

# EFFECTS OF DIFFERENT RECOVERY INTERVENTIONS ON ANAEROBIC PERFORMANCES FOLLOWING PRESEASON SOCCER TRAINING

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**ABSTRACT.** Tessitore, A., R. Meeusen, C. Cortis, and L. Capranica. Effects of different recovery interventions on anaerobic performances following preseason soccer training. *J. Strength Cond. Res.* 21(3):745–750. 2007.—In the preseason soccer training, morning and afternoon training sessions often are scheduled daily. The high frequency of training sessions could place heavy strain on biological systems, and it is necessary to apply proper recovery strategies for improving the players' capability to regain an adequate working state for subsequent training units. However, the effect of recovery interventions following soccer training units is debatable, due to a lack of studies performed in field situations. The aim of this study was to examine, during a 21-day preseason soccer training, the most effective recovery intervention (i.e., passive, dry-aerobic exercises, water-aerobic exercises, electrostimulation) on anaerobic performances (i.e., squat jump, countermovement jump, bounce jumping, and 10-m sprint) and subjective ratings (i.e., perceived exertion and muscle pain), with the conditions before the intervention controlled and standardized. Twelve young (age:  $18.1 \pm 1.2$  years) elite soccer players participated. Data were collected on 4 occasions 2 days apart and at the same time of the day. Activity and dietary intake were replicated on each occasion. After baseline measurements, participants performed a standardized training during which their heart rates and ratings of perceived exertion were recorded. This was followed by a 20-minute recovery intervention. After a 5-hour rest, athletes' ratings of muscle pain were recorded prior to a second test session. There were no significant differences in exercise intensities and baseline anaerobic performances. Significantly ( $p < 0.01$ ) better performances were observed in the afternoon. Although no main effect of recovery intervention was observed on anaerobic performances, dry-aerobic exercises ( $0.6 \pm 0.9$ ) and electrostimulation ( $0.6 \pm 1.2$ ) were more beneficial ( $p < 0.01$ ) than water-aerobic exercises ( $2.1 \pm 1.1$ ) and passive rest ( $2.1 \pm 1.7$ ) for reducing muscle pain, which could affect the player's working ability.

**KEY WORDS.** warm-down, active recovery, passive recovery, muscle soreness

## INTRODUCTION

In soccer, the preparation phase for a long competitive season (several months) is usually rather short (a few weeks) and often includes a higher frequency of training sessions (2 daily units). The intensity, duration, and frequency of the soccer trainings can place a heavy strain on biological systems (38, 45) so that the earlier sessions might compromise the working capacity of players during the later sessions. In particular, they could hamper the strength and power of the lower limbs, which are crucial for soccer performances (6, 11, 15, 28). Thus, coaches are urged to adopt effective recovery strategies between training units, particularly with younger players who show an increased incidence of lower limb injuries during the preseason (45).

Studies involving different exercise stresses reported that 20–40 minutes of light physical activity postexercise establishes a greater blood flow to muscles, prevents venous pooling in the muscles after exercise (7, 41), facilitates restoration from metabolic perturbations (1, 2, 8), attenuates the induction of muscle soreness (29), and increases muscle-damage recovery (14). In particular, exercising in water is strongly recommended as an ideal recovery aid for games players because it naturally massages the muscles, enhances stretching and recovery from musculoskeletal fatigue, and increases physiological and psychological indices of relaxation (9, 10, 24, 40). Finally, specific electrostimulation programs have been marketed recently as increasing blood flow to the exhausted muscles, thus enhancing recovery through metabolite washout. However, there is an ambiguous relationship between measurable physiological parameters and actual performance (16). Furthermore, there is no clear indication regarding the effectiveness of different recovery interventions on subsequent daily training sessions, and there is a need for an ecological study incorporating aspects of practical settings while maintaining experimental control to assess the potential benefits of different recovery interventions on performance.

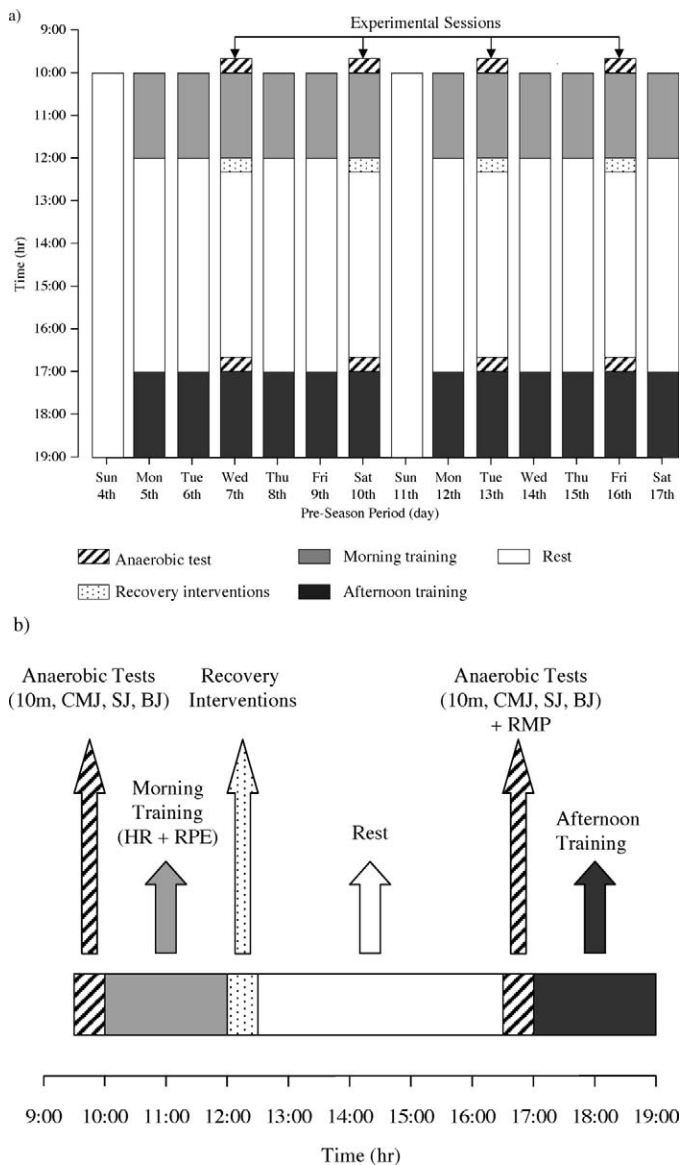
Because no study has considered simultaneously the influence of different recovery interventions on performances in young elite soccer players during their preseason soccer training, this study aimed to determine the most effective recovery method for maximizing their working capacity, using postrecovery anaerobic performance and subjective rating of muscle pain as the dependent criteria.

## METHODS

### Experimental Approach to the Problem

The local Institutional Review Board approved this study designed to investigate the effects, if any, of 2 passive (sitting rest and supine electrostimulation) and 2 active warm-down (dry and water exercises) interventions on anaerobic (sprint and jump) performances and subjective rating of perceived exertion and muscle pain. It was hypothesized that examining young elite soccer players during their actual preseason training period would increase the relevance and the applicability of the results.

Each subject was administered all the recovery interventions that were part of the randomized crossover design of the study, including 4 experimental sessions (Figure 1a). To achieve a matched balance, at the end of each experimental training unit 3 players were assigned randomly to one of the four 20-minute recovery protocols.



**FIGURE 1.** Schema of the preseason weekly training schedule (a) and the experimental design (b). 10m = 10-m sprint; CMJ = countermovement jump; SJ = squat jump; BJ = bounce jumping; HR = heart rate; RMP = rating of muscle pain; RPE = rating of perceived exertion.

## Subjects

Twelve young professional soccer players (age:  $18.1 \pm 1.2$  years; height:  $176.5 \pm 3.6$  cm; body mass:  $67.8 \pm 5.3$  kg) who had at least 10 years of previous soccer training and were members of the Italian first-league A.S. Roma junior (17–19 years of age) team participated in this study. Subjects over 18 years of age gave their written consent, whereas parental consent was obtained for players under the age of 18 years. The athletes were selected on the basis of their participation in Italian National Championships and Junior National teams in order to avoid differences due to their fitness and skill levels (35). Four defenders, 4 midfielders, and 4 forwards were selected (30).

## Experimental Setup

During preseason, participants had 2 daily 2-hour training units (at 1000–1200 hours and 1700–1900 hours) with

a 5-hour rest (Figure 1a,b) during which they were asked to refrain from any additional physical activity. In the morning, participants were provided with individual water bottles and were encouraged to drink as much water as possible before, during (around every 15 minutes), and after the training sessions (12). During the first 2 hours of the rest period, players received a standard meal (32, 41, 43) with a macronutrient distribution of 58% carbohydrates, 27% lipids, 15% proteins (total caloric intake = 900 kcal) determined by a medical doctor nutritionist who had 15 years' experience with soccer players.

Four experimental sessions with 2-day intervals between sessions were organized during the preseason soccer training period (days 7, 10, 13, and 16), during which the same standard trainings were performed outdoors at a temperature of  $23 \pm 3^\circ$  C and humidity of  $62 \pm 16\%$ . The standard morning training consisted of a 100-minute program, including a 15-minute warm-up, 20-minute individual technical drills, 25-minute group technical drills, 20-minute team technical drills, and 20 minutes of 2-minute aerobic circuit training repetitions. To ensure that the morning training did not vary between experimental sessions, the player's heart rate (HR) was recorded during the entire training unit (S810; Polar, Kempele, Finland) and the intensity of effort subsequently was calculated in relation to the estimated HRmax ( $220 - \text{age}$ ). The standard afternoon training consisted of a 120-minute program, including a 15-minute warm-up, 25-minute individual technical drills, 20-minute agility drills, 30-minute tactical drills, and 30-minute friendly match. Furthermore, the coach administered a constant training load during the 2 experimental weeks.

## Anaerobic Evaluations

Before the first and the second daily training units, players performed 4 tests (37), administered in the same order throughout the study: (a) squat jump (SJ); (b) countermovement jump (CMJ); (c) bounce jumping (BJ); and (d) 10-m sprint. Participants were habituated to these tests, routinely administered during the soccer season. For each test, participants were allowed 2 trials, with a 5-minute recovery period between. The best trial was used for subsequent analysis.

Prior to testing, players underwent a 15-minute standardized soccer warm-up period during which they carried out jogging, technical exercises, and stretching at a moderate intensity corresponding to a HR around  $135 \text{ b}\cdot\text{min}^{-1}$  (23, 36). Then, jump performances were evaluated by means of an optical acquisition system (Opto-jump; Microgate, Udine, Italy), which calculates the height of the jump (18). During the jumps the athletes were required to keep their hands on their hips (34). A system of dual infrared reflex photoelectric cells (Polifemo; Microgate) positioned 10 m apart was used to measure running speeds. Players began from a standing start, with the front foot 0.5 m from the first timing gate.

## Subjective Ratings

To assess the players' efforts during their training, athletes were asked to provide a rating of perceived exertion (RPE) for the whole body assessed at the end of their morning training on a 15-point scale (4), ranging from "light" (6 points) to "maximal effort" (20 points). Furthermore, before the second daily training, players provided their rating of muscle pain (RMP) assessed on an 11-point scale (4), ranging from "no pain" (0 point) to "maximal pain" (10 points).

## Recovery Interventions

The recovery protocols to be performed at the end of each experimental training unit were as follows: sitting rest (R); low-intensity dry-aerobic exercises (D; 8 minutes of jogging, 8 minutes of walking and running sideways and backward, and 4 minutes of stretching); 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); and electrostimulation (E) while lying supine (SportP; Compex, Basel, Switzerland). For E recovery, impulses were administered with 1-Hz decrements every 2 minutes from 9 down to 7 Hz and every 3 minutes from 7 down to 2 Hz. Monopolar impulses of 100 mA (rise time = 1.5 second; pulse width = 340  $\mu$ seconds; fall time = 0.5 seconds) were used for the 4 channels. The players selected the most comfortable intensity (i.e., level 20–30). Electrodes were placed on the rectus femoris, vastus medialis, and vastus lateralis, so that one electrode was on the widest part of the muscle belly and the other was on the insertion of the same muscle. Recovery interventions lasted 20 minutes, according to the duration of the E recovery program and to the literature (33).

## Statistical Analyses

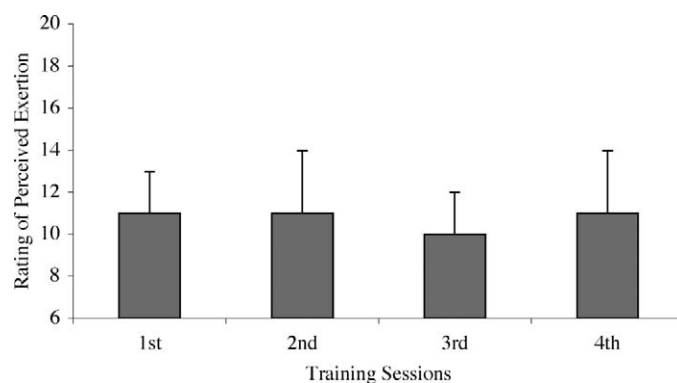
A 0.05 level of confidence was selected throughout the study. A preliminary analysis was performed to verify whether the intensity of the morning training sessions differed throughout the study. Thus, differences in frequencies of occurrence of HR counts during the 4 experimental settings were verified by means of a chi-square test. Furthermore, a preliminary 3 (soccer roles)  $\times$  4 (morning pretraining anaerobic performances) analysis of variance (ANOVA) was applied to ascertain any difference due to soccer roles or training effect. When no differences were found, data were pooled.

To verify the most effective recovery method during the preseason soccer period, the independent variable was the type of recovery (R, D, W, and E) and dependent variables were the perception scales (RPE and RMP) and the anaerobic performances (SJ, CMJ, BJ, and 10-m sprint). The criteria for full recovery were afternoon test performances that achieved at least 97% of the morning pretraining session. An ANOVA for repeated measures with testing time (pre-post) as within-factor and recovery modes (R, W, D, E) as between-factor was applied to jumping and sprint performances. When a significant interaction was obtained, a Tukey post hoc analysis was used to identify differences between means. A 1-factor ANOVA (4 recovery modes) was applied to RPE and RMP dependent variables.

## RESULTS

No significant difference was found for morning performances or soccer roles. Thus, data were pooled and further analysis was allowed. During the morning trainings, the percentages of total time spent at exercise intensities  $\leq 50$ –59, 60–69, 70–79, 80–89, and  $\geq 90\%$  of players' HRmax were  $37.4 \pm 12.5$ ,  $24.3 \pm 7.1$ ,  $26.6 \pm 6.8$ ,  $11.1 \pm 0.8$ , and  $0.7 \pm 2.0\%$  minutes, respectively. Soccer players' RPE of the 4 morning training units (Figure 2) was  $11 \pm 2$ .

No significant difference was found for the 10-m sprint (Table 1) morning ( $1.83 \pm 0.11$  seconds) and afternoon ( $1.82 \pm 0.07$  seconds) training performances and percentages of variations among recovery interventions



**FIGURE 2.** Intensities of the soccer training administered during 4 experimental sessions: means and SD of rating of perceived exertions.

(R:  $99.2 \pm 3.0\%$ ; W:  $99.4 \pm 4.3\%$ ; E:  $100.0 \pm 5.6\%$ ; D:  $104.1 \pm 9.8\%$ ). For the jump tests (Table 2), significant differences ( $F_{(1,84)} = 32.81$ ,  $p < 0.01$ ) were found only between morning and afternoon units; afternoon data always showed better mean values (CMJ: morning =  $33.5 \pm 2.8$  cm, afternoon =  $35.2 \pm 2.3$  cm; SJ: morning =  $32.0 \pm 2.7$  cm, afternoon =  $33.4 \pm 2.8$  cm; BJ: morning =  $29.5 \pm 3.6$  cm, afternoon =  $31.2 \pm 3.4$  cm).

Mean recovery approached 100% for each recovery intervention (Figure 3), with lower percentages for the 10-m sprint. Significant differences among recovery interventions were shown ( $F_{(3,32)} = 5.86$ ,  $p < 0.01$ ) only for leg RMP (Figure 4), where lower values resulted when following D ( $0.6 \pm 0.9$ ) and E ( $0.6 \pm 1.2$ ) than when following W ( $2.1 \pm 1.1$ ) and R ( $2.1 \pm 1.7$ ) modes. However, no muscle pain was ever reported the morning after the experimental sessions.

Because group means and statistical significance might not elucidate the true magnitude of effect of recovery treatments on a single player, the recovery modes also were considered in relation to percentages of success with respect to the number of team members whose afternoon test performances achieved at least 97% of the morning pretraining sessions. Thus, the following data are based only on descriptive statistics. For the SJ, 4 players showed lower afternoon than morning performances (i.e., 82, 91, 95, and 95%, respectively). The most effective recovery intervention result was W, with 100% of the players showing full recovery (R: 83%; E: 92%; D: 92%). For the CMJ, 2 players showed low afternoon performances (i.e., 94 and 96% of their morning performances). All players fully recovered following D and E interventions (W and R: 92% recovered players). For the BJ, 6 players showed low afternoon performances (range, 90–96% of their morning performances). The most effective interventions were R and E, with 92% of players recovering (D and W: 83%). For the 10-m sprints, 6 players showed low afternoon performances (range, 93–96% of their

**TABLE 1.** 10-m sprint test: mean  $\pm$  SD of morning and afternoon training performances and percentages of variations for the 4 recovery modes.

	Morning (s)	Afternoon (s)	Delta (%)
Sitting rest	$1.81 \pm 0.1$	$1.83 \pm 0.1$	$99 \pm 3$
Dry warm-down	$1.88 \pm 0.2$	$1.80 \pm 0.1$	$104 \pm 10$
Water warm-down	$1.81 \pm 0.1$	$1.83 \pm 0.1$	$99 \pm 4$
Electrostimulation	$1.84 \pm 0.1$	$1.84 \pm 0.1$	$100 \pm 6$

**TABLE 2.** Jump tests: mean  $\pm$  SD of morning and afternoon training performances and percentages of variations for the 4 recovery modes.

	Countermovement jump			Squat jump			Bounce jumping		
	Morning (cm)	Afternoon (cm)	Delta (%)	Morning (cm)	Afternoon (cm)	Delta (%)	Morning (cm)	Afternoon (cm)	Delta (%)
Sitting rest	33.6 $\pm$ 2.4	35.1 $\pm$ 3.1	104 $\pm$ 6	31.9 $\pm$ 2.9	33.3 $\pm$ 3.0	104 $\pm$ 7	29.5 $\pm$ 2.5	31.5 $\pm$ 2.5	107 $\pm$ 7
Dry warm-down	34.0 $\pm$ 2.6	34.9 $\pm$ 2.3	103 $\pm$ 4	32.2 $\pm$ 2.6	33.2 $\pm$ 3.2	102 $\pm$ 9	29.5 $\pm$ 2.6	31.3 $\pm$ 4.6	106 $\pm$ 10
Water warm-down	33.2 $\pm$ 3.0	35.7 $\pm$ 1.8	108 $\pm$ 8	32.2 $\pm$ 2.1	34.1 $\pm$ 2.1	105 $\pm$ 3	30.2 $\pm$ 3.5	30.7 $\pm$ 3.6	102 $\pm$ 7
Electrostimulation	33.1 $\pm$ 3.4	34.9 $\pm$ 2.1	106 $\pm$ 7	33.0 $\pm$ 2.6	34.1 $\pm$ 2.1	106 $\pm$ 10	28.7 $\pm$ 3.1	30.2 $\pm$ 3.5	111 $\pm$ 11

morning performances). The most effective interventions were D and R, with 92% of players recovering (W: 83%; E: 75%).

## DISCUSSION

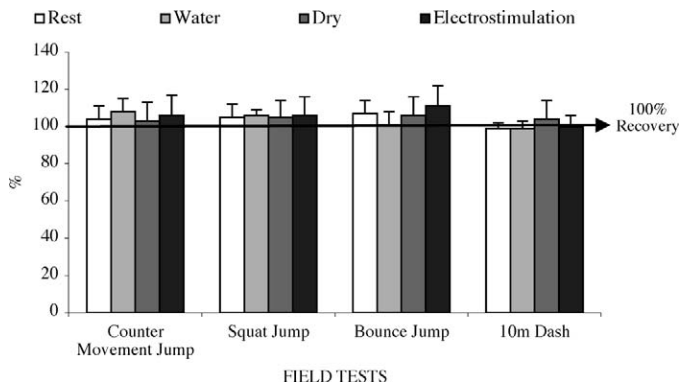
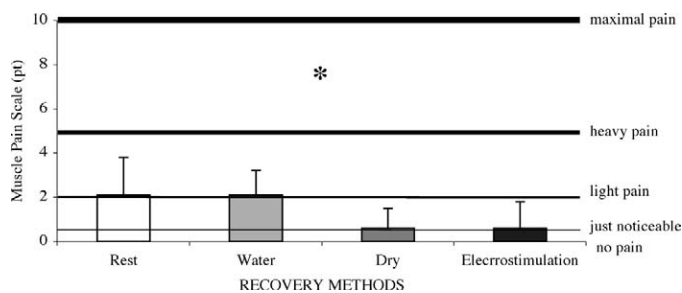
Some authors strongly advise coaches to adopt effective recovery strategies to enhance performance (16, 28, 31) and to avoid the incidence of muscle damage (14), the symptoms of overreaching (19), and the lower limb injuries (45) that result from the high frequency and intensity of training. However, interpretation of the effects of recovery interventions leaves some questions when the experimental conditions and populations differ from the real training of elite athletes (16, 21, 35). In fact, active recovery proved to elicit a significant benefit only on the anaerobic performances of sedentary individuals, whereas athletes maintained their performances after either passive or active recovery (35). Furthermore, it is not clear whether recovery interventions have an impact on the reduction of muscle pain, which is an annoying phenomenon for soccer players and could negatively affect their training.

The present study was designed mainly to explore—without any manipulation of the experimental condition (i.e., eliciting high muscle soreness)—the differences in anaerobic performances and subjective ratings of fatigue in young elite players during their actual preseason training following passive, dry exercise, water exercise, and electrostimulation recovery interventions, mostly used or recommended in soccer (9, 29). In fact, no soccer coach would allow researchers to influence his or her training plan in order to overstress his or her professional players.

The main findings of this study were: (a) passive and active recovery interventions did not induce significant differences in anaerobic performances; (b) there was a tendency toward better afternoon anaerobic performances; and (c) significantly lower muscle pain followed electrostimulation and dry warm-down interventions. How-

ever, this study has 4 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. The second limitation is that when investigating elite soccer training during preseason, training effects or potential adverse reactions might build up from day to day (31, 45). The third limitation is that the observation period was restricted to the preseason, which might be too short to evaluate the effect of recovery interventions over time. In agreement with Kraemer et al. (19), to gain a more complete understanding of the changes that occur during the year-round training it is necessary to monitor soccer players from preseason conditioning to the end of the competitive season. However, it is unfeasible to hypothesize that coaches and professional players will be available for a year-round experimental study, which could interfere with their training program. Instead, the cooperation with the A.S. Roma Calcio presented us with a unique opportunity to collect physiological and performance measurements of young professional soccer players during their actual preseason training. The fourth limitation is that the young age (27) and good athletic condition of the elite players (35), in addition to their very controlled lifestyle, the 5-hour rest between sessions, the well-balanced diet (32, 42, 43), the proper rehydration, and the training program aimed at enhancing soccer performance without overstressing the athletes (19) might have more impact on the recovery process than any of the interventions employed (3).

In this study a standard training was administered for the 4 experimental sessions and the athletes' HR and RPE were used to monitor their training intensity (4, 17). The lack of significant differences among soccer training units for both HR and RPE confirms that the same training load was administered throughout the study. Thus, any observation made should be the direct result of the intervention rather than extraneous factors. The HR was in agreement to that reported for an intense training workload in young professional soccer players (38). However, in this study the participants perceived the inten-

**FIGURE 3.** Percentages of variations of field test performances for the 4 recovery modes.**FIGURE 4.** Means and SD of ratings of perceived muscle pain after the 4 morning training sessions. \*  $p < 0.05$ .

sity of their training as moderate. It might be possible that the elite athletes tended to underestimate the intensity of their soccer training due to its intermittent nature and to their high fitness and skill levels. Furthermore, the fact that low muscle-pain values were always reported was due to several factors: the experimental period was scheduled 1 week after the beginning of the preseason training program when muscle pain is unlikely to occur (31); the coach's plan for the preseason training program distributed the workload so that the morning unit avoided overstressing the athletes; and, as mentioned previously, the young age and high fitness level of the professional players, in addition to the diet planned by a nutritionist in accord with the literature (32, 41, 42) and proper rehydration, might have positively affected the recovery process (3, 22, 44).

Although all-out actions are important in soccer, particularly to gain or to maintain the possession of the ball, the athlete's best performance rarely is observed during preseason, due to the previous detraining and the actual high training volume. In the present study, the 10-m sprint performances did not show any expected diurnal variation (39), were faster than those reported for young professional soccer players (25), and were within the range reported for elite players (6, 37, 39). Jump performances were lower than those reported by Cometti et al. (6) and comparable to those reported by Garganta et al. (13) and Gorostiaga et al. (15) for soccer players. As expected (18), SJ was lower than that resulting from the sequence of eccentric stretch, isometric coupling, and concentric shortening of muscles of CMJ. Obviously, the BJ test reported the lowest mean values due to the technical and biological constraints of the repeated jumping activity. For all the jump tests, the significantly better mean vertical-jump performances shown in the afternoon are probably due to a diurnal effect (5). The lack of significant differences in anaerobic performances between recovery interventions might be due to the fact that the studied variables were not sensitive enough to address changes in the recovery process or that other recovery interventions might be more effective.

In the literature, both the performance ability of elite ice hockey players (21) and the blood biochemistry of rugby players (40) were unaffected by active recoveries (cycling and water exercise, respectively) when compared with passive recovery, even though athletes felt more recovered after active interventions. Actually, the potential for psychological factors influencing the individual's performance is crucial for coaches. Despite the low muscle-pain scores reported in this study, significantly lower mean subjective ratings were found following electrostimulation and dry warm-down interventions, indicating that these recovery modes could represent valuable aids for muscle recovery to improve the player's attitude toward training (20), which otherwise could be hampered by muscle soreness. However, further investigations are needed to understand the beneficial effect of these recovery interventions on the psychological state of the athlete.

Overall, this study demonstrates that when compared with passive recovery, electrostimulation and active recovery interventions between 2 daily soccer trainings do not assist in the maintenance of anaerobic performances of elite players. However, rather than group mean values, coaches might be more interested in the specific effect of a recovery intervention on a particular athlete, especially when small increases in a single athlete's capabilities can have a relevant impact on performance within a compe-

tion. When the consequences on recovery interventions on maintenance of anaerobic performances in a subsequent training session were considered, more players failed to recover their 10-m sprints and the BJ morning performances ( $n = 6$ ). Furthermore, the SJ test was affected to a greater extent by fatigue (range of underrecovery = 82–95%). In fact, concentric contractions are more affected than eccentric contractions by the loss of the force-generating properties of the contractile components, and the stretch-shortening cycle possibly attenuates the detrimental performance effects associated with exercise-induced muscle damage (34). Although Rodacki et al. (34) showed that active individuals executed the vertical jump relying on the same preprogrammed muscle stimulation patterns before and after fatigue and claimed that continuous practice under fatigue likely produces differences in control reorganization to prevent potential disruption of the movement pattern, Pinninger et al. (26) reported that soccer players change muscle stimulation and segmental movement patterns when sprinting under fatigue. Because sprinting is more likely to be performed repeatedly under fatigue conditions during soccer training than jumping is, this test might elucidate better the soccer player's underrecovery. Interesting to note, different percentages of player's full recovery were shown following the 4 considered recovery interventions, indicating that different athletes might benefit from different recovery modes. These results underscore the necessity to implement individualized recovery interventions within the training program.

Surely, the underlying mechanisms of recovery following soccer training in elite players remain debatable and further studies are necessary. However, the data reveal positive effects of different recovery interventions on the rating of muscle pain, thus enhancing the athlete's working attitude toward training.

## PRACTICAL APPLICATIONS

During the few weeks of preseason soccer training, a higher training volume is administered, which could elicit acute psychological, physiological, and performance impairments. Thus, coaches should make efforts to monitor the recovery status of their athletes, using both performance variables and subjective evaluations of fatigue (RPE and muscle pain). In this regard, different recovery interventions currently in use could be of some help. In fact, although no significant differences in anaerobic performances were reported in this study, electrostimulation and low-intensity dry-aerobic activity were more beneficial for reducing muscle pain. A lower perception of muscle soreness could have a positive effect on the player's work attitude during subsequent training sessions. Even though soccer is a team sport, training also should include individualized phases. Because the effectiveness of the studied recovery interventions showed a high inter-individual variability, it is advisable for coaches to make use of different recovery strategies with different players. Coaches also should give consideration to appropriate diet, rehydration, and a controlled lifestyle, which per se might represent a sufficient recovery intervention in young elite athletes.

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### Acknowledgments

The authors would like to express their gratitude to A.S. Roma Calcio, its “Primavera” players, and coach Guido Ugolotti for their support when carrying out the experimental sessions. A special thanks to Federico Gori of Microgate Italia for his generous use of the Optojump and Polifemo photocells for data collection. This study received financial support only from IUSM of Rome.

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