The Effect of Overnight Sleep Deprivation After Competitive Rugby League Matches on Postmatch Physiological and Perceptual Recovery

Melissa Skein, Rob Duffield, Geoffrey M. Minett, Alanna Snape, and Alistair Murphy

Purpose: This study examined the effects of overnight sleep deprivation on recovery after competitive rugby league matches. Methods: Eleven male amateur rugby league players played 2 competitive matches, followed by either a normal night’s sleep (~8 h; CONT) or a sleep-deprived night (~0 h; SDEP) in a randomized fashion. Testing was conducted the morning of the match, immediately postmatch, 2 h postmatch, and the next morning (16 h postmatch). Measures included countermovement-jump (CMJ) distance, knee-extensor maximal voluntary contraction (MVC) and voluntary activation (VA), venous-blood creatine kinase (CK) and C-reactive protein (CRP), perceived muscle soreness, and a word–color recognition cognitive-function test. Percent change between postmatch and 16-h postmatch was reported to determine the effect of the intervention the next morning. Results: Large effects indicated a greater postmatch to 16-h-postmatch percentage decline in CMJ distance after SDEP than in CONT (P = .10–.16, d = 0.95–1.05). Similarly, the percentage decline in incongruent word–color reaction times was increased in SDEP trials (P = .007, d = 1.75). Measures of MVC did not differ between conditions (P = .40–.75, d = 0.13–0.33), although trends for larger percentage decline in VA were detected in SDEP (P = .19, d = 0.84). Furthermore, large effects indicated higher CK and CRP responses 16 h postmatch in SDEP than in CONT (P = .11–.87, d = 0.80–0.88). Conclusions: Sleep deprivation negatively affected recovery after a rugby league match, specifically impairing CMJ distance and cognitive function. Practitioners should promote adequate postmatch sleep patterns or adjust training demands the next day to accommodate the altered physical and cognitive state after sleep deprivation.

Keywords: sleep loss, intermittent-sprint exercise, muscle damage, team sports

Competitive rugby league matches result in high neuromuscular, physiological, and perceptual strain due to repeated high-intensity efforts and interplayer collisions. Accordingly, postmatch recovery can be prolonged, interrupting subsequent recovery or training sessions. For instance, torque and twitch-contractile properties of maximal voluntary contraction (MVC) have been shown to be suppressed 2 hours postmatch. Furthermore, McLellan et al reported that countermovement-jump (CMJ) peak power is reduced up to 24 hours postmatch, alongside elevated biochemical markers of stress and muscle damage. Although there is evidence of alterations in physiological states postmatch and during recovery periods, limited research has examined the influence of postmatch circumstances that potentially impair recovery.

Situations resulting in disruptions to postmatch recovery that are commonly experienced by team-sport athletes may include travel demands, unfamiliar sleeping arrangements, anxiety, or social commitments, all of which are known to interrupt sleep patterns. Sleep deprivation has been shown to negatively affect ensuing exercise performance such as walking time to exhaustion, submaximal strength, peak power during a maximal cycling effort, and distance covered in self-paced treadmill running. More pertinent to rugby league, Skein et al reported a reduction in intermittent-sprint performance, MVC, and muscle glycogen concentration and an increase in perceptual stress after 30-hour sleep deprivation. While these studies provide insight into the effects of sleep deprivation on ensuing performance, minimal research has examined the effects of sleep deprivation on postexercise recovery, particularly from real-world competitive team-sport matches.

The mechanisms that explain reduced performance after sleep deprivation are unknown but are reported to include increased cardiovascular and thermoregulatory strain, alterations in hormone regulation, and increased waking metabolic demands. It is also known that sleep enhances anabolic processes, and, particularly
when tissue damage is present, the rate of healing is greater during sleep.\(^1\) Furthermore, reductions in exercise performance have been attributed to increased perceptual stress, as observed from Profile of Mood States questionnaires,\(^1\) or increased rating of perceived exertion (RPE) for a given workload.\(^1\) The array of purported mechanisms may be due to the inability to blind subjects to the sleep condition, resulting in a negative placebo (nocebo) effect on exercise performance and cognitive function.\(^9\) Nevertheless, it appears that exercise performance and cognitive function are impaired after acute sleep deprivation, although the contribution of the proposed mechanisms are unclear, particularly on the postexercise recovery process.\(^6\)

Accordingly, the current understanding of sleep deprivation and its ensuing effect on recovery after exercise is lacking, particularly in a competitive team-sport scenario. The effects of increased physiological and perceptual stress on performance outcomes are also unclear. Therefore, this study aimed to examine the effect of sleep deprivation on next-day recovery of neuromuscular, physiological, and cognitive function after rugby league competition. We hypothesized that 1 night’s sleep deprivation would negatively affect postmatch recovery of neuromuscular and cognitive function and increase perceptual stress the following morning.

**Methods**

**Subjects**

Eleven male amateur rugby league players volunteered to participate in this study. The mean ± SD age, stature, and body mass for all participants were 20.4 ± 2.5 years, 178.9 ± 5.7 cm, and 83.0 ± 11.3 kg, respectively. Participants competed at first- (n = 7) and second-grade (n = 4) level in a university-grade rugby league competition and reported completing 1 competitive match, 2 sport-specific skills sessions, and 2 or 3 strength-training sessions per week. Written informed consent was obtained after explanation of all procedures and possible risks involved. All experimentation was approved by the university committee on ethics in human research.

**Design**

In a randomized, crossover design, participants completed 2 trials (sleep deprivation [SDEP] vs control [CONT]) to examine the neuromuscular, cognitive, and perceptual recovery the morning after a rugby league match. Participants reported for baseline measures at 8 AM (~7 h prematch), within 10 to 20 minutes immediately postmatch, 2 hours postmatch (at the start of the evening), and the following morning at a standardized time (8 AM; 16 h postmatch). Accordingly, this study simulated an ecologically valid sporting environment where players may encounter sleep disruption after a match but are still required to attend recovery sessions the following morning. Participants abstained from exercise and alcohol 24 hours before and all caffeine 3 hours before each match and throughout the intervention period. After the match, subjects were provided with a standardized evening meal consisting of 30.5 kJ/kg energy, 3.0 g/kg carbohydrate, and 0.9 g/kg protein and did not consume additional food until the following morning after 16-hour-postmatch measures. Self-reported physical activity and dietary records were completed for the 24 hours before exercise for the initial trial and replicated thereafter.

**Methodology**

**Rugby League Match.** Participants completed an 80-minute rugby league match as part of their respective first- and second-grade teams. Matches used throughout the study were midseason home games against teams of similar competition standing. During all matches, distance and speed of movement were recorded by 1-Hz global-positioning-system (GPS; SPI elite, GPSports Systems, Canberra, Australia) devices worn in a customized harness on the cervical vertebrae. Data for distance and mean speeds were reported in the following categories: low-intensity activity (<14.4 km/h), high-intensity running (>14.5 km/h), and very-high-intensity running (>20 km/h).\(^2\) Mean speed (m/s) was calculated based on distance covered divided by time in play. Matches were filmed using a digital video camcorder (Canon MV920, Canon Australia Pty Ltd, Sydney, Australia) positioned at the halfway line of the field. Postmatch notational analysis was performed to quantify the number of tackles and hit-ups during the match as defined by the observation of an impact with the opposition players as part of carrying the ball or tackling the ball carrier. In addition, an RPE (Borg CR-10)\(^2\) was obtained 15 minutes after each match. While competitive matches were not standardized for work, measures of distance, mean speeds, and interplayer contacts allowed comparison of external load between matches.

**Sleep Intervention.** The 2 randomized interventions included 1 night of normal sleep (~8 h; CONT) and 1 night of no sleep (~0 h; SDEP). After 2-hour-postmatch measures, participants remained in the laboratory for the ensuing night. A standardized meal was provided at 8 PM, after which participants were provided with leisure activities (movies, computers, reading material) until 11 PM. In CONT, participants retired to self-provided bedding in the darkened laboratory (0 ± 2 lux; Lux light meter, Digitech, Rydalmere, Australia) by 11:30 PM, while SDEP participants remained awake and sedentary until the next day in a lit part of the laboratory (80 ± 5 lux). The laboratory was monitored by the research team, and participants were observed to ensure compliance with the respective intervention. Heart-rate (HR) monitors (Polar Electro-Oy RS232, Kempele, Finland) were worn by all participants during the night to provide an indirect indication of physical activity between conditions. Core temperature (T\(_{core}\)) was also recorded, via ingestion of a telemetric
capsule (VitalSense, Mini Mitter, Bend, OR, USA) at approximately 10:30 AM to allow passage into the digestive tract, with a telemetric receiver (VitalSense, Mini Mitter, Bend, OR, USA). HR and Tcore measures were recorded at 30-minute intervals throughout the night from 10 PM until 8 AM the following morning without waking participants.

**Measures**

**Neuromuscular Performance.** Participants completed a repeated CMJ protocol prematch, postmatch, 2 hours postmatch, and 16 hours postmatch as a measure of lower-body power output. After a 5-minute warm-up on a cycle ergometer (Ergomedic 828E Monark, Sweden) at 80 rpm with 2 kp resistance (apart from postmatch), participants completed 10 maximal CMJ repetitions. Peak distance was measured using a linear position transducer (G1706374B, Fitness Technology, Adelaide, Australia) attached to a dowel rod positioned across the shoulders and interfaced with specialized software (Ballistic Measurement System Software, Fitness Technology, Adelaide, Australia). The typical error of distance for this measure has been previously reported as 0.023 m for elite athletes, and the coefficient of variation for subelite college athletes CMJ distance has been reported as 2.8%.23

MVC and voluntary activation (VA) of the right knee extensors were assessed using an isokinetic dynamometer (Kincom, Model 125, Chattanooga Group Inc, Hixon, TN, USA). Participants were seated and strapped to the dynamometer across the chest and hips and near the ankle (1.0 cm above the lateral malleolus) on the right leg, with arms crossed to isolate movement of the right knee extensors. Participants’ hip and knee position were kept consistent between sessions. Muscle activation was achieved using a double felt-tip electrode (Bipolar, Cardinal Health, Madison, WI, USA) placed over the femoral nerve on the anterior thigh 1.0 cm below the inguinal fold. The electrical stimulus was delivered via a stimulator (Digitimer Ltd, Welwyn Garden City, Hertfordshire, England) linked to a BNC2100 terminal block and connected to a signal-acquisition system (PXI1024, National Instruments, Austin, TX, USA) that sampled all data at 2000 z. Electrical stimulus was delivered using a single square-wave pulse with a width of 200 microseconds, which was driven using customized software (v8.0, LabView, National Instruments, Austin, TX, USA).

Initially the current was applied in incremental steps until a plateau occurred in peak twitch torque; it was then increased by 10% to ensure supramaximal stimulation. Six resting evoked twitches were delivered to the femoral nerve before participants completed isometric contractions at 60%, 80%, and 100% of maximal effort. The MVC protocol consisted of 15 × 3-second maximal isometric contractions of the right knee extensors with 6-second recoveries between contractions.9 The initial and final 5 contractions were superimposed with an electrical stimulus when peak torque was achieved, and a potentiated twitch was delivered immediately postcontraction when the muscle was at complete rest. Peak MVC was determined as the mean torque produced during the MVC in the 50 milliseconds before the delivery of the stimulus. VA was calculated using the twitch-interpolation technique.24

**Physiological.** Nude body mass was recorded prematch, 2 hours postmatch, and 16 hours postmatch on a set of calibrated scales (BE-150K Scales, A&D, Thebarton, Australia). Participants also provided a midstream urine sample to measure urine specific gravity to indicate hydration status (Refractometer 503, Nippon, Tokyo, Japan). Urine output was also measured throughout the intervention period via collection of urine output in a jar that was weighed to determine total urine volume (BE-150K Scales, A&D, Thebarton, Australia).

Venous blood was collected at each time point using an evacuated venipuncture system and serum separator tubes (BD Vacutainer, Sydney, Australia) and analyzed for creatine kinase (CK) and C-reactive protein (CRP) as markers of muscle damage and inflammation. Samples were allowed to clot at room temperature before centrifugation (4000 rpm at 4°C for 10 min), with serum stored at −20°C until analysis according to assay instructions (Siemens Healthcare Diagnostics Inc, Newark, DE, USA). CK concentrations were determined using an enzymatic method and bichromatic rate technique. CRP samples were manually diluted according to manufacturer’s instructions and analyzed with the particle-enhanced turbidimetric immunosassay technique.

**Perceptual and Cognitive Measures.** Cognitive function was measured at all time points using a modified version of the Stroop color–word test.25 This computer-based test of cognitive function required subjects to react to repeated color and word stimuli, analyzing response time, accuracy, and total duration for congruent and incongruent word–color stimuli responses. Questions answered incorrectly were repeated during the test, causing an increase in total test time. The acceptable reliability of the modified Stroop test has been previously reported with reliability coefficients of .71 to .79.26 Finally, perceptual muscle soreness (0 = normal to 10 = extremely sore) was assessed prematch, postmatch, 2 hours postmatch, and 16 hours postmatch.

**Statistical Analysis**

Data are reported as mean ± SD. A repeated-measures 2-way ANOVA (condition × time) was used to determine significant differences for time and by group, within and between conditions, with significance at P < .05. Effect sizes (Cohen d) were calculated to analyze the magnitude of effect of the sleep intervention, with <.20 considered trivial, .20 to .39 small, .40 to .79 moderate, and >.80 large. Given the inability to standardize the
work completed during the match, a paired t test was also used to determine significant differences in the percentage change of measures from postmatch to 16 hours postmatch, as this is the duration of time over which the intervention was imposed. All analyses were conducted using Statistical Package for Social Sciences (SPSS, v17.0, Chicago, IL, USA).

**Results**

**Match Loads and Neuromuscular Performance**

All GPS parameters, interplayer contacts, and RPE data are presented in Table 1. There were no significant differences observed between conditions for any match-load variables \( (P = .09–.74) \). However, moderate to large effects demonstrated a higher mean speed \( (d = 0.87) \) and peak speed \( (d = 0.48) \) during SDEP trials. This greater match speed reflected a moderately higher RPE in the SDEP condition \( (d = 0.52) \), with trivial to small effects observed between conditions in all remaining match-load variables \( (d = 0.11–0.24) \).

Changes in MVC did not significantly differ between conditions, demonstrating trivial to small effects at all time points \( (P = .40–.75, d = 0.13–0.33; \text{Table 2}) \). Significant differences and moderate to large effects indicated a reduced MVC in both conditions 2 hours and 16 hours postmatch compared with prematch values \( (P = .01–.02, d = 0.63–1.30) \). Furthermore, MVCs were significantly lower than postmatch measures in SDEP trials at the 2-hour and 16-hour time points \( (P = .02, d = 0.67–0.76) \). There were no significant differences and trivial to moderate effects in VA between \( (P = .25–.76, d = 0.16–0.56; \text{Table 2}) \) and within conditions over time \( (P = .12–.76, d = 0.14–0.66) \). Notably, large effects for a reduced percentage change in postmatch to 16 hours postmatch VA were evident in SDEP trials compared with CONT \( (P = .19, d = 0.84) \).

While no significant differences and small effects were apparent in mean and peak CMJ distances between conditions prematch \( (P = .52–.63, d = 0.34–0.38) \), large effects denoted higher mean and peak CMJ performance in SDEP trials postmatch \( (d = 0.81–0.97) \) and 2 hours postmatch \( (d = 0.96–1.18) \). In contrast, SDEP moderately lowered peak CMJ distance compared with CONT 16 hours postmatch \( (d = 0.45) \) and similarly demonstrated larger percentage declines in mean and peak CMJ performance from postmatch to 16 hours postmatch than in CONT trials \( (P = .10–.16, d = 0.95–1.05) \).

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Match Loads During Competitive Rugby League Matches for Each Condition, Mean ± SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Condition</td>
<td>Total distance (m)</td>
</tr>
<tr>
<td>Control</td>
<td>6221 ± 701</td>
</tr>
<tr>
<td>SDEP</td>
<td>6058 ± 1472</td>
</tr>
</tbody>
</table>

Abbreviations: HIR, high-intensity running; VHIR, very-high-intensity running; RPE, rating of perceived exertion; SDEP, sleep deprivation. There were no significant differences between conditions.

| a Large effect size between conditions \( (d > 0.80) \). | b Moderate effect size between conditions \( (d = 0.40–0.79) \). |

<table>
<thead>
<tr>
<th>Table 2</th>
<th>Summary of Absolute Neuromuscular Performance for Each Condition, Mean ± SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Condition</td>
<td>Prematch</td>
</tr>
<tr>
<td>MVC (Nm)</td>
<td>control</td>
</tr>
<tr>
<td>SDEP</td>
<td>203 ± 32</td>
</tr>
<tr>
<td>VA (%)</td>
<td>control</td>
</tr>
<tr>
<td>SDEP</td>
<td>88.1 ± 7.1</td>
</tr>
<tr>
<td>Peak CMJ (m)</td>
<td>control</td>
</tr>
<tr>
<td>SDEP</td>
<td>0.38 ± 0.02</td>
</tr>
<tr>
<td>Mean CMJ (m)</td>
<td>control</td>
</tr>
<tr>
<td>SDEP</td>
<td>0.33 ± 0.02</td>
</tr>
</tbody>
</table>

Abbreviations: MVC, maximal voluntary contraction; SDEP, sleep deprivation; VA, voluntary activation; CMJ, countermovement jump.

| *Significantly different between conditions \( (P < .05) \). | #Significantly different from prematch values \( (P < .05) \). | ^Significantly different from postmatch values \( (P < .05) \). |

| a Large effect size between conditions \( (d > 0.80) \). | b Moderate effect size between conditions \( (d = 0.40–0.79) \). |
Physiological

Significant differences and large effects were observed for a higher Tcore between the hours of 2 and 4 AM during SDEP compared with CONT (P = .004–.04, d = 0.83–3.38; Figure 1). Similarly, there were significant differences and large effects between conditions indicating an elevated HR during the hours of 11:30 PM to 7 AM during SDEP (P = .01–.04, d = 0.80–3.19; Figure 1). Both conditions demonstrated significant change and large effects for HR and Tcore over time (P = .001–.03, d = 1.52–5.62).

Measures of urine specific gravity demonstrated no significant differences and small and moderate effects between conditions prematch (CONT 1.022 ± 0.006 vs SDEP 1.022 ± 0.005, P = .62, d = 0.23) and 2 hours postmatch (CONT 1.027 ± 0.007 vs SDEP 1.025 ± 0.009, P = .07, d = 0.52). Large effects did indicate lower urine specific gravity 16 hours postmatch in SDEP than in CONT (CONT 1.022 ± 0.006 vs SDEP 1.019 ± 0.005, P = .11, d = 0.86). The SDEP intervention elicited no significant changes and trivial to small effects in total urine output (CONT 1.16 ± 0.53 kg vs SDEP 1.05 ± 0.40 kg, P = .98, d = 0.32) and nude mass recorded prematch (CONT 83.04 ± 11.26 vs SDEP 83.84 ± 10.82 kg, P = .11, d = 0.10), postmatch (CONT 82.52 ± 11.39 vs SDEP 83.71 ± 11.32 kg, P = .09, d = 0.15), 2 hours postmatch (CONT 82.95 ± 11.51 vs SDEP 83.71 ± 11.01 kg, P = .13, d = 0.10), and 16 hours postmatch (CONT 83.04 ± 11.59 vs SDEP 84.38 ± 11.07 kg, P = .08, d = 0.17).

Biochemical

Neither CK nor CRP significantly differed between conditions at any time point (P = .11–.87; Figure 2). However, moderate and large effects were apparent to demonstrate elevated CK 2 hours postmatch (d = 0.65) and 16 hours postmatch (d = 0.80) in the SDEP trial compared with CONT. In addition, SDEP induced moderate and large effects for higher CRP values than CONT postmatch (d = 0.48) and 16 hours postmatch (d = 0.88). Competitive rugby league significantly increased CK at all time points compared with prematch values (P = .001–.03, d = 1.66–2.31), and although these findings were not reflected in CRP (P = .20–.87), both conditions demonstrated higher values than at baseline 16 hours postmatch (d = 0.81–1.69).

Figure 1 — (A) Core temperature and (B) heart rate over the intervention night for control and sleep-deprivation (DEP) conditions, mean ± SD. *Significant difference between conditions (P < .05). a Large effect size between conditions (d > 0.80).
Cognitive and Perceptual

Measures of cognitive recovery are presented in Table 3. Postmatch to 16-hour-postmatch percentage change in the incongruent word–color stimuli responses was significantly different between conditions \( (P = .007, d = 1.75) \), and large effects demonstrate a lower decline in total time in SDEP than in CONT \( (P = .05, d = 1.31) \). There were no significant differences and only small to moderate effects between conditions in total test time \( (P = .07-.47, d = 0.25-.70) \) and congruent word–color stimuli responses \( (P = .10-.70, d = 0.17-.68) \). Finally, although largely higher prematch muscle soreness was apparent in CONT \( (P = .18, d = 0.93; \text{Figure 2}) \), no significant differences and trivial to moderate effects were detected between conditions at all other time points \( (P = .37-.59, d = 0.16-.50) \). Significant differences and large effects within both conditions indicate increased muscle soreness...
at all time points compared with prematch ratings (P = .001–.02, d = 1.31–4.23).

Discussion

This study examined the effect of overnight sleep deprivation on the recovery of neuromuscular, physiological, and cognitive function the morning after a rugby league match. These data show that 1 night’s sleep deprivation after a competitive rugby league match delays the recovery of lower-body power (mean and peak CMJ distance) up to 16 hours postmatch, despite similar declines in isolated MVC between conditions. Furthermore, sleep deprivation slowed recovery of reaction-time responses for color–word cognitive tasks. The mechanisms responsible for slowed CMJ and cognitive recovery may be associated with the trends of reduced VA and increased CK and CRP release after sleep deprivation. Furthermore, as previously suggested,12,13,19 the inability to blind subjects to the conditions (CONT vs SDEP) may have influenced recovery, creating a negative placebo effect. Regardless, sleep deprivation after competitive rugby league matches can negatively affect postmatch recovery of CMJ distance and cognitive function.

The context of this study reflects a common issue for team sports, whereby postmatch demands reduce sleep before ensuing morning sessions. The current study used a competitive real-world environment to determine the effects of sleep deprivation on recovery; however, such an environment also presents a limitation in that a lack of difference between conditions in postmatch recovery may have had a placebo effect. Regardless, the current study may be associated with the trend for reduced neural drive (VA) to the active musculature and the increased skeletal-muscle damage (CK and CRP) resulting in suppressed recovery of lower-body power. However, the lack of significant between-conditions differences of the aforementioned variables may be due to shorter duration of sleep deprivation, as previous studies have reported extended sleep-deprivation protocols greater than 30 hours.11–27 Furthermore, suppression of recovery after SDEP may be due to the inability to blind subjects to the conditions (SDEP vs CONT), and the knowledge of being sleep deprived may have had a placebo effect on lower-body power.13 Regardless, the current study suggests that the recovery of lower-body power may be suppressed by sleep loss after rugby matches.

Peak MVC was reduced in both conditions after the rugby league match, further highlighting the effect of match demands on skeletal-muscle force production.3,4 While rugby league matches reduced MVC postmatch, a lack of difference between conditions in postmatch to 16-hour-postmatch percentage change indicates that recovery of isolated-joint MVC torque was minimally affected by sleep deprivation, per se. These findings are contrary to those of Skein et al,13 who reported reductions in MVC and VA after 30-hour sleep deprivation, with

<table>
<thead>
<tr>
<th>Table 3</th>
<th>Summary of Cognition Results for Each Condition During a Modified Stroop Test, Mean ± SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Condition</td>
<td>Prematch</td>
</tr>
<tr>
<td>CRT (ms)</td>
<td></td>
</tr>
<tr>
<td>control</td>
<td>86.3 ± 12.3</td>
</tr>
<tr>
<td>SDEP</td>
<td>82.1 ± 12.6[a]</td>
</tr>
<tr>
<td>IRT (ms)</td>
<td></td>
</tr>
<tr>
<td>control</td>
<td>623.2 ± 117.3</td>
</tr>
<tr>
<td>SDEP</td>
<td>575.1 ± 80.0[b]</td>
</tr>
<tr>
<td>SDEP</td>
<td>690.4 ± 140.6</td>
</tr>
<tr>
<td>Total test time (s) control</td>
<td>86.3 ± 12.3</td>
</tr>
<tr>
<td>SDEP</td>
<td>82.1 ± 12.6[a]</td>
</tr>
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<td>SDEP</td>
<td>690.4 ± 140.6</td>
</tr>
<tr>
<td>IRT (ms) control</td>
<td>661.3 ± 145.9</td>
</tr>
<tr>
<td>SDEP</td>
<td>661.3 ± 145.9</td>
</tr>
</tbody>
</table>

Abbreviations: SDEP, sleep deprivation; CRT, congruent word-color reaction time; IRT, incongruent word-color reaction time.

*Significantly different between conditions (P < .05).

[a] Large effect size between conditions (d > 0.80). [b] Moderate effect size between conditions (d = 0.40–0.79).
neuromuscular function measured in the afternoon after the intervention. As mentioned previously, the shorter sleep deprivation in the current study may explain the lack of difference in MVC torque between conditions. Furthermore, the trends for a greater reduction in VA after sleep loss despite minimal effects on MVC suggest that other factors associated with sleep deprivation—the knowledge of being in a sleep-deprived state, increased perceptual stress, increased metabolic activity, and cognitive impairment—may have influenced recovery of dynamic lower-body power, with limited effect on isolated muscle contractile force.

Competitive rugby league can invoke substantial structural damage to muscle tissue. The progressive increase in CK after the match is an indirect indication of muscle damage. Although not significantly different between conditions, large effect sizes suggest a greater rise in CK after sleep deprivation. However, the variation in CK between players and in the match results in high variability, potentially affecting the lack of significance. Similar to CK, moderate to large effect sizes suggest trends for increased CRP after sleep loss, further indicating that sleep loss may have a negative effect on the recovery of muscle-damage markers after competitive matches. Sleep is known to enhance anabolic processes, particularly in the presence of tissue damage, which may account for the observed trends in lowered CK and CRP responses after a night’s sleep. However, a lack of statistical significance may also be due to postmatch CK requiring ~72 hours to return to baseline and therefore an insufficient duration to monitor postmatch responses was available in the current study. Accordingly, while these findings indicate the presence of muscle damage after the rugby league match, trends indicate that 24-hour sleep deprivation can delay the recovery of postmatch skeletal-muscle damage markers, although longer sleep deprivation may be required to observe statistical significance.

Finally, cognitive function is an important factor during training and competition football and was assessed in the current study via a modified Stroop test. Results suggest that the cognitive response time to word–color stimuli was negatively affected the morning after sleep deprivation. Furthermore, large effect sizes suggest that total reaction time and congruent reaction time were also slowed by 24-hour sleep deprivation. Such findings corroborate previous studies reporting reaction time to be significantly slower after sleep deprivation and suggest that sleep deprivation can reduce alertness and attention, ultimately causing an increase in reaction time to simple and choice cognitive tasks. These slowed cognitive responses after sleep deprivation have been suggested to be more apparent in simple tasks that involve minimal environmental stimulation. While it is not suggested such simple word–color tasks represent the cognitive demands of training or competitive football, the controlled context of the laboratory allows some suggestion that response times to visual stimuli may be affected by sleep loss. Accordingly, postmatch sleep deprivation may result in altered cognitive functioning the following morning, which may affect attention and decision-making skills during ensuing training sessions.

In summary, the current data highlight the detrimental effects of sleep deprivation on next-day recovery after a competitive rugby league match. Sleep loss increased cardiovascular and thermal loads during the night and slowed cognitive responses the next morning, highlighting the altered physiological load of wakefulness. Whether these exacerbated physiological and cognitive loads resulted in the blunted recovery of lower-body power (CMJ distance) observed the following morning remains unknown. While differences in CMJ percentage change were evident between conditions, the lack of difference in absolute values and the minimal effect on MVC may be a time-of-day effect, in that sleep deprivation induces greater decrements later in the day with a longer duration of wakefulness. Regardless, practitioners should note that the loss of sleep during the night after competitive matches may result in players presenting for next-day sessions with augmented physical fatigue, slower cognitive function, and some suppression of lower-body power.

Practical Applications

Despite the extreme nature of sleep deprivation used here, postmatch sleep loss after competitive matches results in augmented physical fatigue, slower cognitive function, and lower-body power suppression. As such, players may present for training sessions the following morning in a suboptimal state of preparedness for training. Accordingly, while obvious, avoidance of sleep deprivation is recommended for rugby league players, along with tailoring training sessions to suit the state of the players based on the specificity of the circumstances.

References


