Effectiveness of Active Versus Passive Recovery Strategies After Futsal Games

Antonio Tessitore,[1,2] Romain Meeusen,[2] Rita Pagano,[1] Cinzia Benvenuti,[1]
Monica Tiberi,[3] and Laura Capranica[1]

[1]*Department of Human Movement and Sport Science, University Foro Italico, Rome, Italy;* [2]*Vrije University of Brussels, Brussels, Belgium;* [3]*Center for Preventive Medicine, Azienda Sanitaria Unica Regionale Marche, Ancona, Italy*

Abstract

Tessitore, A, Meeusen, R, Pagano, R, Benvenuti, C, Tiberi, M, and Capranica, L. Effectiveness of active versus passive recovery strategies after futsal games. *J Strength Cond Res* 22(5): 1402–1412, 2008—This study aimed to investigate the effects of immediate postgame recovery interventions (seated rest, supine electrostimulation, low-intensity land exercises, and water exercises) on anaerobic performance (countermovement jump [CMJ], bounce jumping, 10-m sprint), hormones (salivary cortisol, urinary catecholamines), and subjective ratings (rate of perceived exertion [RPE], leg muscle pain, Questionnaire of Recovery Stress for Athletes [RestQ Sport], 10-point Likert scale), and hours of sleep of futsal players. Heart rate (HR), blood lactate, and RPE were used to evaluate the intensity of 4 futsal games in 10 players using a crossover design ($P < 0.05$), randomly allocating athletes to 1 of the 4 recovery interventions at the end of each game. No significant difference emerged between HR, blood lactate, RPE, and level of hydration of the games. A significant difference ($P < 0.001$) between games emerged for total urinary catecholamines, with an increase from the first to the second game and a gradual reduction up to the fourth game. After the game, significant reductions in CMJ ($P < 0.001$) and 10-m sprints ($P < 0.05$) emerged. No significant difference was found between recovery interventions for anaerobic performances, hormones, muscle pain, and RestQ Sport. Even though a well-balanced diet, rehydration, and controlled lifestyle might represent a sufficient recovery intervention in young elite athletes, the players perceived significantly increased benefit ($P < 0.01$) from the electrostimulation (7.8 $\pm$ 1.4 points) and water exercises (7.6 $\pm$ 2.1 points) compared to dry exercises (6.6 $\pm$ 1.8 points) and seated rest (5.2 $\pm$ 0.8 points.), which might improve their attitude toward playing. To induce progressive hormonal adaptation to the high exercise load of multiple games, in the last 2 weeks of the preseason, coaches should organize friendly games at a level similar to that of the competitive season.

Key Words cool down, active recovery, passive recovery, muscle soreness

Introduction

More than 12 million players in more than 100 countries play futsal, the official form of indoor soccer approved by the Fédération Internationale de Football Association (17). Two teams, consisting of five players, one of whom is the goalkeeper, play futsal games on a 38–42 $\times$ 18–25-m pitch. Official futsal games consist of two 20-minute clock time (i.e., excluding breaks in play) halves, so that a game may extend to 70–80 minutes (12). In Italy, university team players might play 2 games on a weekly basis (for their institution at mid-week and for their club on weekends). Such an unrelenting game schedule is also common during international tournaments and has been hypothesized to determine the players' underperformance and burnout (36). Despite the growing popularity of futsal, there is scant information regarding the physical load imposed on players during games. In fact, compared to soccer, the reduced dimensions of the pitch require players to perform frequent bouts of high-intensity activity with limited rest periods that are not sufficient for full recovery (3,12). Considering that the recovery process is strictly related to the previous exercise stress (6), an optimal balance between exercise load and recovery is required to maintain a high physical performance. Thus, coaches need to adopt effective recovery strategies to preserve the athlete's best performances throughout their competitive season (36).

The importance of recovery interventions lies in the common belief in their beneficial effects on performance during subsequent exercise sessions (4,6). Some authors (36,37) claim that sleep, well-balanced diet, rehydration, and different recovery interventions (i.e., passive, which might involve massages, saunas, iced baths; or active, which includes low-intensity exercises) contribute to restoring

Address correspondence to Dr. Laura Capranica, laura.capranica@iusm.it.

22(5)/1402–1412

Journal of Strength and Conditioning Research

players' playing capacity. In particular, low-intensity land and water cool-down are gaining popularity as means to reduce muscle pain, restore or enhance performance, improve thermoregulation, and increase relaxation (13,36,37,50,51). Conversely, some electrostimulators include specific programs that might facilitate the recovery process by increasing blood flow and metabolite washout of muscles.

Research on the effectiveness of active recovery interventions in performance found divergent findings due to several reasons. First, it is not always possible to translate laboratory observations to competitive situations presenting different exercise loads (15). Second, sedentary individuals seem to benefit from active recovery interventions, while athletes show similar performance after either passive or active recoveries (4,43). Third, the effects of different recovery interventions have been often investigated separately (37,39,43), not controlling for important aspects affecting recovery such as sleep (41), diet (28,32,47), and level of hydration (31,41). Fourth, few studies investigated simultaneously the different recovery methods in field situations (28,47), and limited information is available regarding the effectiveness of postgame recovery interventions (11,19). In fact, these studies did not employ a fully random research design nor monitored the intensity of the games, so that a relatively harder or easier game in either trial might have affected the results (11). Finally, there is scant information regarding the beneficial effect of recovery interventions on the psychological state and sleep disturbances of players after the exercise stress of a game (41,47), especially when players must play 2 games on a weekly basis. Thus, a need exists for an ecological study incorporating aspects of practical settings while maintaining experimental control to assess the potential benefits of active recovery interventions on the recovery status of players.

Therefore, the present study was mainly designed to explore the effectiveness, if any, of the recovery interventions mostly used or recommended in team sports (13,36,37) using a randomized, crossover design. It was hypothesized that young players might not be supported by a postgame active recovery strategy when a controlled lifestyle (i.e., sleep, well-balanced diet, and rehydration) is maintained.

Methods

Experimental Approach to the Problem

When games are scheduled twice in a week, players might have insufficient time to recover in order to be at their best in all games (36). Since recovery from competition is a multidimensional process affecting both performances, physiological and psychological stress-related aspects of team sport players (36), in this study, it was hypothesized that examining the effects of postcompetition recovery interventions on performances, subjective feeling of recovery, lifestyle factors, and hormonal levels of players during an unrelenting fixed schedule would increase the relevance and applicability of the results. Thus, during a 2-week period, 4 friendly futsal games were organized with a 3-day interval in between. A within-subjects design was used to evaluate the effects, if any, of 2 passive (seated rest and supine electrostimulation) and 2 active cool-down (dry and water exercises) interventions on anaerobic (sprint and jump) performances, subjective ratings of recovery and muscle pain, hormones, and sleep of futsal players after games. All experimental trials were conducted in a randomized, counterbalanced order so that all the players performed the four 20-minute recovery protocols at the end of the experimental period. To minimize the effect of diurnal variations on the selected parameters during the experimental sessions, measurements were conducted at the same time of day. Each session included 6 data

Table 1. Schema of the experimental design.

Time	Stages	Data collection
07:30–08:00	Pregame (home)	Cortisol, catecholamines
08:30–09:30	Pregame (laboratory)	Blood lactate, body mass, questionnaires (Sleep, RestQ Sport), warm-up, CMJ, BJ, 10-m sprint
10.30–11:30	Game	HR, video recording, blood lactate
11:30–12:00	Postgame	Body mass, cortisol, blood lactate, questionnaires (RPE), CMJ, BJ, 10-m sprint
12:00–12:20	Recovery intervention	–
13:00–13:30	Lunch	–
13:30–17:00	Rest	–
17:00–17:30	Postrest	Cortisol, body mass, questionnaire (RMP, Likert), water intake, warm up, CMJ, BJ, 10-m sprint
07:30–08:00	Next morning	Catecholamines, cortisol, questionnaires (RMP, sleep)

RestQ Sport = Questionnaire of Recovery Stress for Athletes; CMJ = countermovement jump; BJ = bounce jumping; HR = heart rate; RPE = rate of perceived exertion; RMP = rate of muscle pain.

collection stages (Table 1): pre-game (at home = 07:30–08:00; in laboratory = 08:30–09:30); game (10:30–11:30); post-game (11:30–12:00); recovery intervention (12:00–12:20); post-rest (17:00–17:30); and next morning (at home = 07:30–08:00).

The subjects were instructed to maintain their normal lifestyle during the 2-week period and to refrain from high-intensity physical activities the day before the experimental sessions. The stability of the player's body mass, sleep, and anaerobic performances during the experimental period was established comparing the data collected the mornings of the games. Since recovery is affected by the exercise intensity of the previous exercise load (2,7,20,34), the hydration status of the athletes (16), and the diet (40,47,48), these factors were monitored throughout this study. If these parameters were found to be stable, differences emerging in the dependent variables would be attributed to the recovery interventions.

Subjects

Ten male futsal players (age, 23 ± 2 years; height, 176 ± 4.7 cm; body mass, 73 ± 7 kg; percentage of body fat, 8.2 ± 1.2%; $\dot{V}O_2max$, 52.2 ± 2.7 mL·kg·min^{-1}; maximum heart rate [HRmax] 196 ± 6 b·min^{-1}; peak blood lactate concentration, 12.8 ± 2.6 mmol·L^{-1}), members of their college futsal team, gave their written consent to participate in this study, previously approved by the local institutional review board. They had at least 10 years of previous futsal training (four 1.5-hour training sessions weekly). To avoid the influence of different athlete's fitness and skill levels on the effects of the recovery interventions, participants were selected on the basis of their participation in Italian Futsal championships (at least third league) and European college futsal tournaments. The study was scheduled 2 weeks after the end of the Italian futsal championships and 3 weeks before the beginning of a European university tournament that included games organized on a twice-weekly basis.

Experimental Design

Five experimental sessions separated at least by 3 days were organized. The first session was designed to determine the athlete's height, body mass, percentage of body fat (skinfold method) (22), and $\dot{V}O_2max$ test on a treadmill (RunRace HC 1200, Technogym, Cesena, Italy). The other 4 experimental sessions, scheduled on a twice-weekly basis for a period of 2 weeks, were designed to investigate the effects of different recovery interventions after a futsal game. The postgame recovery interventions lasted about 20 minutes and included 1) seated rest (R), 2) low-intensity dry aerobic exercises (D) (8 minutes of jogging, 8 minutes of walking and running sideways and backward, and 4 minutes of stretching), 3) shallow water aerobic exercises with no buoyancy aids (W) (8 minutes of jogging, 8 minutes of walking and running sideways and backward, and 4 minutes of stretching) in a 1.20 m deep swimming pool with a water temperature of 30°C, and 4) electrostimulation (E) lying supine (Recovery SportP, Compex, Basel, Switzerland). For E recovery, impulses with 1-Hz decrements every 2 minutes starting from 9 down to 7 Hz, and every 3 minutes starting from 7 down to 2 Hz. Monopolar impulses of 100 mA (rise time = 1.5 μs; pulse width = 340 μs; fall time = 0.5 μs) were used for the 4 channels. Electrodes were placed on the rectus femoris, vastus medialis, and vastus lateralis muscles, with 1 electrode on the widest part of the muscle belly and another on the insertion of the same muscle (47).

Aerobic Evaluation

Before assessment of $\dot{V}O_2max$, the athletes were familiarized with the treadmill exercise protocol and were instructed to avoid food and caffeine for at least 2 hours before exercise testing. Following a 5-minute warm-up running at 8 km·h^{-1}, the test was conducted at the initial speed of 10 km·h^{-1} and was increased by 2 km·h^{-1} every 3 minutes until exhaustion. Then a 5-minute active recovery at 6 km·h^{-1} was allowed. Subjects were continuously urged to reach the highest exercise intensity possible. During the test, HR, oxygen consumption ($\dot{V}O_2$), carbon dioxide production ($\dot{V}CO_2$), and ventilation were recorded as averaged values every 5 seconds by a telemetric open-circuit oxygen uptake measurement system (K4b^2; Cosmed, Rome, Italy). The K4b^2 Cosmed flow meter (accuracy: 1%) was calibrated with a 3-L syringe (Hans Rudolph Inc., Dallas. TX), and the gas analyzer (accuracy: O_2 = 0.02%, CO_2 = 0.01%) was calibrated with known gas mixtures (O_2: 16% and 20.9%; CO_2: 5% and 0.03%). Blood lactate determinations were performed at rest, at every stage, and at the third, sixth, and ninth minutes of the recovery phase using capillary blood from a fingertip immediately analyzed using an Accusport Lactate Analyzer (Roche, Basel, Switzerland), with a 0.992 single-trial intraclass reliability (5). The criterion used to assess the individual's $\dot{V}O_2max$ was the occurrence of a plateau or a $\dot{V}O_2$ increase $<$1 mL·kg^{-1}·min^{-1} despite further increases in the exercise intensity and a respiratory exchange ratio greater or equal to 1.15. In case the test ended before the attainment of $\dot{V}O_2max$, $\dot{V}O_2max$ was calculated averaging values of the final 30 second of the exercise test.

Hormonal Essays

The concentration of catecholamine (18,29) and cortisol (30) can provide information about the physiological and psychological stress levels of athletes during training and competition. However, players are reluctant to participate in experimental settings under tournament conditions, especially when invasive methods are applied. Therefore, salivary and urinary samples are often favored (18,30). To avoid the effects of the circadian rhythm and variations in food intake, in the present study, basal and experimental samples were collected at the same time of the day (cortisol: immediately after awakening, 08:00; before lunch, 12:00; and in the evening, 17:00; catecholamines: immediately after getting up, 08:00). As it is difficult to assess athletes in an absolutely rested condition, the hormone baseline of cortisol and catecholamines was taken after the 3-day break from routine training. To determine cortisol concentrations over the day, 3 saliva samples (>0.05μL) were taken with a collecting device (Salivettes with no preservative; Sarstedt, Nümbrecht, Germany). Before analysis, the saliva samples were stored at −70°C. Concentrations of salivary cortisol were measured using an enzyme immunoassay with an accuracy of 10.5% and an intra-assay reproducibility of 6.1%. All hormone samples were tested in the same series to avoid any variations between tests. Catecholamines were measured from 50 mL of overnight urine sample collected the day of the game and the next day immediately after awakening (07:30–08:00) and stored at −70°C before analysis. Urinary excretion of epinephrine and norepinephrine were determined using Waters 717 Autosampler (Waters Corporation, Milford, MA) by high-performance liquid chromatography with electrochemical detection (Chromsystems, Munich, Germany) after purification with an ion exchange technique. The lower detection limit was 2 $\mu g \cdot L^{-1}$ for epinephrine and 20 $\mu g \cdot L^{-1}$ for norepinephrine with a coefficient of variation of 1.6% for norepinephrine and 4.9% for epinephrine.

Subjective Ratings

The psychological status of the athlete was explored by means of questionnaires designed to represent his recovery-stress state or to assess potentially stressful events and their consequences on general fatigue and on muscle groups. Thus, the Borg's scale of perceived exertion for the whole body (RPE) between 6 (no exertion at all) and 20 (maximal exertion) (7), the 11-point scale of perceived muscle pain for lower limbs between 0 (nothing at all) and 11 (maximum pain) (7), the Questionnaire of Recovery Stress for Athletes (RestQ Sport) (23), and the sleep (41) questionnaires were administered. The test-retest reliability was >0.90 and for the Borg's scales (7) and >0.79 for the RestQ Sport (23). In particular, the 6–20 RPE scale was favored with respect to the Borg's category ratio (CR-10) scale because players were used to this instrument, routinely administered during their futsal season. The RestQ Sport was selected because it has been specifically validated to indicate the recovery-stress state of athletes by means of 76 items assessed on a 7-point Likert scale, ranging from "never" (0 points) to "always" (6 points). The items represent 19 scales. High scores in the general stress, emotional stress, social stress, conflicts/pressure, fatigue, lack of energy, physical complaints, disturbed breaks, emotional exhaustion, and injury scales reflect intense subjective stress. On the other hand, high scores in the success, social recovery, physical recovery, general well-being, sleep quality, being in shape, personal accomplishment, self-efficacy, and self-regulation scales reflect plenty of recovery. Since the interpretation of the RestQ Sport profile should refer to either a reference group of the athletes or to the mean and variability of single samples, to explore the effects of recovery interventions on the recovery-stress state of futsal players, the 19 scales were analyzed separately. To provide information regarding the sleeping quantity, athletes were also asked to report the time they start sleeping (i.e., lights off), the time they woke up (i.e., lights on), sleeping arrangements (i.e., partner/no partner), and sleeping location (i.e., home/partner's home) as well as any other relevant comments for experiencing troubles falling asleep (41). Considering that the athlete's psychological well-being could have an effect on the recovery process (11,27), at the end of each experimental session, subjects were asked to evaluate the recovery intervention ("how recovered do you feel after this recovery intervention?") by means of a 10-point Likert scale (48), ranging from "not at all" (1 point) to "very, very much" (10 points). Scores were recorded to the nearest 0.5.

Anaerobic Evaluations

According to the literature (11,38,47), measurements of anaerobic performance included vertical jump tests (i.e., countermovement jump [CMJ], bounce jumping) and 10-m sprint. These tests were also routinely administered during the futsal season. CMJ and bounce jumping were evaluated using an optical acquisition system (Optojump; Microgate, Udine, Italy), developed to measure with 10^{-3}-second precision all flying and ground contact times. The Optojump photocells are placed 6 mm from the ground and are triggered by the feet of the subject at the instant of take-off and at contact on landing. Then, calculations of the height of the jump are made (25). For the CMJ, from the standing position, the futsal players were required to bend their knees to a freely chosen angle and perform a maximal vertical thrust. For the bounce jumping test, athletes performed seven consecutive jumps keeping their body vertical throughout the jump and landing with knees fully extended. For both tests, the effect of the arm swings was minimized by asking the athletes to keep their hands on their hips. Since it was assumed that subjects maintained the same position at take-off and landing, any jump that was perceived to deviate from the required instructions was repeated. The test-retest intraclass correlation coefficients (ICCs) were 0.98 and 0.94 for CMJ and bounce jumping, respectively. Sprints were measured by means of a dual infrared reflex photoelectric cell system (Polifemo; Microgate, Udine, Italy) positioned 10 m apart with the first timing gate at 0.5 m from the start. This test showed a test-retest ICC of 0.93. Anaerobic performances were measured indoors to avoid external interferences and to control that the compliance of the surface on which jump and run tests were executed did not affect the scores. Furthermore, to avoid the effects of different athletic equipment on anaerobic performances, players were required to wear the same shoes during the experimental sessions. Before pregame (08:30) and postrest (17:00) anaerobic testing, players underwent a 15-minute standardized warm-up period (i.e., jogging and stretching) at a moderate intensity corresponding to HR around 60% of HRmax (34,44). Then anaerobic tests were administered in the same order throughout the study: 1) CMJ, 2) bounce jumping, and 3) 10-m sprint.

For each test, players were allowed 2 trials with a 5-minute recovery period between trials and received verbal encouragement. Thus, their best performance was used for statistical analysis.

Fluid Intake Assessment and Meal Administration

In the morning, subjects were provided with individually colored water bottles and were encouraged to drink ad libitum before, during (around every 15 minutes), and after the games. Although water is not the best means of restoring body fluids (36,37), it was favored considering that players were not used to drinking electrolyte-carbohydrate solutions. The players were instructed to drink only from their own bottles and not to spit out any drink. Observers monitored the drinking behavior to ensure that players used only the correct bottles and that they did not discard any fluid. All bottles were weighed in the morning and after the afternoon test stage in order to establish the volume of each athlete's water intake during the experimental session. Each athlete's body mass was determined with an accuracy of 100 g for each experimental session at pregame, postgame, and postrest stages (36). During the first 2 hours of the rest period, players received a standard meal (36,40,47) with a macronutrient distribution of 58% carbohydrates, 27% lipids, and 15% proteins (total caloric intake 900 kcal) determined by a medical doctor nutritionist with 15 years of experience with soccer players.

Statistical Analyses

The study was performed with a randomized, crossover design, and a <0.05 level of confidence was selected. To evaluate the stability of the pregame condition of players, ICCs were calculated for body mass, sleep, and jump and sprint performances. To evaluate the stability of the exercise load imposed by the competition, differences in frequencies of occurrence of HR counts during the 4 experimental settings were verified by means of a χ^2 test. Furthermore, ICCs were calculated for the RPE ratings after the game and the post/pre ratio of blood lactate.

To study the effectiveness of different postgame recovery interventions, the independent variable was the type of recovery interventions (R, D, W, and E), and dependent variables were the perception scales (Borg's muscle pain, RestQ Sport, sleep, and Likert), the anaerobic performances (CMJ, bounce jumping, and 10-m sprint), the hormone concentrations (cortisol and catecholamines), and the water intake. For the anaerobic performances in each session, postgame and pregame ratios were calculated. In interpreting the performance ratios, a good degree of recovery from the game had been achieved when the ratio was close to 1.0. Furthermore, to provide meaningful analysis for comparisons from small groups, the Cohen's effect sizes with respect to pregame values were also calculated (10). An effect size ≤ 0.2 was considered trivial, from 0.3 to 0.6 small, <1.2 moderate, and >1.2 large (21). A 3 (testing time) $\times$ 4 (recovery modes) analysis of variance (ANOVA) for repeated measures was performed to compare the effects of recovery interventions on jumping and sprint performances and muscle pain scale. A 4 (testing time) $\times$ 4 (recovery modes) ANOVA for repeated measures was performed to compare the effects of recovery interventions on cortisol concentrations. A 2 (testing time) $\times$ 4 (recovery modes) ANOVA for repeated measures was performed to compare the effects of recovery interventions on catecholamine concentrations and sleeping quantity. A two-way ANOVA was performed for muscle pain and RestQ Sport scales, water intake, and Likert scale. When a significant interaction was obtained, post hoc comparisons were performed using Fisher's least significant difference test and the Bonferroni α level correction was applied to eliminate an inflated type I error for multiple comparisons.

Results

Stability of Pregame Condition of Players and Game Load

Intraclass correlation coefficients for pregame data ranged from 0.70 (sleep and 10-m sprint) to 0.99 (CMJ and bounce jumping = 0.94, body mass = 0.99), with no significant difference emerging between experimental sessions. Intraclass correlation coefficients values for postgame data were RPE = 0.90, body mass = 0.99, and blood lactate concentration = 0.87. No significant difference was found between the futsal games for HR and match analysis data. Therefore, dependent variables were submitted to comparisons between the recovery interventions.

During the games, walking comprised 31%, running 35%, positioning 21%, and inactivity 13%. Most of the players' motor activities lasted less than 5 seconds and never exceeded 20 seconds (Figure 1). The percentages of total HR spent at relative intensities during the 2 halves of the games were 2.5 ± 4.4%, 4.7 ± 5.4%, 13.4 ± 10.0%, 47.4 ± 20.8%, and 32.1 ± 28.4% for the first half and 1.5 ± 3.7%, 3.8 ± 3.7%, 13.9 ± 9.3%, 43.9 ± 21.0%, and 36.9 ± 30.4% for the second half at exercise intensities ≤60%, 70%, 80%, 90%, and >90% of players' HRmax. Blood lactate values were 2.0 ± 0.5 $mmol \cdot L^{-1}$, 4.4 ± 2.4 $mmol \cdot L^{-1}$, and 3.8 ± 2.0 $mmol \cdot L^{-1}$ before a game,

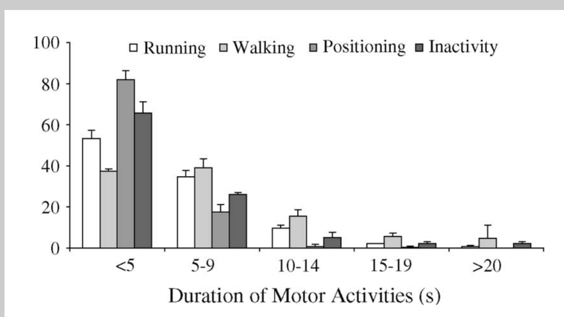

Figure 1. Means and standard deviations of frequency distributions relative to the duration of motor activities during the futsal games.

after the first half, and after the second half, respectively. RPE ranged from 7 to 18 (first game: 12.2 ± 2.8; second game: 12.6 ± 2.7; third game: 12.5 ± 3.1; fourth game: 14.2 ± 2.7). Players reported low muscle pain values (range, 0–4.5) both in the postrest and in the next morning stages with no significant difference between recovery interventions. Players' body mass was higher before the game (73.0 ± 6.9 kg), lower at the end of the game (72.3 ± 6.9 kg), and close to pregame values in the afternoon (72.8 ± 6.4 kg).

Effects of Recovery Interventions

No significant effect due to recovery interventions was found on anaerobic performances, hormones, rating of muscle pain, recovery-stress state, and amount of sleep. Table 2 reports the performance scores for the variables measured during the pregame, the postgame, and the postrest stages. Anaerobic performances were better in the morning (CMJ: 39.7 ± 4.1 cm; bounce jumping: 34.5 ± 4.5 cm; 10-m sprint: 1.80 ± 0.06 seconds), decreased after the futsal game (CMJ: 38.8 ± 4.2 cm; bounce jumping: 33.9 ± 3.9 cm; 10-m sprint: 1.83 ± 0.08 seconds), and remained low in the afternoon (CMJ: 38.3 ± 3.8 cm; bounce jumping: 33.9 ± 4.3 cm; 10 m: 1.81 ± 0.06 seconds). Significant differences were found between testing time for CMJ ($P < 0.001$; power = 0.98) and for the 10-m sprint ($P < 0.05$; power = 0.64; ES ranging from 0.2 to 0.7) performances only. For CMJ, post hoc analysis showed significantly better morning performances (ES ranging from 0.1 to 0.5) with respect to the other 2 measures. For the 10-m sprint, pregame performances were significantly better (ES ranging from −0.2 to −0.5) only with respect to postgame ones.

Postrest/pregame ratios of anaerobic performance (Table 3) approached 1.0 (CMJ: 0.97 ± 0.05; bounce jumping: 0.99 ± 0.07; 10-m sprint: 0.99 ± 0.04). Generally, small to medium effect sizes with respect to *R* were found (range, 0.02–0.7). A large effect size was found only for postrest D recovery (ES = −1.5).

Players reported that they always slept at home with no partner. They also reported no sleeping disturbances. Significantly longer sleeping times ($P < 0.01$, power = 0.92; ES = 0.95) after the games (7:43 ± 0:13) than the nights before the games (6:34 ± 0:24) were found, with no significant differences between recovery interventions (ES respect to *R*: range, 0.1–0.5). The stress-recovery state of the players associated to the futsal games and their consequences assessed by means of the RestQ Sport (Figure 2), showed low mean values for the stress-associated activity scales (general stress: 0.6 ± 0.5; emotional stress: 1.0 ± 0.7; social stress: 1.3 ± 1.0; conflicts/pressure: 1.9 ± 1.0; fatigue: 1.5 ± 1.0; lack of energy: 1.6 ± 0.7; physical complaints: 1.2 ± 0.8; disturbed breaks: 1.2 ± 0.8; emotional exhaustion: 0.3 ± 0.4; injury: 1.2 ± 0.7) and high values for the recovery-oriented scales (success: 2.1 ± 0.9; social recovery: 3.6 ± 0.9; physical recovery: 3.2 ± 1.1; general well-being: 4.0 ± 1.3; sleep quality: 4.1 ± 1.0; being in shape: 3.2 ± 1.2; personal accomplishment: 3.3 ± 0.8; self-efficacy: 3.4 ± 1.1; self-regulation: 2.3 ± 1.3).

Table 2. Mean ± *SD* of performances scores (countermovement jump, bounce jump, and 10-m sprint) recorded during the pregame, postgame, and postrest stages.

	Pregame (08:30–09:30)	Postgame (11:30–11:50)	Postrest (17:00–17:30)
Countermovement jump (cm)*†			
Water exercises	39.3 ± 4.0	38.7 ± 4.9 (0.2)	37.0 ± 4.0 (0.3)
Dry exercises	39.7 ± 4.3	39.5 ± 4.4 (0.1)	38.5 ± 4.3 (0.3)
Electrostimulation	40.1 ± 4.7	38.2 ± 3.7 (0.4)	38.1 ± 3.6 (0.4)
Seated rest	39.6 ± 4.2	38.6 ± 4.4 (0.2)	38.7 ± 4.2 (0.2)
Bounce jumping (cm)			
Water exercises	33.8 ± 4.1	33.4 ± 4.2 (0.1)	33.3 ± 4.1 (0.1)
Dry exercises	33.7 ± 5.0	34.5 ± 4.1 (−0.2)	33.7 ± 5.2 (<0.1)
Electrostimulation	35.4 ± 4.7	33.6 ± 3.7 (0.1)	34.1 ± 4.2 (−0.1)
Seated rest	34.9 ± 4.6	34.0 ± 4.1 (0.1)	34.5 ± 4.4 (−0.2)
10-m sprint (s)*			
Water exercises	1.80 ± 0.06	1.83 ± 0.08 (−0.5)	1.82 ± 0.06 (−0.3)
Dry exercises	1.78 ± 0.06	1.80 ± 0.06 (−0.3)	1.81 ± 0.04 (−0.5)
Electrostimulation	1.81 ± 0.07	1.85 ± 0.09 (−0.6)	1.80 ± 0.05 (0.1)
Seated rest	1.80 ± 0.07	1.82 ± 0.11 (−0.3)	1.83 ± 0.09 (−0.4)

*$P < 0.01$; postgame score significantly different from pregame.
†$P < 0.01$; postrest score significantly different from pregame.
Effect sizes (with respect to seated rest condition) are shown in parentheses.

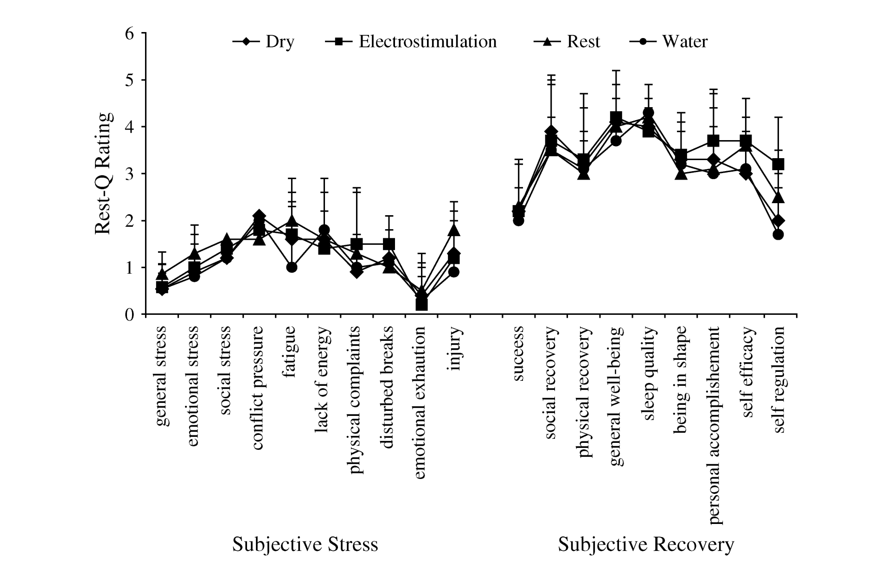

Figure 2. Mean and *SD* of the 19 items of the Questionnaire of Recovery Stress for Athletes in relation to the 4 recovery interventions. Rating scale: 0 = never, 1 = seldom, 2 = sometimes, 3 = often, 4 = more often, 5 = very often, 6 = always.

Basal cortisol concentrations demonstrated a diurnal rhythm, with concentrations higher in the morning (8:00 = 9.6 ± 4.6 ng·mL^{-1}), and reduced during the day (12:00 = 7.7 ± 2.1 ng·mL^{-1}; 17:00 = 4.9 ± 1.0 ng·mL^{-1}). The days of the games cortisol concentrations were 8.2 ± 2.5 ng·mL^{-1}, 8.0 ± 2.4 ng·mL^{-1}, 6.2 ± 1.1 ng·mL^{-1}, and 9.8 ± 2.3 ng·mL^{-1} at 8:00, 12:00, 17:00, and 08:00 after the game, respectively. A significant difference ($P < 0.001$, power = 1.0) was found between testing times. Post hoc analysis showed no effect only between the 08:00 and 12:00 samples. When values were expressed as ratios between the cortisol concentrations measured during the experimental sessions and baseline values, higher pregame values than baseline values were found. Significant differences ($P < 0.01$, power = 0.92) between testing time (08:00: 0.96 ± 0.43; 12:00: 1.07 ± 0.35; 17:00: 1.34 ± 0.40; 08:00 morning after the game: 1.12 ± 0.39) were found, and post hoc analysis showed significant higher concentrations at 17:00 with respect to the 08:00 (ES = 0.9) and 12:00 ones (ES = 0.8).

A significant difference ($P < 0.001$; power = 0.95) between games emerged for total urinary catecholamines. With respect to the first game (pre-game: 23.9 ± 4.4 μg·L^{-1}; following morning: 32.2 ± 7.5 μg·L^{-1}), post-hoc analysis showed a significant increase during the second (pre-game: 35.0 ± 6.9 μg·L^{-1}; following morning: 39.2 ± 12.4 μg·L^{-1}) and third (pre-game: 31.4 ± 2.5 μg·L^{-1}; following morning: 34.7 ± 6.5 μg·L^{-1}) games. Instead, the fourth game (pre-game: 26.3 ± 3.1 μg·L^{-1}; following morning: 30.6 ± 6.2

Table 3. Mean ± *SD* of the ratios calculated between postgame and pregame performances (countermovement jump, bounce jump, and 10-m sprint).

	Postgame	Postrest
Countermovement jump		
Water exercises	0.98 ± 0.06 (−0.21)	0.97 ± 0.06 (+0.22)
Dry exercises	0.99 ± 0.06 (−0.54)	0.97 ± 0.06 (+0.16)
Electrostimulation	0.96 ± 0.05 (+0.46)	0.95 ± 0.04 (+0.51)
Seated rest	0.98 ± 0.04	0.98 ± 0.05
Bounce jumping		
Water exercises	0.99 ± 0.08 (−0.39)	0.99 ± 0.07 (+0.02)
Dry exercises	1.03 ± 0.11 (−1.5)	1.00 ± 0.09 (−0.15)
Electrostimulation	0.95 ± 0.07 (+0.58)	0.97 ± 0.06 (+0.24)
Seated rest	0.97 ± 0.04	0.99 ± 0.07
10-m sprint		
Water exercises	0.98 ± 0.03 (+0.03)	0.99 ± 0.03 (−0.31)
Dry exercises	0.99 ± 0.03 (−0.11)	0.99 ± 0.03 (−0.25)
Electrostimulation	0.98 ± 0.05 (+0.06)	1.01 ± 0.04 (−0.69)
Seated rest	0.98 ± 0.04	0.98 ± 0.05

Effect sizes (with respect to seated rest condition) are shown in parentheses.

$\mu g \cdot L^{-1}$) showed only a significant difference with respect to the second game. Total catecholamines were also significantly ($P < 0.01$; power = 0.98) lower the morning before the games (29.2 ± 6.2 $\mu g \cdot L^{-1}$) with respect to the morning after the games (34.2 ± 8.8 $\mu g \cdot L^{-1}$), with a postgame/pregame ratio of 1.19 ± 0.26 (ES = −0.8).

Although no effects of recovery interventions were found on water intake, anaerobic performance, hormone concentrations, ratings of muscle pain, recovery-stress state, and amount of sleep, according to the Likert scale, players perceived significantly increased benefit ($P < 0.01$; power = 0.91) from the E (7.8 ± 1.4 points) and W (7.6 ± 2.1 points) compared to D (6.6 ± 1.8 points) and R (5.2 ± 0.8 points). Large effect sizes (>1.8) were always found with respect to R.

Discussion

Professional and university team games are often played on a twice-weekly basis, and postgame recovery interventions could have practical relevance to maintain and/or enhance the athletic performance of players during the competitive season (4,11,36). Several postgame recovery interventions have been suggested (36,37), despite the lack of scientific agreement regarding their efficacy. The discrepancies of the results might be due to different methodologies (i.e., laboratory versus field testing), populations (i.e., sedentary versus athletes), and research designs (i.e., separate versus counterbalanced) employed, also considering the mode, volume, and intensity of the previous training load (4). Thus, the present study was mainly designed to explore the effectiveness of immediate postgame recovery interventions on anaerobic performance and the recovery-stress state in futsal players using a multiple-system approach of measurement (performance, psychological, hormonal) and an experimental setting with a high ecological validity. In fact, competitive games stress players both physiologically and psychologically (36), and there is no laboratory setting that actually reproduces the exercise stress of the game or a single aspect able to fully reflect the recovery status of the athlete. Furthermore, to prevent some limitations of the previous studies (4,11), a fully random administration of the postgame recovery interventions (i.e., passive, dry exercise, water exercise, and electrostimulation) was employed and load of the competitions, food intake, rehydration, and sleep of the athletes were monitored. Finally, since recovery is strictly related to the previous exercise stress, it is not advisable to apply information derived from other team sports played on pitches of different dimensions, with different rules, game duration, technical and tactical aspects, and movement patterns. On the other hand, the investigation of the mechanisms assisting each recovery intervention was beyond the scope of this study.

To overcome the practical difficulty connected with data collection during actual competitions, this study was conducted during friendly games. However, to simulate real competition, the players were told that the friendly games were intended as selection trials for their participation in the upcoming European college tournament. The athletes' HR, RPE, and match analysis were used to monitor the exercise intensity (2,7,20,34). During the games, players were inactive for only 13% of the game, spending most of the time running and walking (35% and 31%, respectively). According to the literature (12), their activities generally lasted less than 5 seconds and rarely more than 10 seconds. HR was higher than that reported for recreational futsal players (9) and comparable to that reported in young professional soccer players (45) and young elite basketball players (1), with 80% of game time spent with a HR response >80% HRmax. Thus, futsal games proved to be a high-intensity activity, placing a heavy cardiac load on athletes. On the other hand, the athletes perceived the intensity of their efforts as "somewhat hard" (7), despite spending 58% of the games at an HR >85% HRmax. It might be possible that they tended to underestimate their efforts due to both the intermittent nature of the game and their high fitness and skill levels (9,47). The lack of significant differences between futsal games for the above-mentioned parameters confirms that the exercise load was similar throughout the study. Thus, any observation made should be the direct result of the intervention rather than extraneous factors.

The main findings of this study were that passive and active recovery interventions did not induce significant differences in the studied parameters and players liked significantly more electrostimulation and water cool-down recovery interventions. However, this study has 3 major limitations. The first is that the strict criteria for inclusion ensured a homogeneous group of elite players but limited its sample size, which might have affected the statistical significance. These results are consistent with those of the most recent literature comparing different recovery interventions after other team sport competitions (11) and training (47). It is possible that the young age and the good athletic condition of the subjects, in addition to their very controlled lifestyle, well-balanced diet, and proper rehydration, might have more impact on the recovery process than any of those interventions employed (6,28,32,47). The second limitation is that the observations were obtained during friendly games and a quite different picture could emerge after full competitive games, especially considering the relevance of their outcomes (36). The third limitation is that the experimental period was restricted to 2 weeks, which might be too short to evaluate the effect of recovery interventions over time (26). On the other hand, this study not only contributes to the debate on the effects of recovery interventions after team sport games, but also provides precious information regarding the stress imposed by futsal games on elite players.

In many team sports, such as futsal, successful performance depends on cognitive function for decision making as well as proper execution of complex skills under high physical load. During prolonged intermittent exercise in hot environments, decreased performance has been related to dehydration (42), and impairment of soccer-specific skills has been reported when 2.4% body mass reductions occurred (33). The exercise intensity and duration, the ambient temperature, and humidity influence the sweat rate, whereas each sport allows fluid intake during competition. Futsal players have more opportunity to rehydrate during competition with respect to soccer players, minimizing reductions in game performance. Although in the present study, the hot environmental conditions (temperature: 23 ± 3°C; humidity: 62 ± 16%), together with the high intensity of playing, were sufficient to stimulate significant sweating, a mild reduction of body mass (1%) was observed at the end of the games. This dehydration was less than expected (8), probably due to the fact that the players were accustomed to training and playing in the heat, were provided with individual water bottles always available during the time outs of the game, and were encouraged to drink. Despite the report of Watson et al. (49) of no impairment of anaerobic performances due to a mild dehydration, at the end of the game, CMJ and 10-m sprint performance significantly decreased, confirming the high physical demands of the games. According to previous studies that used explosive exercises to investigate both the effects of fatigue and the recovery process after team sport training (47) and games (11,38), these variables were sensitive enough to address changes as a result of intense exercise load. Considering the practical relevance of jump and sprint tests to team sports, Dawson et al. (11) claimed that players might be able to produce "one off" efforts close to their maximum after games and suggested that repeated effort jump tests might be more effective in assessing any reduction in the functional capacity of players. However, in the present study, the statistical analyses showed that the magnitude of change of CMJ and sprint tests reflected fatigue after a futsal game, while the bounce jumping test failed to discriminate between pre- and postgame conditions. These results suggest that after the futsal games, athletes were unable to give their best all-out performances while maintaining their submaximal ones. In fact, the bounce jumping test always had the lowest mean jump values (88.1 ± 0.1% with respect to CMJ) due to the technical and biological constraints of the repeated jumping activity. On the other hand, the lack of a significant difference between recovery interventions and the marginal effect sizes indicates that none of the studied interventions significantly affect the player's postrest peak performance. Surely, further research is needed to explore more sensitive markers of recovery and whether recovery interventions might facilitate aerobic rather than anaerobic performance in team players.

Regardless whether active or passive postgame recovery interventions were performed, players reported low muscle soreness (7). This is in contrast to what was reported for other team sport athletes at the end of their games (11,38), probably due to several factors: the experimental period was scheduled at the beginning of the competition period when muscle pain is unlikely to occur (37), friendly games less likely involve body contact and tackles, which might cause a higher rating of muscle soreness; and futsal would likely involve less body contact than soccer, rugby, and Australian football. Therefore, further research is needed to evaluate the effectiveness of recovery interventions on muscle pain after games involving intense body contact between players.

Hormonal concentrations (30,31) have been proposed to characterize psychological symptoms that indicate a state of underrecovery coinciding with increased exercise loads. As other team sports, a futsal game requires very intensive physical load, which is known to act positively on the cortisol level (15). In this study, cortisol levels in the rest day ranged from approximately 9.6 $ng\cdot mL^{-1}$ for the morning value to 4.9 $ng\cdot mL^{-1}$ for the evening value, according to its circadian rhythm (24). A completely different picture might emerge during real competitions. In the present study, there was a lack of higher precompetition cortisol levels, indicating that the friendly games did not elicit cognitive anticipation and anxiety (35). Nonetheless, the futsal games required an intensive physical strain (80% of game spent at an HR > 80% of players' HRmax), which is known to act positively on cortisol (15). As expected, postcompetition cortisol levels were higher than baseline (15,30), altering the regular diurnal rhythm (24). Although a progressive decrease was observed, the afternoon concentrations remained high and tended to return to the resting level the morning after the game. Also catecholamines are expected to be elevated after exercise, and elevations over time have been associated with overreaching (29), which might happen when 2 games are scheduled within a week. In fact, in this study, catecholamine levels significantly increased after competitions and remained elevated before the second and the third games and returned close to basal values only before the fourth game. These results might indicate that a progressive adaptation to the stress caused by multiple games occurs within 10 days. However, it has to be noted that during the first 10 days of the experimental period, all the players were administered at least 3 recovery interventions, which might have had a cumulative effect. Since a different research design is needed to verify the difference in effectiveness of recovery strategies over time, further investigation is needed.

Sleep is crucial for recovery from exercise, probably helping energy conservation, body restoration, and thermoregulation (14). Important contributing factors to the sleep response include exercise intensity, type of exercise, and the timing of exercise in relation to sleep. With respect to the rest day, sleep quantity and quality tend to increase when fit individuals exercise at high intensity (75%–80% of $\dot{V}O_2max$ for an average of 1.2 hours) at least 6 hours before bedtime (14). However, many other factors could negatively affect the sleeping pattern of team players, such as the satisfaction with their own performances (36,41). Richmond et al. (41) reported that Australian football players slept less on the night of the game due to late night celebrations and alcohol consumption after winning games. In the present study, the longer sleep time recorded on the day of the game could be attributed to the effect of exercise, the low pressure to win the friendly games, and the controlled lifestyle of the players. Therefore, it is possible that a completely different picture might appear after real competitions.

Some authors (27,37,46,47) claimed that recovery interventions might have a beneficial effect on the psychological state of the athlete, which might help maintain their maximal performance. In this study, a high levels of stress-recovery status of the futsal players emerged, independently from recovery interventions. However, the futsal players attributed higher effectiveness to the electrostimulation and water exercise cool-down, while seated rest was perceived as the least effective. These results are generally in agreement with the literature (11,47), indicating that recovery strategies could represent valuable aids to improve the player's attitude toward training (27). Even though this study did not focus on the mechanisms by which these recovery interventions may assist regeneration, it is possible to hypothesize that electrostimulation and water exercising provide massaging effects, which increase physiological and psychological indices of relaxation (13,37,46,47). However, these hypotheses should be explored in further research. In conclusion, the current study suggests that a well-balanced diet, rehydration, and a controlled lifestyle might represent a sufficient recovery intervention in young elite athletes. Since a better perception of recovery status could have a positive effect on a player's attitude to perform at his best during games, the currently used recovery interventions could also be helpful. However, the underlying mechanisms of recovery after team games remain debatable and further studies are necessary.

Practical Applications

Recovery strategies from team games should incorporate hydration, a well-balanced diet, and sufficient sleep. In addition, the positive subjective perception generated from some cool-down interventions could be relevant to increasing the player's attitude toward subsequent training sessions. Furthermore, coaches could be advised to use questionnaires to monitor the recovery stress of the athlete, especially when the competitive season requires frequent games. Finally, in the last 2 weeks of the preseason, coaches should organize friendly games at a level similar to that of the competitive season to induce progressive hormonal adaptation to the high exercise load of multiple games.

References

1. Apostolidis, N, Nassis, GP, Bolatoglou, T, and Geladas, ND. Physiological and technical characteristics of elite young basketball players. *J Sports Med Phys Fitness* 43: 157–163, 2003.
2. Baangsbo, J. Physiology of training. In: *Science and Soccer.* Reilly, T, ed. London: E. & F.N. Spon, 2002. pp. 51–64.
3. Barbero Alvarez, JC, Soto Hermoso, VM, and Granda Vera, J. Effort profiling during indoor soccer competition. *J Sports Sci* 22: 500–501, 2004
4. Barnett, A. Using recovery modalities between training sessions in elite athletes: Does it help? *Sports Med* 36: 781–796, 2006.
5. Bishop, D. Evaluation of the Accusport lactate analyzer. *Int J Sports Med* 22: 525–530, 2001.
6. Bompa, TO. Periodization: theory and methodology of training. London: Blackwell Scientific, 1999. pp. 95–146.
7. Borg, G. *Borg's Perceived Exertion and Pain Scales* Champaign, IL: Human Kinetics, 1998. pp. 2–16.
8. Broad, EM, Burke, LM, Cox, GR, Heeley, P, and Riley, M. Body weight changes and voluntary fluid intakes during training and competition sessions in team sports. *Int J Sports Nutr* 6: 307– 320, 1996.
9. Castagna, C, Belardinelli, R, Impellizzeri, FM, Abt, GA, Coutts, AJ, and D'ottavio, S. Cardiovascular responses during recreational 5-a-side indoor-soccer. *J Sci Med Sport* 10: 89–95. 2007.
10. Cohen, J. *Statistical Power Analysis for the Behavioral Sciences* (2nd ed.). Hillsdale, NJ: Lawrence Erlbaum, 1988.
11. Dawson, B, Gow, S, Modra, S, Bishop, D, and Stewart, G. Effects of immediate post-game recovery procedures on muscle soreness, power and flexibility levels over the next 48 hours. *J Sci Med Sport* 8: 210–221, 2005.
12. Dogramaci, SN and Watsford, ML. A comparison of two different timing methods for time–motion analysis in team sports. *Int J Perform Anal Sport* 6: 73–83, 2006.
13. Dowzer, CN and Reilly, T. Deep-water running. *Sport Exerc Inj* 4: 50–61, 1998
14. Driver, HS and Taylor, SR. Exercise and sleep. *Sleep Med Rev* 4: 387–402, 2000.
15. Elloumi, M, Maso, F, Michaux, O, Robert, A, and Lac, G. Behaviour of saliva cortisol [C], testosterone [T] and the T/C ratio during a rugby match and during the post–competition recovery days. *Eur J Appl Physiol* 90: 23–28, 2003.
16. Fallowfield, JL, Jackson, AG, Wilkinson, DM, Harrison, JHH. The influence of water ingestion on repeated sprint performance during a simulated soccer match. In: *Science and Football III* Reilly, T, Bangsbo, J, and Hughes, M, eds. London: Routledge, 1997. pp. 60–65.
17. Fédération Internationale De Football Association. Available at: www.fifa.com. Accessed June 6, 2007.
18. Ferrauti, A, Neumann, G, Weber, K, and Keul, J. Urine catecholamine concentrations and psychophysical stress in elite tennis under practice and tournament conditions. *J Sports Med Phys Fitness* 41: 269–274, 2001.
19. Gill, ND, Beaven, CM, and Cook, C. Effectiveness of post-match recovery strategies in rugby players. *Br J Sports Med* 40: 260–263, 2006.
20. Hoff, J, Wisløff, U, Engen, LC, Kemi, OJ, and Helgerud, J. Soccer specific aerobic endurance training. *Br J Sports Med* 56: 218–221, 2002.
21. Hopkins, WG. A scale of magnitudes for effect statistics 2002. Available at: http: //www.sportssci.org/resource/stats/effectmag.html. Accessed July 4, 2008.
22. Jackson, AS and Pollock, ML. Practical assessment of body composition. *Phys Sports Med* 13: 76–80, 1985.
23. Kellmann, M. Underrecovery and overtraining. In: *Enhancing Recovery: Preventing Underperformance in Athletes* Kellmann, M, ed. Champaign, IL: Human Kinetics, 2001. pp. 3–24.
24. Kirschbaum, C and Hellhammer, DH. Salivary cortisol in psychophysiological research: an overview. *Neuropsychobiology* 22: 150–169, 1989.
25. Komi, PV and Bosco, C. Utilization of stored elastic energy in leg extensor muscles by men and women. *Med Sci Sports Exerc* 10: 261–265, 1978.

26. Kraemer, WJ, French, DN, Paxton, NJ, Häkkinen, K, Volek, JS, Sebastianelli, WJ, Putukian, M, Newton, RU, Rubin, MR, Gómez, AL, Vescovi, JD, Ratamess, NA, Fleck, SJ, Lynch, JM, and Knuttgen, HG. Changes in exercise performance and hormonal concentrations over a big ten soccer season in starters and nonstarters. *J Strength Cond Res* 18: 121–128, 2004.

27. Lattier, G, Millet, GY, Martin, A, and Martin, V. Fatigue and recovery after high-intensity exercise. Part II: Recovery interventions. *Int J Sports Med* 25: 509–515, 2004.

28. Lau, S, Berg, K, Latin, RW, and Noble, J. Comparison of active and passive recovery of blood lactate and subsequent performance of repeated work bouts in ice hockey players. *J Strength Cond Res* 15: 367–371, 2001.

29. Lehmann, M, Schnee, W, Scheu, W, Stockhausen, R, and Bachl, N. Decreased nocturnal catecholamine excretion: parameter for an overtraining syndrome in athletes. *Int J Sports Med* 13: 236–242, 1992.

30. Maso, F, Lac, G, Filaire, E, Michaux, O, and Robert, A. Salivary testosterone and cortisol in rugby players: correlation with psychological overtraining items. *Br J Sports Med* 38: 260– 263, 2004.

31. Maughan, R and Shirreffs, S. Exercise in the heat: challenges and opportunities. *J Sports Sci* 22: 917–927, 2004.

32. McAinch, AJ, Febbraio, MS, Parkin, JM, Zhao, S, Tangalakis, K, Stojanovska, L, and Carey, MF. Effect of active versus passive recovery on metabolism and performance during subsequent exercise. *Int J Sport Nutr Exerc Metab* 14: 185–196, 2004.

33. McGregor, S, Nicholas, C, Lakomy, H, and Williams, C. The influence of intermittent high-intensity shuttle running and fluid ingestion on the performance of a soccer skill. *J Sports Sci* 17: 895–903, 1999.

34. Mohr, M, Krustrup, L, Nybo, L, Nielsen, JJ, and Bangsbo, J. Muscle temperature and sprint performance during soccer matches– beneficial effect of re-warm-up at half–time. *Scand J Med Sci Sports* 14: 156–162, 2004.

35. Passelergue, P, Robert, A, and Lac, G. Salivary cortisol and testosterone variations during an official and a simulated weightlifting competition. *Int J Sports Med* 16: 298–303, 1995.

36. Reilly, T. *The Science of Training–Soccer*. London: Routledge, 2007. pp. 107–125.

37. Reilly, T and Ekblom, B. The use of recovery methods post-exercise. *J Sports Sci* 23: 619–627, 2005.

38. Reilly, T and Rigby, M. Effects of an active warm-down following competitive soccer. In: Science and Football IV. Sprinks, W, Reilly, T, and Murphy, A, eds. London: Routledge, 2002. pp. 226–229.

39. Reilly, T and Thomas, V. A motion analysis of work-rate in different positional roles in professional football match-play. *J Hum Mov Stud* 2: 87–97, 1976.

40. Riach, IE, MacDonald, R, and Newell, J. Nutritional and anthropometric assessment of elite soccer players. *J Sports Sci* 22: 559–560, 2004.

41. Richmond, L, Dawson, B, Hillman, DH, and Eastwood, PR. The effect of interstate travel on sleep patterns of elite Australian Rules footballers. *J Sci Med Sport* 7: 186–196, 2004.

42. Shirreffs, SM, Aragon-Vargas, LF, Chamorro, M, Maughan, RJ, Serratosa, L, and Zachwieja, JJ. The sweating response of elite professional soccer players to training in the heat. *Int J Sports Med* 26: 90–95, 2005.

43. Spierer, DK, Goldsmith, R, Baran, DA, Hryniewicz, K, and Katz, SD. Effects of active vs passive recovery on work performed during serial supramaximal exercise tests. *Int J Sports Med* 25: 109–114, 2004.

44. Stewart, D, Macaluso, A, and De Vito, G. The effects of an active warm-up on surface EMG and muscle performance in healthy humans. *Eur J Appl Physiol* 89: 509–513, 2003.

45. Strudwick, A and Reilly, T. The physiological load imposed on elite young professional soccer players during intense training and competitive match-play. *J Sports Sci* 17: 925, 1999.

46. Suzuki, M, Umeda, T, Nakaji, S, Shimoyama, T, Mashiko, T, and Sugawara, K. Effect of incorporating low intensity exercise into the recovery period after a rugby match. *Br J Sports Med* 38: 436–440, 2004.

47. Tessitore, A, Meeusen, R, Cortis, C, and Capranica, L. Effects of different recovery interventions on anaerobic performances following soccer training. *J Strength Cond Res* 21: 745–750, 2007.

48. Tipton, KD and Wolfe, RR. Protein and amino acids for athletes *J Sport Sci* 22:65–79, 2004

49. Watson, G, Judelson, DA, Armstrong, LE, Yeargin, SE, Casa, DJ, and Maresh, CM. Influence of diuretic-induced dehydration on competitive sprint and power performance. *Med Sci Sports Exerc* 37: 1168–1174, 2005.

50. Wilcock, IM, Cronin, JB, and Hing, WA. Physiological response to water immersion: a method for sport recovery? Sports Med 36: 747–765. 2006.

51. Wilcock, IM, Cronin, JB, and Hing, WA. Water immersion: does it enhance recovery from exercise? *Int J Sports Physiol Perform* 1: 195–206, 2006.