Title: Morning resistance exercise and cricket-specific repeated sprinting each improve indices of afternoon physical and cognitive performance in professional male cricketers

Running head: Morning priming in cricket

Fergus Nutt [a]. Samuel P. Hills [b], Mark Russell [c], Mark Waldron [a,d], Phil Scott [e], Jonty Norris [f], Christian J. Cook [g], Billy Mason [h], Nick Ball [h], Liam P. Kilduff [a,d]*

[a] Applied Sports Technology, Exercise Medicine Research Centre (A-STEM), Swansea University, Swansea, United Kingdom.

[b] Faculty of Health and Social Sciences, Bournemouth University, Bournemouth, United Kingdom

[c] School of Social and Health Sciences, Leeds Trinity University, Leeds, United Kingdom

[d] Welsh Institute of Performance Science, College of Engineering, Swansea University, Swansea,

United Kingdom.

[e] England and Wales Cricket Board, Leicestershire, UK

[f] Derbyshire County Cricket Club, Derby, UK

[g] School of Science and Technology, University of New England, Armidale, Australia

[h] Research Institute for Sport and Exercise, University of Canberra, Canberra, Australia

*Corresponding author: Professor Liam P. Kilduff; l.kilduff@swansea.ac.uk

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Figures: 3

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Abstract

Objectives: To compare two modes (general and cricket-specific) of morning priming exercise on afternoon physical and cognitive performance, and subjective readiness to perform in professional male cricketers.

Design: Randomised, crossover, counterbalanced.

Methods: On three occasions, 16 professional men's cricketers completed afternoon tests of countermovement jump height, cricket-specific sprint performance (running between the wickets, two runs), cognitive function (Stroop test, time taken), and subjective readiness to perform. Control (CON; passive rest), lower-body resistance exercise priming (LIFT; trap bar deadlifts, 6 x 4 repetitions up to 85% of one repetition maximum), or cricket-specific running priming (RUN; 6 x 35.36 m sprints including a 180° change of direction) interventions were implemented 5.5 h before testing.

Results: Afternoon sprint times were faster in RUN (-0.04 s, $p = 0.013$) and LIFT (-0.07 s, $p<0.001$) versus CON, and faster in LIFT than RUN (-0.03 s, $p = 0.032$). Jump height (+1.1 cm, $p = 0.021$) and cognitive function (-3.83 s, $p = 0.003$) were greater in LIFT than CON, whilst RUN outperformed CON for cognition (-2.52 s, $p = 0.023$). Although perceived readiness was not influenced by trial ($p >0.05$), players reported favourable responses on the "aggression" subscale in LIFT relative to CON (+1 arbitrary unit, $p = 0.022$).

Conclusions: Both general (lower-body resistance exercise) and cricket-specific (simulated running between wickets) morning priming are effective match-day strategies to improve afternoon markers of physical and cognitive performance in professional men's cricketers. Practitioners may thus be afforded flexibility in situations where resistance exercise is not feasible on the morning of a match.

Key words

Strength; Speed; Power; Potentiation, Preparation, Team sports

Introduction

Although cricket match-play involves mostly low-intensity activities, crucial moments require explosive high-speed movements such as power hitting, sprinting, bowling, diving, and throwing.[1, 2] For example, batters score by running 17.68 m from one crease to another (often multiple times in succession, including turns), while horizontal velocity during a fast bowler's pre-delivery stride is positively related ($r = 0.73$) to ball speed upon release.[3] Fielders produce high-intensity efforts such as dives, throws, and sprints to help save runs and take wickets.[1, 2] Cricketers also face substantial cognitive demands, including anticipating and reacting to myriad environmental stimuli.[4, 5] Limited-overs matches in particular are often decided based on fine margins, each delivery potentially having a meaningful impact on the match outcome.[6, 7]

Performing resistance exercise on the morning of competition could improve indices of afternoon physical performance. Whilst several mechanisms such as increased joint stiffness, high-frequency motor neuron activation, and greater muscle fibre sensitivity to calcium ions have been proposed to contribute to such responses,[8] a body of evidence suggests that hormonal changes likely play a substantial role. Specifically, testosterone concentrations are positively associated with indices of explosive physical performance in trained populations[9-11] and potentially influence other psychological or behavioural responses such as motivation, confidence, and cognitive function.[9, 12] Whereas endogenous testosterone concentrations typically demonstrate diurnal variations, characterised by an early morning peak followed by a transient decline through the day,[13, 14] resistance exercise may acutely elevate testosterone.[15] Such hormonal responses could enhance athletic performance if these elevations are maintained at the onset of subsequent exercise.[16, 17].

Well-trained shot putters who performed back squats and power cleans in the morning produced greater throwing performance 4-6 h later, compared with a rested condition.[18] Similarly, semi-professional rugby players improved afternoon strength, as well as jump and sprint performance, after completing morning resistance training.[16] Notably, priming offset circadian declines in salivary testosterone concentrations that were otherwise observed.[16] Although delayed potentiation or 'priming' effects could exist for ~1-48 h following resistance exercise, the greatest benefits are realised between ~6-33 h after the priming stimulus.[8] However, several barriers including travel demands, and a lack of time or access to facilities may often limit the feasibility of resistance exercise-based priming interventions as a competition-day strategy.[19] Indeed, a survey of high-performance sport practitioners suggested that many respondents had never (19%) or no longer (30%) implemented priming exercise despite 84% believing the practice to be efficacious.[19]

Russell et al.[17] confirmed that more flexible modes of priming exercise could improve afternoon athletic performance in professional rugby union players. Whilst morning resistance exercise improved repeated sprint responses compared with a rested control condition, performing six 40 m sprints also improved sprint times, and augmented jumping performance ~5 h later.[17] Such findings may suggest a role for alternative methods of morning priming (i.e., repeated sprinting) that could be more practically achievable in an applied scenario. Further research is warranted to confirm this suggestion by examining the role of priming specificity and assessing the potential for feasible modes of priming exercise to benefit indices of sport-specific physical and cognitive performance in a broader range of athletic populations. Indeed, resistance exercise has also been linked with acutely improving aspects of cognitive function,[20] although the effects of exercise priming on cognitive responses remain unclear.[17] This study aimed to examine the influence of two different modes of morning priming exercise on indices of cricket-specific physical performance, cognition, and subjective readiness to perform in professional men's cricketers.

Materials and methods

Following ethics approval from Swansea University Ethics Committee, 16 professional male cricketers (age 26 ± 6 years, mass 88.1 ± 8.4 kg, stature 184.5 ± 3.6 cm) volunteered to participate. All participants were healthy and injury-free and were informed of the risks and benefits of participation before providing written consent prior to the study commencing.

Participants completed three trials in a randomised, counterbalanced, cross-over fashion. A no-priming control condition and two priming interventions were each separated by at least seven days. Participants were asked to maintain consistent nutritional practices and abstained from any caffeine, alcohol, and physical training on the day of each trial and during the preceding 24 h. Participants arrived at the testing venue in the morning of each trial and completed a standardised active warm-up, consisting of dynamic stretching, activation work, and sprints of increasing intensity. Timings remained consistent between trials to avoid the influence of diurnal variation in performance.[14] The intervention stimulus followed five minutes thereafter, whereby players completed either general lower-body resistance exercise (LIFT) or a cricket-specific repeated sprint protocol (RUN) in the priming interventions. A control condition (CON) involved no morning exercise.

For LIFT, participants performed one set of four repetitions of trap bar deadlifts at each of 50%, 70%, 80% of an individual's predicted one repetition maximum (1RM), before three sets of four repetitions at 85% 1RM. Inter-set rest was 120 s. The RUN condition involved a cricket-specific repeated sprint protocol, consisting of six sets of 35.36 m sprints, separated by 30 s passive rest. Each sprint required a 180° change of direction after the first 17.68 m, which aligned with the standard England and Wales Cricket Board (ECB) 'run-two' test.[5]

Participants rested for 5.5 h after the morning priming protocol. Players completed a subjective readiness to perform questionnaire, before undertaking the standardised warm-up. The afternoon testing battery followed thereafter; a Stroop test of cognitive ability and then two physical performance tests. Testing was conducted at the team indoor practice facilities. Participants wore their normal indoor training footwear and apparel, which remained consistent across trials. All participants and assessors were familiar with testing and priming procedures as part of normal training and monitoring practices.

Subjective ratings of readiness were assessed via a scale adapted from Mason et al.[21]. Players documented their perceived 'fatigue', 'aggression', 'soreness', 'mood', and 'motivation'. Each was rated on a five-point Likert scale ranging from '1' (least) to '5' (most ready), to give a score for each subscale and an overall readiness score.[21] Higher scores indicated greater readiness. Questionnaires were provided in paper format, which participants completed in isolation and without communication with others. Cognitive function was then assessed via a Stroop test on a mobile tablet device (EncephalApp, HindSoft, India), in which players were required to repeatedly identify the colour of printed text appearing on different coloured backgrounds.

Physical performance was assessed via countermovement jumps (CMJ) and 'run-two' sprint tests. Each CMJ commenced in a static standing position, from which participants performed a preparatory 'dip' before explosively jumping to attain maximum height. Arms remained akimbo, while jump height (JH) was calculated from flight time data derived from photoelectric cells (Optojump, Microgate, Italy, v1.12.1.). This technology has demonstrated excellent test-retest reliability (intraclass corelation coefficient; ICC: 0.99, coefficient of variation; CV: 2.2%) for estimating vertical JH in physically active induividuals,[22] while ICC of 0.99 has been reported in professional cricketers.[23] Participants performed four repetitions on each occasion, with the greatest JH achieved being retained for analysis.

The 'run-two' is an established ECB standard test, designed to replicate completing two runs. Participants sprinted 35.36 m whilst carrying a standard cricket bat, including a 180° turn after 17.68 m.[5] Sprints commenced from 0.5 m behind the start line, where participants waited for the verbal start command. Time taken to complete 35.36 m was recorded using electronic timing gates (Brower Timing Systems, USA), with the fastest of three completed sprints being retained for analysis.[24] In professional cricketers performing this test once per week, CV $<1\%$ and ICC of 0.99 have been reported,[5, 25] while the current sample have produced CV of 1.4% over three repetitions.

Statistical analyses were conducted using SPSS (Version 27; SPSS Inc., USA) with significance established when $p < 0.05$. One-way repeated measures analyses of variance were used to determine whether 'trial' influenced afternoon assessments of physical or cognitive performance. Mauchly's test was consulted, and the Greenhouse–Geisser correction was applied if the assumption of sphericity was violated. Significant trial effects were further investigated using post-hoc Sidak-adjusted pairwise comparisons. Between-trial differences in total readiness and scores for each readiness subscale were assessed via Friedman's analyses of variance with pairwise post-hoc comparisons. Hedge's g effect sizes (ES) were calculated for post-hoc comparisons, and were interpreted as trivial (0.00−0.19). small (0.20−0.49), moderate (0.50–0.79), or large (>0.80).[26] Pearson's product moment correlations were calculated to assess bivariate relationships between 1RM strength and changes in performance following priming relative to CON. Data are reported as mean ± standard deviation unless otherwise stated.

Results

Table 1 shows that trial influenced sprint performance ($F_{(2,30)} = 16.971$, $p < 0.001$, partial-eta$^2 = 0.531$), with faster sprints in RUN ($p = 0.013$, ES: 0.26, *small*) and LIFT ($p < 0.001$, ES: 0.43, *small*) relative to CON. Sprints were also faster in LIFT than RUN ($p = 0.032$, ES: 0.18, *trivial*).

****INSERT TABLE 1 HERE****

Trial influenced JH ($F_{(2,30)} = 3.551$, $p = 0.041$, partial-eta$^2 = 0.191$) and cognition ($F_{(2,30)} = 12.419$, $p < 0.001$, partial-eta$^2 = 0.453$), which are also shown in Table 1. Greater JH ($p = 0.021$, ES: 0.15, *trivial*) and cognitive performance ($p = 0.003$, ES: 0.56, *moderate*) were observed for LIFT compared with CON, whilst cognitive performance in RUN also exceeded that in CON ($p = 0.023$, ES: 0.90, *large*). Neither JH nor cognitive performance differed between RUN and LIFT, and JH remained similar in RUN compared with CON.

Trial did not influence overall readiness but did influence the 'aggression' subscale ($\chi^2_{(2)} = 9.053$, $p = 0.011$). This subscale indicated greater self-reported readiness in LIFT relative to CON ($p = 0.022$, ES: 0.95, *large*). No significant relationships were identified between 1RM deadlift strength and changes in any performance parameter following priming (all $p > 0.05$).

Discussion

This study examined the influence of general and cricket-specific modes of morning priming on indices of cricket-specific physical performance, cognition, and subjective readiness in professional men's cricketers. Lower-body resistance exercise and cricket-specific repeated sprinting performed in the morning improved afternoon sprinting and cognitive performance relative to a rested control condition. Resistance-based priming also enhanced afternoon CMJ performance, while improving aggression markers of readiness compared with CON and producing faster sprints than RUN. These findings indicate that both lifting- and sprinting-based morning priming exercise can improve indices of cricket-specific athletic performance, while also highlighting the potential for feasible or flexible modes of morning priming exercise to enhance cognitive responses in professional men's cricketers.

Relative to CON, completing six sets of trap bar deadlifts, ranging from 50% to 85% of 1RM, enhanced JH (+1.1 ± 0.4 cm; ~2.5%) and cricket-specific sprint performance (-0.07 ± 0.01 s; ~1.2%) when assessed ~5.5 h later. Such findings support that morning resistance exercise can improve afternoon performance in explosive activities requiring stretch-shortening cycle contributions.[8, 16, 17] Whilst the precise mechanisms behind these delayed potentiation effects remain somewhat unclear, it has been proposed that transient hormonal responses to resistance exercise may be partly responsible.[8, 16, 17] In support, benefits to afternoon sprint performance have been observed following upper-body resistance exercise in professional rugby union players, despite a lack of movement specificity.[17] This upper-body priming exercise (bench press: five sets of 10 repetitions at 75% 1RM) attenuated diurnal declines in testosterone concentrations that were observed in the control condition, resulting in ~17% greater testosterone concentrations at the onset of afternoon performance.[17] As other research has found similar findings following whole-body resistance exercise,[16] it seems plausible that favourable hormonal responses may at least partly explain the improved physical performance observed in LIFT compared with CON.

In line with existing research that has reported improvements in sprint times following running-based priming activities,[16, 17] this study supports the potential for repeated sprinting in the morning to enhance afternoon sprinting performance, as 'run-two' times were improved in RUN (-0.04 ± 0.01 s; ~0.7%) compared with CON. Practitioners working in high-performance sport have expressed a reluctance to prescribe high-intensity resistance exercise on the day of competition, noting that this strategy may not fit within a typical training schedule.[19] Moreover, professional cricketers often play matches that require long-distance travel and/or use hotel accommodation before a match. A lack of facilities may thus make heavy resistance exercise difficult to implement.[19] The results of the current study suggest that given the likely presence of substantial barriers preventing competition-day resistance exercise, morning sprinting may offer a more feasible alternative to elicit a performance priming response in professional cricket.

The efficacy of repeated sprinting as a priming stimulus notwithstanding, afternoon sprints were faster (-0.03 ± 0.01 s; ~0.5%) in LIFT compared with RUN. Similar findings have been reported in professional rugby players, for whom morning resistance exercise also offset diurnal declines in testosterone concentrations.[16] Whilst hormonal responses were not assessed in the current study, these observations appear to indicate that high-load (reaching ≥85% 1RM) resistance exercise-based priming may produce more favourable explosive physical performance responses relative to morning running interventions. Conversely, Russell et al.[17] reported that afternoon testosterone concentrations were preserved more effectively by morning repeated sprinting than by morning resistance exercise. These hormonal responses were reflected in the fact that running-based priming improved a broader range of physical performance measures (i.e., improved sprinting and CMJ performance following running, versus improved sprinting performance alone following weights). Although the reasons for such discrepancies remain unclear, it is possible that between-study differences in priming stimuli may be somewhat responsible. Indeed, whereas the resistance exercise stimulus implemented by Russell et al.[17] consisted of upper-body exercise at ~75% 1RM, the current investigation, plus other research showing favourable priming effects following morning weight training compared with morning running, incorporated lower-body resistance exercises that were performed at higher intensities (i.e., ≥85% 1RM).[16] Collectively, these findings may suggest the importance of choosing priming movements that achieve a sufficient intensity and/or biomechanical or potentially muscle group specificity when seeking to maximise the ergogenic benefits of morning resistance exercise.[8]

It seems likely that movement intensity may also be relevant with regard to running-based priming exercise. The superior outcomes observed by Russell et al.[17] following running-based priming (i.e., compared with upper-body resistance exercise) could also be partly attributable to the changes of direction that were incorporated within the repeated sprint protocol. Adding turns increases the intensity of submaximal shuttle running,[27] thus this inclusion may have produced greater performance priming effects than did the straight line running protocol implemented by Cook et al.[16] That said, incorporating a 180° turn into each morning sprint in the current study produced less substantial afternoon performance benefits when compared with a high-intensity lower-body resistance exercise session.

Whereas previous evidence in professional rugby players has suggested no improvement in reaction times following morning priming exercise,[17] both RUN (-2.52 ± 0.82 s; ~4.9%) and LIFT (-3.83 ± 0.95 s; ~7.4%) enhanced afternoon cognitive performance in the present study. Although more research is required to elucidate cognitive responses following morning exercise, some evidence has suggested a positive association between testosterone concentrations and aspects of cognitive ability.[28] Acknowledging the lack of physiological or hormonal measurements in the current study, it is possible that elevations in testosterone concentrations following morning exercise at least partially explain the benefits observed. Irrespective of the prominent mechanism(s), the potential to enhance afternoon cognitive function through morning priming exercise may be particularly valuable in relation to cricketers, for whom concentration, reaction speed, and anticipation are crucial aspects of match-play performance.[4, 5]

Practitioners may harbour concerns about the potential for morning priming exercise to elicit additional physical and mental fatigue and/or decrease perceived ‘readiness’ to perform.[19] It is therefore notable that neither priming intervention decreased players’ subjective readiness, while LIFT improved readiness responses on the ‘aggression’ subscale. Alongside aggression responses potentially suggesting favourable testosterone responses in LIFT,[9] these observations confirm that the volume and intensity of morning priming exercise in this study was appropriate to improve physical and cognitive performance while maintaining or even improving a player's feelings of readiness amongst this sample of professional cricketers. Such findings may be particularly important given the well-established positive relationship between self-confidence and successful sporting performance.[29]

Although this study observed potentially important performance benefits following morning priming exercise in men's professional cricketers, the specific causative factor(s) could not be determined. Morning priming exercise has previously demonstrated efficacy in offsetting the circadian declines in testosterone concentrations that are typically observed throughout the day,[16, 17] with positive correlations having been identified between endogenous testosterone concentrations and indices of physical and potentially cognitive performance.[9-11] However, muscle and deep-body temperature also demonstrate diurnal variations throughout the day while themselves correlating with indices of physical performance.[24, 30] Temperature or other physiological responses (e.g., oxygen consumption, heart rate, ventilation) may have contributed to the beneficial priming effects observed in LIFT and RUN. Notwithstanding, this study provides valuable data to indicate physical and cognitive performance benefits following cricket-specific sprinting or general lower-body resistance exercise priming for tasks commenced ~5.5 h thereafter. Future research investigating the impact of various practically implementable forms of morning priming (including cricket-specific movements such as bowling) on a range of other cricket-specific performance indicators (fast bowling ability, throwing, catching, etc) may add further valuable information.

Conclusion

Morning priming exercise consisting of cricket-specific repeated sprint running or lower-body resistance exercise can improve indices of afternoon physical and cognitive performance when commenced ~5.5 h after the priming stimulus. Although the greatest = improvements were observed in LIFT, RUN produced superior responses to CON and may represent a viable when morning resistance exercise is not feasible. Such findings allow practitioners to make informed decisions regarding match-day preparatory strategies. Moreover, logistical factors such as travel often make it difficult to schedule resistance training during professional cricketer season. This study may suggest that match-day could represent an opportunity to undertake low-volume resistance exercise in situations where it would be feasible.

Practical implications

- Morning lower-body resistance exercise reaching ~85% 1RM represents an effective match-day strategy to improve physical and cognitive performance in professional men's cricketers.
- Simulated running between the wickets offers a viable alternative priming stimulus if circumstances preclude competition-day resistance exercise.
- The volume and intensity of priming exercises did not reduce perceived readiness.
- Coaches and players should note the potential influence of general and specific morning activities on afternoon performance, including avoiding excessive exercise volumes which may elicit additional fatigue.

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Table 1. Differences in countermovement jump height, sprint time, and Stroop test completion time between the three conditions.

	Jump height (cm)	Sprint time (s)	Stroop test time (s)
CON	44.6 ± 7.0 [c]	5.97 ± 0.16 [b, cc]	51.53 ± 5.12 [b, c]
RUN	45.2 ± 7.2	5.93 ± 0.15 [a, c]	49.02 ± 3.34 [a]
LIFT	45.7 ± 6.9 [a]	5.89 ± 0.15 [aa, b]	47.71 ± 2.82 [a]

CON: Control condition, LIFT: Resistance exercise priming condition, RUN: Repeated sprinting priming condition. Data are presented as mean ± standard deviation. a: Significantly different from CON, b: significantly different from RUN, c: significantly different from LIFT. A single letter indicates differences at the $p < 0.05$ level, whilst two of the same letter represents differences at the $p < 0.001$ level).