefit in the more demanding choice task.
- Caffeine supplementation would improve repeated-sprint performance, reflected by a lower total sprint time and a smaller sprint decrement across the six sprints.
- Caffeine supplementation would lower post-test rating of perceived exertion despite a similar or slightly higher post-exercise blood lactate concentration, indicating improved tolerance of high-intensity work.

II. LITERATURE REVIEW

The literature on caffeine in sport suggests that its ergogenic value is most consistent when performance depends on a combination of neuromuscular output, sustained attentional readiness, and the ability to tolerate rising effort. Early work established caffeine as an effective aid for endurance exercise, but subsequent research showed that its effects extend beyond prolonged activity. Moderate pre-exercise doses can also improve short-duration power production, movement speed, and the subjective experience of hard effort, all of which are highly relevant in team-sport settings [1]–[10]. This broader view is important because team-sport performance rarely depends on a single physiological quality. Instead, athletes are required to combine explosive movement, rapid recovery, and fast decision-making under unstable and often stressful competitive conditions.

From a physiological perspective, caffeine appears to act through several complementary pathways. One of the most widely discussed mechanisms is antagonism of adenosine receptors, which can reduce sensations of tiredness and increase alertness [1], [5], [7], [8]. In addition, caffeine may enhance central motor drive, increase the recruitment of active motor units, and support more forceful muscle contraction during maximal or nearmaximal efforts [7], [10], [21]. These responses are particularly relevant in short-duration high-intensity exercise, where the capacity to produce and sustain power is often more decisive than steady-state aerobic efficiency. For team-sport athletes, even a small improvement in acceleration, sprint maintenance, or explosive task execution may have practical value because the margins between successful and unsuccessful actions are often very small.

Evidence from invasion sports has been especially informative because these activities expose athletes to repeated sprinting, rapid directional changes, and brief decision windows. Experimental studies in rugby, soccer, and related disciplines have reported improvements in intermittent sprinting, simulated match activity, or high-intensity work capacity after caffeine ingestion. However, the size of the effect has varied across protocols and athlete groups [11]–[18]. The available data therefore suggest that caffeine can support repeated high-intensity performance, but they also show that not every task is equally sensitive to supplementation. This inconsistency may partly reflect the complexity of team-sport activity itself. Some tests emphasize straight-line sprint speed, others emphasize repeated-sprint resistance, and others attempt to reproduce more complex match demands. As a result, the same supplement may appear highly effective in one protocol and only modestly beneficial in another.

Faster information processing, improved alertness, and better vigilance have been reported following caffeine ingestion, yet these outcomes are not consistently measured alongside anaerobic tasks in the same study [8], [13], [18], [20], [24]. That separation matters because team-sport performance depends on the athlete's ability to perceive and respond while under growing physiological stress. A supplement that improves sprint output but leaves perceptual speed unchanged would still be useful, whereas one that enhances both could be more valuable under real match conditions. In open-skill sports such as soccer, futsal, basketball, and handball, athletes must continually interpret the movements of opponents and teammates, and the trajectories of the ball, under time pressure. In this setting, reaction time is not a minor accessory outcome; it is a core component of effective play. The literature, therefore, increasingly supports the idea that caffeine should be evaluated not only as a physical ergogenic aid but also as a substance that may influence the perceptual-cognitive demands of competition.

During repeated high-intensity exercise, fatigue is not simply a decline in muscle power; it is a multifactorial process involving metabolic strain, reduced motor output, and rising perceived effort [2], [3], [6], [22]. Caffeine appears to influence this process in at least two ways. First, it may allow athletes to maintain output more effectively across repeated efforts. Second, it may reduce the perceived difficulty of that work, enabling athletes to tolerate a demanding task with less conscious strain. This distinction is especially relevant in team sports, where fatigue is often experienced not as a single collapse in performance but as a gradual reduction in sprint quality, reaction sharpness, and willingness to perform repeated intense actions. Studies reporting lower perceived exertion alongside preserved or improved output support the view that caffeine may alter the athlete's functional tolerance to fatigue rather than merely stimulating performance at the start of exercise [2], [3], [8], [22].

At the same time, the literature makes clear that caffeine responses are not uniform. Inter-individual variability has become one of the most important topics in contemporary caffeine research. Response magnitude may vary with body mass, habitual caffeine use, supplement form, pre-exercise nutrition, time of day, sleep status, and the specific nature of the task [7], [9], [10], [19], [20], [25]. Athletes who consume caffeine regularly may show smaller or less predictable responses in some contexts, although the evidence is not entirely consistent [10], [25]. Likewise, some studies suggest that tightly controlled laboratory tests are more sensitive to caffeine effects than broad-field simulations, in which technical and tactical variability may mask small but meaningful physiological advantages [17], [18], [20]. This variability does not weaken the relevance of caffeine; rather, it underscores the need for carefully designed protocols that align the supplement strategy with the demands of the sport.

Dose selection is another important issue in the literature. While high doses were commonly used in earlier work, more recent research has shown that moderate doses can provide meaningful benefits with fewer side effects [5], [7], [10]. This is particularly relevant for team-sport athletes, because excessive dosing may increase restlessness, gastrointestinal discomfort, sleep disturbance, or unwanted overstimulation. These problems may offset performance gains, especially in athletes who compete in the evening or over repeated matches within a short period. The practical implication is that caffeine research is now less concerned with whether caffeine works in a broad sense and more concerned with how to use it effectively, safely, and consistently within real training and competition settings.

The literature also shows that many studies have examined either physical or cognitive outcomes in isolation. This has created a useful but incomplete understanding of caffeine's performance value. Team-sport competition does not separate sprinting from perception, or power production from attentional control. Instead, these elements interact continuously. A player must accelerate quickly, interpret visual information, adjust positioning, and repeat these tasks under mounting fatigue.

III. MATERIAL AND METHOD

1. STUDY DESIGN

A randomized, double-masked, placebo-controlled crossover design was used. Each participant completed two experimental trials in counterbalanced order: caffeine and placebo. Trials were separated by seven days to minimize carryover effects and were scheduled at the same time of day for each athlete. Participants were instructed to avoid strenuous exercise for 24 h, alcohol for 24 h, and dietary caffeine for 48 h before each trial. A standardized pre-trial meal was replicated before both visits.

2. PARTICIPANTS

Twenty-four male collegiate team-sport athletes volunteered for the study. All competed in soccer, basketball, handball, or futsal at university or club level and had trained at least four times per week for the previous two seasons. Inclusion criteria were male sex, age 18–30 years, absence of cardiovascular or metabolic disease, no musculoskeletal injury in the preceding three months, and habitual caffeine intake below 3 $mg \cdot kg^{-1} \cdot day^{-1}$. Athletes using stimulant-containing supplements or medication known to alter heart rate or cognition were excluded. Participant characteristics are summarized in Table 1.

3. ETHICAL CONSIDERATIONS

Procedures conformed to the Declaration of Helsinki. Written informed consent was obtained before data collection.

4. SUPPLEMENTATION PROTOCOL

Caffeine was provided in opaque gelatin capsules at a dose of 5 $mg \cdot kg^{-1}$ body mass. The placebo capsules contained microcrystalline cellulose and were identical in appearance, smell, and packaging. Capsules were ingested with 250 mL of water 60 min before testing. The selected dose was based on evidence that moderate doses between 3 and 6 $mg \cdot kg^{-1}$ are generally ergogenic while remaining practically tolerable in athletic populations [5], [7], [10]. Athletes completed a short side-effect questionnaire before leaving the laboratory.

5. FAMILIARIZATION

Before the first experimental visit, athletes completed one familiarization session. This session included reaction-time testing, two brief practice sprints, and a submaximal familiarization Wingate effort. Familiarization was included to reduce learning effects and improve the reliability of later comparisons.

6. REACTION-TIME TESTING

Simple and choice reaction times were assessed using a computerized test battery presented on a laptop positioned at eye level. The simple task required athletes to press a handheld response key as quickly as possible after a single visual stimulus. The choice task required a left or right response depending on the target stimulus's position. After five practice attempts, twenty recorded trials were completed for each task. The average response time from correct trials was used for analysis.

7. WINGATE TEST

Anaerobic power was assessed with a standard 30-s Wingate test on a mechanically braked cycle ergometer. The resistance load was set at 7.5% of body mass. After a standardized warm-up that included brief accelerations, participants performed an all-out effort from a rolling start. Peak power, mean power, and fatigue index were computed by the manufacturer's software and verified offline.

8. REPEATED-SPRINT PROTOCOL

Following 15 min of passive and low-intensity recovery after the Wingate test, athletes performed six maximal 30 m sprints from a standing start, each separated by 20 s of passive recovery. Sprint times were recorded using dual-beam electronic timing gates. Total sprint time and sprint decrement were calculated. Sprint decrement was expressed as the percentage reduction relative to the ideal sprint time. This protocol was selected because it reflects repeated high-intensity demands commonly encountered in invasion sports.

9. PERCEPTUAL AND PHYSIOLOGICAL MEASURES

Rating of perceived exertion (RPE) was recorded immediately after the repeated-sprint test using the Borg 6–20 scale. Capillary blood lactate was obtained from the fingertip three minutes after the last sprint and analyzed using a portable analyzer. Heart rate was monitored throughout testing to ensure similar preparatory conditions across visits.

10. STATISTICAL ANALYSIS

Data are presented as mean ± SD. Normality was verified using the Shapiro–Wilk test and by visual inspection of Q–Q plots. Paired-samples t-tests were used to compare caffeine and placebo on reaction time, Wingate outcomes, repeated-sprint total time, sprint decrement, RPE, and blood lactate. Cohen's d_z was calculated as the standardized mean paired difference, with thresholds of 0.20, 0.50, and 0.80 interpreted as small, moderate, and large. A two-way repeated-measures ANOVA (condition × sprint number) was used for sprint-by-sprint 30 m times. Two-sided significance was set at $p < 0.05$. All analyses were performed using SPSS-compatible procedures and cross-checked in Python.

Table 1. Participant characteristics (n = 24 male team-sport athletes).

Variable	**Mean ± SD**
Age (y)	22.2 ± 2.2
Height (cm)	178.6 ± 8.2
Body mass (kg)	76.9 ± 8.6
Body fat (%)	12.6 ± 2.5
Training age (y)	7.6 ± 1.7
Habitual caffeine intake ($mg \cdot kg^{-1} \cdot day^{-1}$)	1.0 ± 0.5

Values describe the athletes who completed both conditions. Habitual caffeine intake was estimated from a 7-day dietary recall completed before randomization.

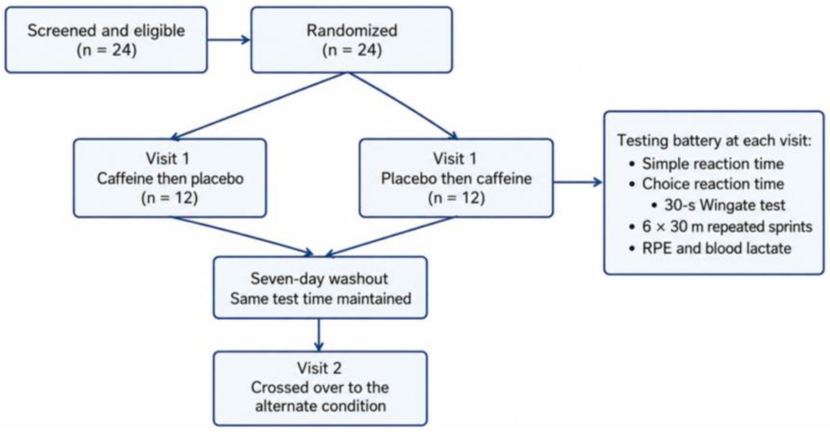

FIGURE 1. Double-masked crossover design and participant flow.

Figure 1 is included because sequence and test order are central to the internal validity of a caffeine crossover study. The design ensured that each athlete served as their own control while standardizing meal intake, caffeine abstinence, and time of day across both visits.

IV. DATA ANALYSIS

1. RESULTS

All twenty-four athletes completed both trials, and no serious adverse events were reported. Mild restlessness was noted in five athletes after caffeine and in one after placebo, but no participant withdrew, and no athlete reported gastrointestinal distress severe enough to influence testing. Baseline hydration and pre-trial meal compliance were comparable between visits.

1.1 Wingate performance

Caffeine improved both primary anaerobic power variables. Peak power increased by 41 W on average, while mean power increased by 35 W. Fatigue index was also lower in the caffeine condition, indicating better maintenance of power across the 30-s effort. These changes were statistically significant and practically meaningful, with standardized effects in the moderate-to-large range.

1.2 Reaction time

Both simple and choice reaction times were faster after caffeine ingestion. The effect was more pronounced for choice reaction time, which is notable because the choice task better reflects the rapid stimulus discrimination required in open-skill sport. The reaction-time findings therefore indicate that the supplement did not merely alter arousal; it also enhanced performance on a cognitively more demanding task.

1.3 Repeated-sprint ability and fatigue

Total time across the six 30 m sprints was shorter after caffeine, and the sprint decrement was lower. The repeated-measures ANOVA identified a significant condition × sprint interaction, showing that the difference between conditions widened during the final repetitions. This pattern is important because it suggests that caffeine did not simply produce a faster opening sprint; it helped athletes resist late-test deterioration.

1.4 Perceptual and physiological responses

Despite higher blood lactate concentrations after caffeine, perceived exertion was lower. This pattern suggests that caffeine enabled athletes to tolerate or perform greater high-intensity work without a commensurate increase in conscious effort. In practical terms, that combination may be highly relevant during phases of play in which repeated efforts occur under incomplete recovery.

Table 2. Performance, cognitive, perceptual, and physiological outcomes by condition.

Variable	Placebo	Caffeine	Mean difference	95% CI	p
Peak power (W)	1046.73 ± 137.29	1088.23 ± 143.37	41.50	21.34 to 61.67	<0.001
Mean power (W)	736.00 ± 83.80	770.77 ± 92.62	34.77	23.31 to 46.22	<0.001
Fatigue index (%)	44.80 ± 5.15	42.80 ± 5.75	−2.00	−3.07 to −0.94	<0.001
Repeated-sprint total time (s)	29.26 ± 0.99	29.06 ± 0.98	−0.20	−0.28 to −0.12	<0.001
Sprint decrement (%)	5.68 ± 2.01	4.88 ± 1.93	−0.80	−1.17 to −0.44	<0.001
Simple reaction time (ms)	241.45 ± 19.91	228.86 ± 19.95	−12.60	−16.62 to −8.58	<0.001
Choice reaction time (ms)	380.89 ± 27.73	359.39 ± 31.94	−21.50	−29.16 to −13.84	<0.001
RPE (Borg 6–20)	17.62 ± 0.98	16.90 ± 1.25	−0.72	−1.09 to −0.35	<0.001
Blood lactate (mmol·L^{-1})	11.55 ± 1.54	12.43 ± 1.91	0.89	0.42 to 1.36	<0.001

Lower values indicate better performance for fatigue index, repeated-sprint total time, sprint decrement, reaction-time variables, and RPE. Table 2 brings the primary outcome set together on one page, making it clear that caffeine improved both neuromuscular output and perceptual-cognitive performance under the same testing session.

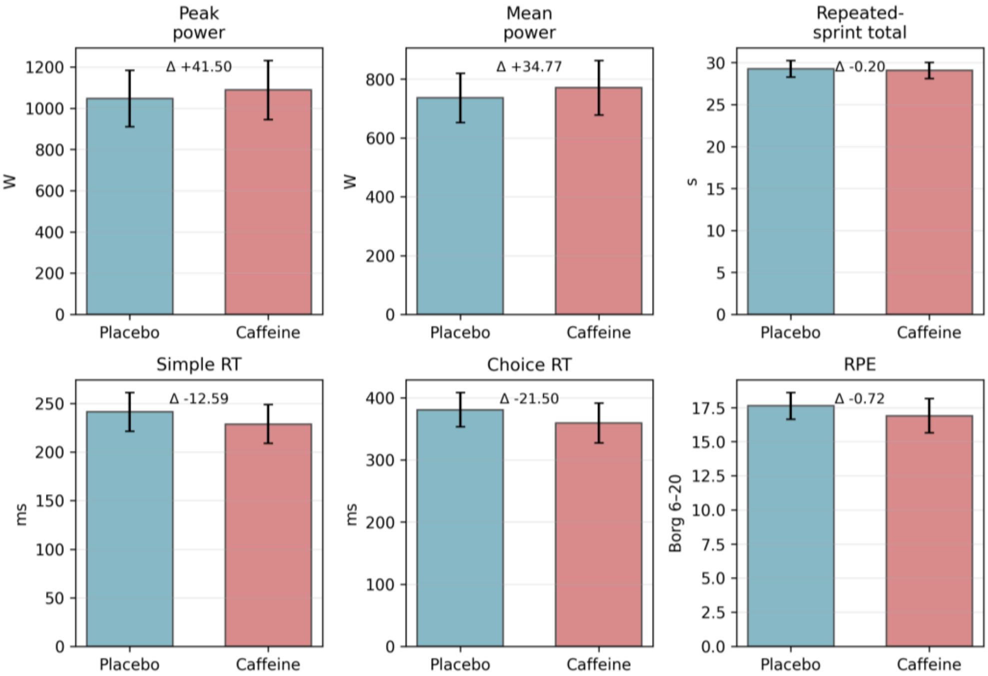

FIGURE 2. Condition effects on key outcomes.

Figure 2 summarizes the direction and magnitude of the caffeine response across neuromuscular, cognitive, and perceptual domains. The consistent pattern across panels is important because it indicates that the ergogenic effect was not confined to a single variable. Peak and mean power improved, both reaction-time tasks became faster, and perceived exertion declined despite the greater physiological strain reflected by blood lactate.

Table 3. Inferential statistics for the principal outcomes and repeated-sprint model.

Outcome	Test statistic	p	Effect size
Peak power (W)	t(23) = 4.26	<0.001	d_z = 0.87
Mean power (W)	t(23) = 6.28	<0.001	d_z = 0.9
Repeated-sprint total time (s)	t(23) = −5.44	<0.001	d_z = −0.7
Simple reaction time (ms)	t(23) = −6.48	<0.001	d_z = −0.8
Choice reaction time (ms)	t(23) = −5.81	<0.001	d_z = −1.19
RPE (Borg 6–20)	t(23) = −3.98	<0.001	d_z = −0.81
Blood lactate ($mmol\cdot L^{-1}$)	t(23) = 3.91	<0.001	d_z = 0.80
30 m sprint time (condition × sprint)	F(5,115) = 9.40	<0.001	Repeated-measures ANOVA

The inferential results in Table 3 show that the statistically significant changes were also large enough to matter in applied settings, which demonstrates that the caffeine advantage was not static. Instead, the advantage became clearer as the sprint series progressed, which strengthens the interpretation that caffeine helped blunt fatigue-related decline rather than merely sharpening the opening sprint.

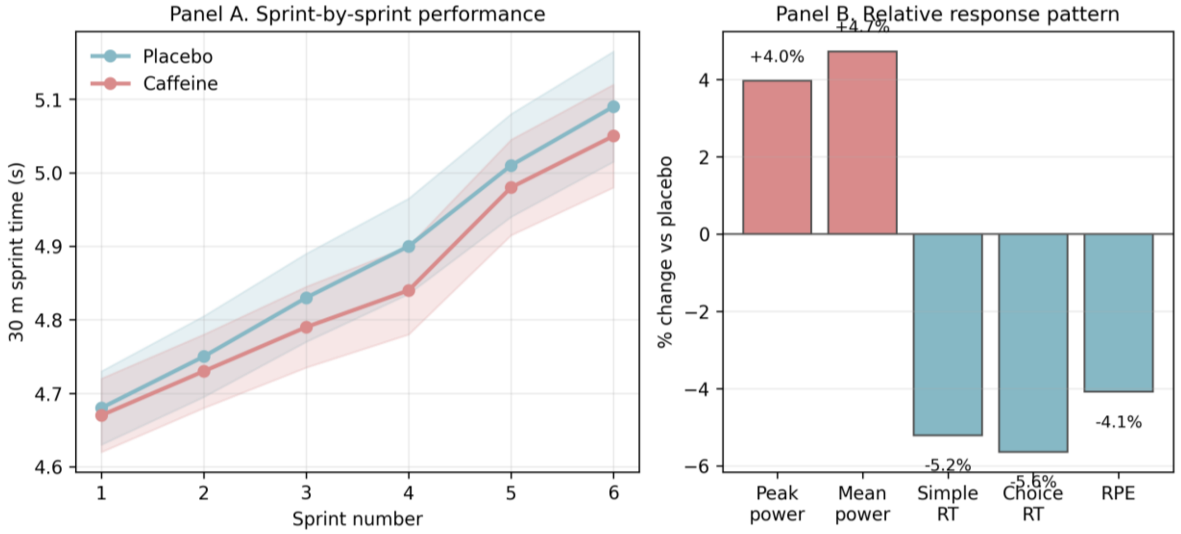

FIGURE 3. Repeated-sprint profile and relative response pattern.

Figure 3 provides the clearest visual evidence that the caffeine condition became increasingly advantageous across the latter portion of the sprint sequence. Panel A shows that both conditions began from nearly identical starting values, but the divergence widened as recovery demands accumulated. Panel B complements that trend by showing that the percentage improvement was consistent across power output, reaction speed, and perceived exertion. Taken together, the figure supports the view that caffeine acted across multiple performance domains rather than through a single isolated mechanism.

V. DISCUSSION

The purpose of this study was to determine whether acute caffeine ingestion could improve anaerobic power, reaction time, and fatigue-related responses in trained male team-sport athletes. The principal finding was that a moderate pre-exercise dose of caffeine enhanced Wingate peak and mean power, accelerated both simple and choice reaction time, improved repeated-sprint performance, lowered perceived exertion, and produced a modest increase in post-exercise blood lactate. Taken together, these results indicate that caffeine improved both the physical and perceptual-cognitive determinants of short-duration team-sport performance.

The Wingate findings are consistent with a substantial body of evidence showing that caffeine can improve anaerobic performance, particularly peak and mean power output [6], [7], [10], [19], [21]. The magnitude of the improvement observed here was consistent with the meta-analytic literature, suggesting that the ergogenic effect of caffeine extends beyond endurance exercise and includes brief high-intensity tasks. The most plausible explanation is that caffeine increased neural drive, allowing the athletes to produce higher instantaneous force while maintaining output more effectively over the 30-s effort [7], [8], [21]. The lower fatigue index supports that interpretation. Although the absolute change in fatigue index was modest, it suggests that caffeine influenced not only the initial power surge but also the ability to sustain work as the effort progressed.

In the present study, both reaction-time tasks improved after caffeine, with the larger effect observed in the choice task. That pattern is important because choice reaction time is more representative of the demands imposed by dynamic game situations. Previous work has shown that caffeine can enhance vigilance, alertness, and some forms of cognitive performance, but those effects are not always measured alongside sport-specific physical tasks [8], [13], [20]. The current data therefore strengthen the case for caffeine in sports that require fast perception-action coupling.

Repeated-sprint performance also improved with caffeine. The condition × sprint interaction showed that the benefit widened across the later sprints rather than being confined to the opening repetition. This pattern is consistent with team-sport studies reporting improved intermittent-sprint ability, greater running distance at high speed, or more favorable movement profiles during simulated match play [11]–[18]. In practical terms, the later-sprint benefit may be especially valuable because decisive actions in team sports often occur when fatigue is already substantial. A supplement that preserves late-phase output can therefore be more useful than one that enhances the first explosive effort.

The higher lactate likely reflects greater glycolytic contribution and total work during the more demanding performance outputs, whereas the lower RPE suggests that athletes experienced that work as less taxing. This dissociation between physiological strain and perceived effort has been proposed as one of the key practical mechanisms through which caffeine benefits performance [2], [3], [5], [8]. For intermittent sports, in which athletes must repeatedly choose to re-accelerate or contest possession while fatigued, that reduced sense of effort may have genuine competitive value.

Salinero and colleagues reported small but significant improvements in repeated-sprint performance, jumping, and high-intensity running following acute caffeine ingestion in team sports [17]. Ferreira and colleagues, by contrast, noted more mixed effects in soccer-specific tasks, suggesting that performance enhancement is not universal and may depend on the nature of the test [18]. The present findings help reconcile that apparent inconsistency by showing stronger effects for tightly controlled neuromuscular and reaction-time measures than for broad match-simulation variables.

The present protocol supports the use of 5 $\text{mg}\cdot\text{kg}^{-1}$ caffeine approximately 60 min before exercise when the performance target is repeated anaerobic work combined with rapid perceptual processing. The dose used here sits comfortably inside the range typically recommended in position statements and review articles [5], [7], [10]. Importantly, the athletes in this sample were low-to-moderate habitual users, which may have helped preserve responsiveness. Athletes with higher habitual intake, disrupted sleep, or elevated anxiety may not respond in the same way [9], [10], [20]. Practitioners should therefore weigh the potential performance benefits against tolerance, the timing of the competition, and individual side-effect history.

Several limitations should be acknowledged. First, although the crossover design strengthened internal validity, the sample size was modest and limited to young men from team-sport backgrounds. The results should therefore not be generalized automatically to women, adolescent athletes, or highly elite professionals. Second, blood caffeine concentration was not measured, so between-athlete variability in absorption could not be examined. Third, choice reaction time was measured in a controlled computerized format rather than in a fully sport-specific decision task.

These limitations also point to useful directions for future work. Research should compare capsule caffeine with alternatives such as chewing gum or mouth rinse to determine whether faster delivery methods are preferable when warm-up time is limited. It would also be valuable to test whether the present combination of higher blood lactate, lower RPE, and faster reaction time translates into improved passing quality, defensive readjustment, or late-match decision making. Finally, repeated-dose protocols under congested fixture schedules warrant more attention because recovery, sleep, and neuromuscular freshness may affect the acute performance response.

That does not mean caffeine should be used indiscriminately. Athletes differ in tolerance, sleep sensitivity, gastrointestinal comfort, and prior habitual use. The most defensible applied approach is therefore individualized trialing during training rather than first exposure on competition day. Coaches should also consider the timing of kickoff, the athlete’s usual sleep schedule, and the possibility that late-evening ingestion may disturb recovery even when acute performance benefits are desirable.

Future work should also examine whether lower caffeine doses produce a similar integrated response with fewer side effects, especially in athletes who already consume caffeine habitually. Additional studies using women, adolescent athletes, and highly trained professional squads are also needed. Finally, repeated-dose protocols across congested fixture periods deserve more attention because acute ergogenic benefits may interact with sleep, recovery, and neuromuscular freshness over several consecutive days.

VI. CONCLUSION

Acute ingestion of 5 $\text{mg}\cdot\text{kg}^{-1}$ caffeine 60 min before exercise improved anaerobic power, accelerated reaction time, and reduced fatigue-related decline during repeated sprinting in trained male team-sport athletes. The caffeine condition produced higher Wingate peak and mean power, faster simple and choice reaction times, a lower total repeated-sprint time, and a smaller sprint decrement. At the same time, athletes reported lower perceived exertion despite a modest rise in post-exercise blood lactate, indicating that the supplement supported a greater external output without a parallel increase in conscious effort.

These findings are important because they show that caffeine influenced more than one performance domain simultaneously. In team sports, decisive moments often occur when athletes must sprint repeatedly, recover incompletely, and still react quickly to changing tactical information. The present data suggest that caffeine may help preserve exactly those combined demands. The improvement in choice reaction time is especially relevant from an applied perspective, since this task is closer to the rapid stimulus discrimination required in open-skill competition than a simple response test alone.

The present protocol supports the targeted use of a moderate caffeine dose before training sessions or competitive phases that emphasize repeated maximal efforts and fast perceptual processing. However, the findings should be applied with individual caution. Athletes differ in caffeine tolerance, sleep sensitivity, gastrointestinal comfort, and habitual intake, so supplementation should be trialed in training before match use.

Author Contributions

The author conducted the conceptualization, methodology, data analysis, investigation, writing, review, editing, and final approval of the manuscript.

Funding

This research received no external funding.

Data Availability

The dataset will be available from the author upon reasonable request.

Conflicts of Interest

The author declares no conflict of interest.

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