RESEARCH ARTICLE

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Acute Effects of Knowledge of Results on Repeated Sprint Ability Iin Adolescent Male Team Sports Athletes

J. Morris [a, *], J. Moody [a, b], J. Esformes [a]

[a] Cardiff School of Sport and Health Sciences, Cardiff Metropolitan University, Cardiff, United Kingdom

[b] Nişantaşı University, Istanbul, Turkey

* Corresponding Author e-mail: 20283881@outlook.cardiffmet.ac.uk

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Abstract: Repeated-sprint ability is critical for sustaining performance in team sports. Augmented feedback, particularly knowledge of results, may enhance athletic performance. However, its effects on repeated-sprint ability in young athletes remain underexplored. This study aimed to evaluate the impact of knowledge of results on repeated-sprint ability among adolescent male team sport athletes. A randomised crossover design was employed with 13 participants (age = 15 ± 1 years; height = 1.74 ± 0.07 meters; body mass = 61.0 ± 8.4 kilograms) completing linear sprints, shuttle sprints, and change of direction sprints to assess initial sprint time, average sprint time, total sprint time, and percentage decrement score. Data were analysed using repeated measures analysis of variance. The results indicated no significant interactions for initial sprint time (p = 0.503), average sprint time (p = 0.639), total sprint time (p = 0.635), or percentage decrement score (p = 0.600) across feedback conditions. In conclusion, providing knowledge of results in the form of sprint times did not enhance performance or mitigate fatigue in junior athletes during repeated-sprint ability protocols. Coaches should consider alternative strategies to enhance athlete performance during training and competition.

Keywords: Augmented feedback, Knowledge of results, Repeated sprint ability, Adolescent athletes, Team sports

1. Introduction

Many team sports require athletes to perform repeated maximal or near-maximal sprints of short duration (less than 6 seconds) with brief recovery periods over an extended duration (60 to 90 minutes; Bishop *et al.*, 2004), referred to as repeated-sprint ability (RSA; Gabbett, 2010). In contrast, the term 'repeated-sprint' (RS) generally refers to the actual execution of multiple sprints without necessarily indicating the athlete's ability to maintain performance levels throughout those sprints (Girard *et al.*, 2011).

One approach that can help enhance performance and reduce the effects of fatigue during exercise is augmented feedback (AugFb; Weakley *et al.*, 2020). According to Petancevski *et al.* (2022), AugFb comprises information provided to the learner by an external source. It is generally categorised into knowledge of performance (KP) and knowledge of results (KR). Knowledge of performance focuses on skill mechanics, while KR emphasises the outcomes (Nagata *et al.*, 2020).

Weakley *et al.* (2019) demonstrated that KR improved jump, sprint, and strength measures in semi-professional male rugby union players compared to a non-feedback group. Keller *et al.* (2014) examined the impact of AugFb on the stretch-shortening cycle (SSC) using frequencies of 100%, 50%, and 0% KR. The results revealed that both the 100% and 50% KR groups experienced immediate improvements in jump height. However, the 100% KR group displayed the greatest long-term adaptation, achieving a 14% increase in overall performance. Keller *et al.* (2014) concluded that short-term learning could not explain KR's immediate effects, but motivation is a possible mechanism. Bella *et al.* (2023) investigated the impact of feedback types, including KP and KR, on different aspects of sprint performance, motivation, and mood in highly trained female rugby league players. The study found that all feedback conditions resulted in higher motivation and enjoyment compared to a control group, with faster sprint times recorded for KR for both linear and curved agility sprints (3.54s and 5.42s) compared to KP (3.64s and 5.61s) and control (3.58s and 5.57s).

However, Bella *et al*. (2023) the first to examine the acute effects of AugFb on RSA, found no significant differences between feedback conditions.

The ability to perform repeated sprints is a key predictor of success in team sports (Wong *et al*., 2012). Various RSA tests have been proposed to assess and develop this fitness quality, typically involving 3–15 unidirectional sprints of 15–40 meters with recovery periods of 15–30 seconds (Selmi *et al*., 2016; Schimpchen *et al*., 2016). However, many sports require athletes to quickly and repeatedly change direction to outperform opponents (Young *et al*., 2001). Linear sprints and change of direction (COD) tasks represent distinct physical qualities, with COD requiring higher neuromuscular effort for braking and propulsion (Brughelli *et al*., 2008). Conversely, RSA, including COD, is likely a general quality, as, besides the initial sprint, the ability to repeat maximal sprints is more related to metabolic factors (Buchheit *et al*., 2012). Therefore, incorporating COD into RSA protocols ensures testing and training specificity (Buchheit *et al*., 2012). However, to date, no studies have examined the acute effects of KR on various modes of RSA, including linear, shuttle, and COD, which could have important implications for training in team sports. Understanding how KR influences performance in these diverse sprinting scenarios could help coaches tailor AugFB and training strategies to optimise athletes' performance during competition.

Despite increasing knowledge and interest in RSA, little is known about its evolution with age (Mujika *et al*., 2009). Research suggests that children and adolescents recover from RS exercise more quickly than adults, primarily due to their increased reliance on oxidative metabolism and faster phosphocreatine (PCr) resynthesis (Mujika *et al*., 2009). However, Falk and Dotan (2006) argue that children's lower anaerobic power might indicate they have less from which to recover.

While providing KR appears to enhance high-intensity performance (Weakley *et al*., 2020), its effectiveness for maximal effort performance whilst fatigued remains debated (Bella *et al*., 2023). According to Motivational Intensity Theory, task performance is influenced by perceived exertion and motivation, with task termination occurring when the effort required aligns with the maximum exertion an individual is willing to provide (Richter, 2013). Importantly, the prerequisite for maximal motivation during RS exercise cannot be assumed to be the same for children and adults (Falk and Dotan, 2006). Consequently, the motivational benefits of AugFb may diminish during exercise that requires maximal effort while the individual is fatigued (Dallaway *et al*., 2022; Bella *et al*., 2023). Additionally, age-related differences (Mendez-Villanueva *et al*., 2011) and the demands of various RSA protocols reveal a limited understanding of how KR impacts motor performance in youth team athletes, potentially hindering their development (Müller *et al*., 2022).

Therefore, the current study aimed to examine whether KR can influence the acute performance of adolescent male team sports athletes during various RSA protocols that closely mimic the demands of team sports. The primary research objectives were to examine 1) the effect of KR on the performance of junior team sports athletes during different modes of RS exercise and 2) its impact across each mode. It was hypothesised that KR, provided as sprint times, would not improve performance during any mode of RS exercise.

2. Method

2.1. Participants

A convenience sample of 13 adolescent male team sport athletes participated in the study (age = 15 [1] years, height = 1.74 [0.07] m, body mass = 61.0 [8.4] kg). The sample size was calculated using G*Power software, with an effect size of 0.5, an alpha level of 0.05, and a power of 0.80. This sample is consistent with previous research that analysed the impact of AugFb on sprint performance (Bella *et al*., 2023; Doma *et al*., 2020). Participants were recruited from a U15 rugby union team in West Wales, U.K., with testing conducted during pre-season training. All participants followed a similar training schedule, including one weekly skills session supervised by their respective coaches. All participants met inclusion criteria, were free from injury, and were active members of the previous season's team. They were advised to avoid strenuous activity 48 hours before testing, refrain from caffeine and supplements 2 hours before, and wear their club kit and football boots. All participants and parents received information sheets detailing the study's risks and benefits and signed informed assent and consent forms. Experimental protocols received approval from the Institutional Human Research Ethics Committee.

2.2. Data Collection Process

This crossover, randomised study was conducted across three testing sessions, separated by a week. All participants completed the three tests in a randomised order during each testing session (Table 1). The testing sessions took place outdoors on a natural grass field from 4-7 PM, avoiding severe weather to minimise its impact on performance. The temperature and wind speed over the three days were between 16-18°C and 12.5-14.6 mph, respectively.

Table 1. Testing sequence.

Group	Familiarisation	Experimental 1	Experimental 2
1	BCA	CAB	ABC
2	CAB	ABC	BCA
3	ABC	BCA	CAB

A, linear sprint; B, shuttle sprint; C, change of direction sprint.

The study comprised two testing sessions and one familiarisation session, during which participants' body mass and stature were recorded. Participants completed a standardised warm-up, which included jogging, dynamic stretching, and sprints with COD at 75, 85, and 100% maximal speed 5 minutes before the first RSA test of each session. The participants arrived and were tested in subgroups (4-5) to allow for setting up time. Baseline measures of participants' initial sprint during each RSA test without KR were recorded during the familiarisation session and used to control for any pacing strategy during subsequent sessions. The familiarisation session was comparable to experimental sessions, allowing participants to be accustomed to all testing procedures, feedback, and equipment. A non-blinded, single-randomisation sequence was performed by tossing a coin at the beginning of each experimental session. The testing sessions consisted of testing under separate, randomised experimental conditions, including a control condition (CON) and 100% knowledge of results (KR) for all RSA tests, which included linear sprint (LS), shuttle sprint (SS) and change of direction sprint (COD). The control group received no feedback on their immediate performance, whereas the KR group received KR immediately after each sprint in each RSA test. KR was verbally provided as sprint times by the lead researcher. The participants were required to complete all three RSA tests during each session, with a minimum 10-minute recovery period between each test, to allow for complete recovery of phosphocreatine stores. Extra rest time was allowed upon request to ensure full recovery. Each participant was instructed to sprint as quickly as possible and examined individually to ensure that their performance was not affected by additional environmental constraints, such as competition from other participants.

2.3 Repeated Sprint Ability Tests

The work: rest ratio for LS, SS, and COD was 1:5, 1:3 and 1:2, respectively (Table 2). LS comprised 7 x 30-m straight sprints (~5 seconds) departing every 25 seconds; SS, 7 repetitions of 2 x 15-m shuttle sprints (~7 seconds) departing every 20 seconds; and COD, 7 repetitions of 6 x 5m sprints with 60° COD (~12 seconds) departing every 25 seconds (Figure 1). The estimated performance times and work-to-rest ratios were based on Ruscello *et al*. (2016), who used a similar subject group.

Table 2. Testing protocols.

Protocol	No. of Reps	Work-to-Rest Ratio	Type of Recovery
Linear sprint 7 x (30m)	7	1: 5	Passive
Shuttle sprint 7 x (15 + 15m)	7	1: 3	Passive
COD sprint 7 x (6 x 5m)	7	1: 2	Passive

COD = change of direction.

During the recovery between sprints, participants stood passively. Three seconds before starting each sprint, participants were asked to assume the start position, ~0.5 m behind the sensor, and await the start signal from a Bluetooth speaker. Sprint times were measured to the nearest 0.01 s using an infrared timing system (Brower Timing Systems, South Fort Street, Draper, USA) positioned at the starting and finishing lines, 1 m above the ground and 2 m apart, with one set of timing gates required for the shuttle test, allocated at the start/finish line. The participants had to rest for 5 minutes before recommencing if the initial sprint in each RSA test was not within 5% of their baseline measure.

Time-derived measures included initial sprint time (IST), average sprint time (AST), total sprint time (TST), and percentage decrement score (%dec). The IST is the fastest sprint. However, it is worth noting that the fastest time does not always occur during the first sprint. The AST is the average of all seven sprints, TST is the total time for all seven sprints, and %dec is the actual performance compared to the ideal performance, calculated as %dec = ((S1 + S2 + ... + Sfinal)/Sbest * 7 - 1) x 100, where S is a sprint, and 7 is total sprints. According to Glaister *et al*. (2008), %dec is the most valid and reliable method for quantifying fatigue during RSA testing.

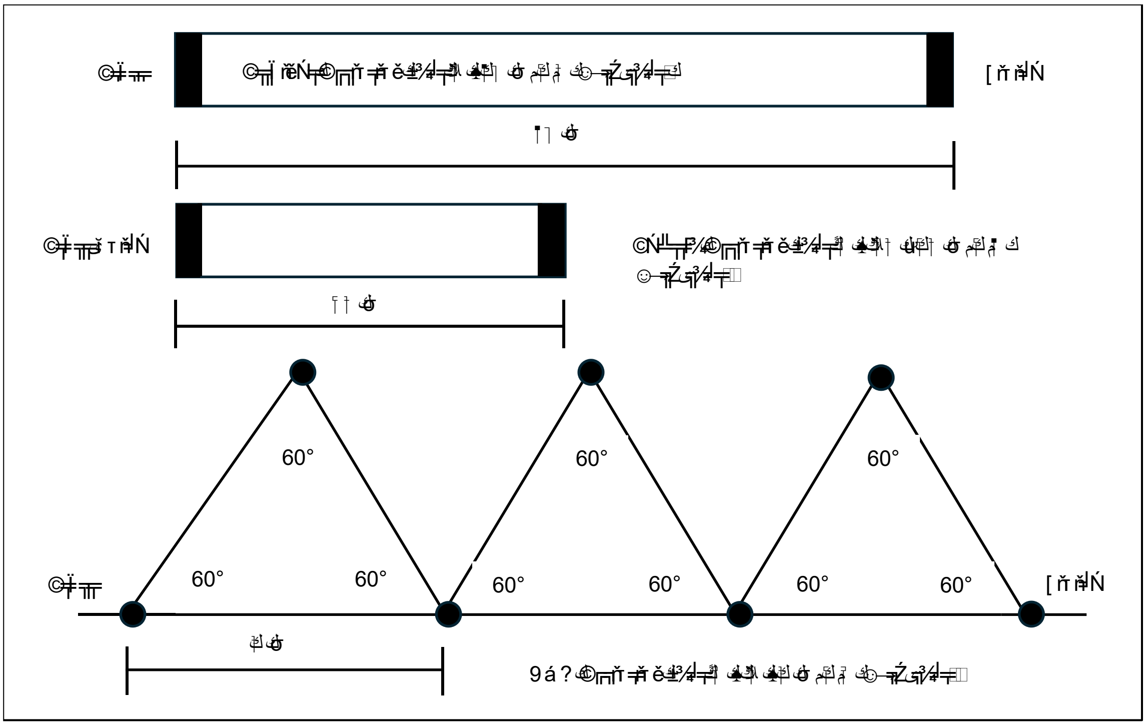

Figure 1. RSA tests, including straight, shuttle, and COD sprinting. COD = change of direction.

If a faster time than the initial sprint was recorded during familiarisation or experimental sessions, it served as the baseline for calculating %dec, which only occurred during the LS.

2.4 Statistical Analysis

Descriptive statistics (mean [SD]) and mean differences (95% confidence interval) between conditions were calculated. The normality of the data was assessed using the Shapiro-Wilks test, which revealed that all parameters were normally distributed. Repeated measures ANOVA (2 x 3) examined differences between the KR and CON groups across each test (Linear, Shuttle, and COD) and interactions for all independent variables. After performing the Mauchly test of sphericity, the Greenhouse-Geisser adjustment was applied when appropriate. Additionally, t-tests were employed to determine differences in the first sprint times between groups for each test prior to the provision of KR. This analysis enabled us to determine whether the groups exhibited statistically significant differences in performance at the point when KR was first available for subsequent sprints. The alpha level for all analyses was set at .05. Data analysis was carried out using IBM SPSS Statistics for Windows (Version 28).

3. Results

Two participants withdrew from the study due to acute injuries sustained while playing rugby, resulting in a final analysis of eleven participants. No significant differences were observed between the KR and CON groups for the first sprint times across the LS (5.12s vs 5.04s), SS (6.54s vs 6.60s), and COD (11s vs 11s) conditions (p = .142, p = .461, p = .975), respectively.

The IST (fastest time) for KR and CON during SS and COD was measured during the first sprint and was within less than 5% of the baseline measure recorded during the familiarisation session. Notably, while this was also the case for the CON group during the LS, the IST only occurred 64% of the time during the first sprint for the KR group. However, KR's first sprint during the LS remained within 5% of baseline measures.

Descriptive statistics (M ± SD) of the performance times and rate of fatigue for all RSA tests are presented in Table 3. Additionally, Table 4 displays the mean differences in performance and fatigue measures between the KR and CON groups, along with their corresponding 95% confidence intervals.

Table 3. Results of each repeated sprint ability test for the knowledge of results and CON conditions. Mean (SD).

RSA test	Knowledge of results	CON
Linear		
IST (s)	5.08 (0.41)	5.03 (0.44)
AST (s)	5.31 (0.45)	5.30 (0.46)
TST (s)	37.14 (3.15)	37.11 (3.23)
%dec	4.38 (2.67)	5.49 (2.60)
Shuttle		
IST (s)	6.53 (0.46)	6.59 (0.50)
AST (s)	6.84 (0.53)	6.91 (0.51)
TST (s)	47.86 (3.72)	48.38 (3.57)
%dec	4.61 (1.57)	4.90 (2.71)
Change of direction		
IST (s)	10.96 (0.78)	10.95 (0.65)
AST (s)	11.66 (0.86)	11.77 (0.78)
TST (s)	81.59 (6.05)	82.42 (5.43)
%dec	6.40 (3.04)	7.65 (3.84)

*P<.05 compared to control

Table 4. Mean differences (95% CI) between KR and CON groups for the linear, shuttle and change of direction tests.

RSA test	KR vs. CON
Linear	
IST (s)	0.06 (-0.04 – 0.15)
AST (s)	0.01 (-0.07 – 0.07)
TST (s)	0.01 (-0.49 – 0.52)
%dec	-1.05 (-2.07 – -0.02)
Shuttle	
IST (s)	-0.05 (-0.24 – 0.13)
AST (s)	-0.07 (-0.24 – 0.09)
TST (s)	-0.51 (-1.69 – 0.66)
%dec	-0.34 (-2.05 – 1.37)
COD	
IST (s)	0.002 (-0.22 – 0.22)
AST (s)	-0.12 (-0.51 – 0.27)
TST (s)	-0.82 (-3.57 – 1.92)
%dec	-1.18 (-4.13 – 1.78)

For the primary dependent variables, a repeated measures ANOVA with Greenhouse-Geisser adjustment indicated no significant group-by-test interaction for AST (p = .639) or TST (p = .635). Analysis using Sphericity Assumed revealed no significant group by test interaction for IST (p = .582) or %dec (p = .600).

4. Discussion

The present study examined the acute effect of KR on RSA in adolescent male team sport athletes under different sprinting conditions. The primary finding supported the hypothesis, indicating that KR cannot significantly affect the IST, AST, TST, or %dec compared to no feedback during the examined RSA protocols (p > 0.05). These results suggest that providing KR to junior athletes (U15s) during different modes of RS exercise does not enhance sprint performance or mitigate fatigue.

These findings align with previous research by Bella *et al.* (2023), which reported no significant differences in average time and percentage decrement across different AugFb conditions, including KR, compared to a control condition. Conversely, Doma *et al.* (2022) found that both athlete-driven (KR provided in response to athlete reflection) and traditional KR were effective in improving average times during an RS swim protocol compared to a non-feedback condition (p = .014, p = .023). The differences between these results may be attributed to the different modes of exercise, as the muscles engaged and the energy required to sustain motion during swimming differ from those involved in running (Suriano and Bishop, 2010). However, considering RS exercise is predominantly influenced by metabolic factors (Buchheit *et al.*, 2012), a more likely explanation may lie in the variations in work-to-rest ratios used in the protocols.

The work-to-rest ratio used by Doma *et al.* (2022) was 1:3, whereas the present study, during the LS, and the study by Bella *et al.* (2023) utilized work-to-rest ratios of 1:5 and 1:4, respectively, which are commonly used in RSA training for team sports (Ruscello *et al.,* 2013). Furthermore, it is essential to consider that the absolute rest period during RS exercise is calculated following the completion of each sprint bout to standardise relative recovery (La Monica *et al.*, 2016). Therefore, although the 1:3 work-to-rest ratio used by Doma *et al.* (2022) appears less, in absolute terms, as completion times were between 32 and 34 seconds for all conditions, the swimmers were given approximately 90 seconds of recovery time. Conversely, the average times for the present study during the LS were 5.31 and 5.30 seconds for KR and CON, respectively. Therefore, participants were given approximately 25 seconds of recovery time. Similarly, Bella *et al.* (2023), who used a 12 × 20 m linear sprint protocol, reported that average times were approximately 4 seconds for all conditions, yielding only 16 seconds of recovery time.

Given that RS exercise is characterised by <10-second sprints paired with <60 seconds recovery periods (Girard *et al.*, 2011), the protocol used by Doma *et al.* (2022) may be more representative of intermittent sprint exercise, which typically features longer recovery periods (60-300 seconds) allowing for near-complete recovery of sprint performance (Girard *et al.*, 2011). Consequently, KR may not significantly influence performance measures such as average time and percentage decrement during linear RS exercise.

Additionally, the results indicate that KR did not significantly impact any performance measures during the SS and COD tests (p > 0.05). No studies have examined KR's effect on different RSA modes, making comparisons difficult for SS and COD. However, Wong *et al.* (2012) investigated the relationship between RSA and repeated sprints with a change of direction (RCOD), matching them in terms of intervals and distances. Their findings showed a strong correlation between RSA and RCOD for IST, AST, and TST, with correlation coefficients ranging from r = 0.69 to 0.71 (p < 0.05). However, they found no significant correlation for the %dec.

Buchheit *et al.* (2012) indicate that sprint times increase with the angle and frequency of COD, complicating any analyses of COD's impact on performance during RS exercise. To address this, they employed an experimental design that included single sprints and RS sequences with either two 45°, 90°, or 135° COD, compensating for time lost during directional changes. Their findings revealed reductions in running distance by 7%, 26%, and 35% for 45°, 90°, and 135° COD sprints, respectively.

In the present study, the average sprint times for both groups during LS were notably faster than those during SS and COD, with COD times being more than twice as long as those recorded during LS. Our results further highlight the significant impact that directional changes have on performance, challenging the traditional definitions of RSA (Girard *et al.*, 2011).

According to Buchheit *et al.* (2012), the adjusted distances for SS and COD in this study were 23 and 14 meters, respectively. This recalibration yielded average times of 5.24 seconds for KR and 5.30 seconds for CON during SS, 5.45 seconds for KR and 5.49 seconds for CON during COD. These adjustments would align average sprint times and metabolic demands across RSA protocols, allowing for a fairer assessment of the impact of KR on different modes of RS exercise.

Augmented feedback enhances performance by increasing motivation and providing task guidance (Bugnon *et al.*, 2023). Kella *et al.* (2023) demonstrated that motivation contributes to short-term effects, resulting in immediate improvements in jump performance with AugFb or declines after withdrawal. Bella *et al.* (2023) found that participants experienced greater motivation and enjoyment with AugFb compared to a control group. Wulf and Lewthwaite (2016) noted that positive feedback enhances perceived competence and reduces performance anxiety, while negative feedback can lower self-esteem and negatively impact future performance (Motro *et al.*, 2021).

Our study did not assess motivation but suggests that declining performance due to fatigue during RS exercise (Girard *et al.,* 2011) may lead participants to view KR from sprint times as negative feedback, which can undermine self-esteem, evoke negative emotions, and negatively impact future performance (García *et al.*, 2019). Moreover, Bella *et al.* (2023) suggest that an athlete's experience level plays a crucial role in receiving feedback. Experts may seek more critical feedback to enhance their motivation, while novice athletes may experience feedback-induced anxiety and dejection (Fishbach *et al.*, 2010). Therefore, the KR provided to the junior athletes in the current study may have inadvertently diminished their motivation.

To address this, future research assessing the impact of KR on different modes of RS exercise should explore more constructive methods of delivering sprint times. For instance, instead of providing KR as a sprint time for comparison with previous repetitions, feedback could be offered on the same repetition performed during a comparable prior test. Additionally, rather than presenting KR as a specific sprint time, it could be communicated verbally using terms like "faster" or "slower" or visually indicated through a colour-coded system (e.g., green for faster, red for slower). This approach could facilitate more positive AugFb and, consequently, enhance motivation.

While this study is the first to examine the impact of AugFb on various modes of RS exercise in adolescent male team sport athletes, it is essential to note its limitations. First, the homogeneity of adolescent male athletes may limit the generalisability to female and senior-level athletes. Second, differences in growth rates among participants may have impacted their athletic performance. Nonetheless, a single age group (U15) was used to control for age differences, ensuring that all participants were born within 12 months. However, as RSA is mediated by growth and maturation (Mendez-Villanueva *et al.*, 2011), it is recommended that future studies examine the acute effects of KR among different age groups. Third, pacing strategies occur in demanding events based on pre-exercise expectations (Billaut *et al.*, 2011), which may have affected the participants' performance. However, we controlled for pacing by recording baseline measures of participants' initial sprints during each RSA test without KR and then setting a minimum threshold of 95% for subsequent tests.

Finally, it remains evident that a definitive understanding of RSA, including its measurement and enhancement techniques, still needs to be elucidated. However, incorporating COD is essential for the training and assessment of team sport athletes. Therefore, future research investigating the impact of KR on various modes of RS exercise should consider factors such as work-to-rest ratios and sport-specific angles.

Knowledge of results, provided as sprint times, is effective in single-sprint tasks (Bella *et al.*, 2023) and in RS exercises with longer absolute recovery periods (Doma *et al.*, 2022). However, the point at which feedback ceases to be effective warrants further investigation. Future studies should, therefore, explore the effects of KR across different absolute recovery intervals in various RSA protocols, keeping in mind that RSA is generally characterised by <10-second sprints followed by recoveries of less than 60 seconds. Future studies could identify effective feedback strategies and the critical moments when feedback may hinder performance in RS scenarios.

5. Practical Applications

Augmented feedback, specifically KR, did not enhance RSA among male adolescent team sport athletes in this study. Therefore, while recording sprint times is critical for monitoring progress (Kamarudin *et al.*, 2022), coaches should consider implementing more cost-effective strategies during training, such as providing verbal encouragement (Weakley *et al.*, 2020).

6. Conclusion

This study examined the impact of knowledge of results (KR) on various repeated sprint ability (RSA) protocols among adolescent male team sport athletes. The findings revealed that KR, provided as sprint times, had no significant effect on key performance metrics, including initial sprint time, average sprint time, total sprint time, or percentage decrement, indicating it does not enhance RSA in young athletes. Although these results align with previous research, discrepancies may arise from differences in sprinting modes and work-to-rest ratios employed in various studies. Consequently, while recording sprint times is crucial for monitoring athlete progress, coaches should consider alternative, cost-effective methods for improving performance. Future investigations should explore more constructive feedback techniques and assess the impact of varied work-to-rest ratios, particularly in protocols that more closely mimic competitive scenarios, to identify effective strategies for enhancing RSA in young athletes.

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Authors Contribution Statement

J. Morris: Conceptualization, Methodology, Data collection, Validation, Formal analysis, Investigation and Writing Original Manuscript. J. Moody: Formal analysis, Writing - Review & Editing J. Esformes: Formal analysis, Writing - Review & Editing. All the authors read and approved the final version of the manuscript.

Ethics Approval Statement

Ethics approval was obtained from the Institutional Review Board (IRB).

Participants Consent

The participants and parents received information sheets detailing the study's risks and benefits and signed informed assent and consent forms.

Does this article pass screening for similarity?

Yes

Informed Consent

The consent form was signed before the commencement of the study.

Conflict of Interest

The authors declare that there was no conflict of interest.

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