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Human Kinetics
ORIGINAL INVESTIGATION

Morning Priming Exercise Strategy to Enhance Afternoon Performance in Young Elite Soccer Players

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Purpose: To compare the effects of different modalities of morning priming exercise on afternoon physical performance with the associated hormonal and psychophysiological responses in young soccer players. ***Methods:*** In a randomized counterbalanced crossover design, 12 young soccer players completed 3 different morning conditions on 3 different days: repeated-sprint running (6 × 40 m), easy exercise (4 × 12 fast half squats, 6 speed ladder drills, and 20-m sprints), and control (no exercise). Blood testosterone and cortisol concentrations were assessed upon arrival (approximately 8:30AM) and approximately 5 hours and 30 minutes later. Body temperature, self-reported mood, quadriceps neuromuscular function (maximal voluntary contraction, voluntary activation, rate of torque development, and twitch contractile properties), jump, and sprint performance were evaluated twice per day, while rating of perceived exertion, motivation, and the Yo-Yo Intermittent Recovery level 2 (IR2) tests were assessed once per day. ***Results:*** Compared with the control, repeated-sprint running induced a possible positive effect on testosterone (+11.6%) but a possible to very likely negative effect on twitch contractile properties (−13.0%), jump height (−1.4%), and Yo-Yo IR2 (−7.1%). On the other hand, easy exercise had an unclear effect on testosterone (−3.3%), resulted in lower self-reported fatigue (−31.0%) and cortisol (−12.9%), and had a possible positive effect on the rate of torque development (+4.3%) and Yo-Yo IR2 (+6.5%) compared with the control. ***Conclusions:*** Players' testosterone levels were positively influenced by repeated-sprint running, but this did not translate into better physical function, as both muscular and endurance performance were reduced. Easy exercise seemed to be suitable to optimize the physical performance and psychophysiological state of young soccer players.

Keywords: delayed potentiation, match day, readiness, team sport

Soccer match days anecdotally include light activities in the morning when the kickoff occurs in the late afternoon or evening. Indeed, due to the reluctance of coaches and athletes to perform high-intensity exercise on a game day, light physical and technical-tactical exercises are usually preferred to avoid fatigue.[1] Despite this common practice, there seems to be a lack of evidence regarding its usefulness and benefits on physical performance during the match, which is characterized by a multitude of energy-demanding events (high-intensity running, accelerations, decelerations, sprints, tackles, changes of direction, and jumps) interspersed with less intense actions.[2]

The effect of these so-called priming activities performed some hours before performance has already been investigated in several sports, with contradictory results regarding their effectiveness and suitable exercise type.[1,3–8] Semiprofessional rugby players had better sprint, jump, and strength performance 6 hours after heavy strength-training exercises conducted in the morning.[4] Furthermore, a study on elite rugby players reported that repeated-sprint running (RSR: 6 × 40 m with 20 s of recovery) was an effective priming strategy to improve afternoon sprint performance.[5] In contrast, young elite rugby 7's players showed no improvement in sprint ability 2 hours after a 30-minute session consisting of accelerations, small-sided games, and 2 × 50-m maximal sprints.[7] Similarly, amateur soccer players who completed small-sided games and repeated sprints at different intensities in the morning showed no differences in a football-specific endurance test performed in the afternoon.[8] However, to our knowledge, no studies have examined the effect of morning activity on afternoon performance in young elite soccer players.

In these previous studies, performance enhancements following high-intensity morning exercise were mainly ascribed to an attenuated circadian decline of testosterone.[1,4,5] The level of testosterone in the blood normally displays a circadian profile, with an early morning peak and a subsequent decrease during the day.[9] Testosterone has a substantial influence on skeletal muscle contractile function[10] and motor cortex output facilitation,[11] but also on mental aspects, such as motivation[12] and confidence to compete.[6] As a result, the level of testosterone was found to be related to different expressions of strength and power and also to physical performance.[1,6] However, factors other than testosterone concentration could also be responsible for the performance improvements detected in the afternoon following morning priming exercise,[5] and thus, strict monitoring of psychophysiological variables such as mood, motivation, body temperature,[6] cortisol levels,[9] and neuromuscular function[9] is warranted.

The purpose of this study was to investigate the priming effect induced by different exercise protocols in young elite soccer players. More specifically, we aimed to determine the type of exercise that could best fit the need of the prematch period, while also investigating the psychophysiological mechanisms potentially underlying the priming effect. Beside the RSR protocol,[5] which has already been shown to be effective in other team sports but somehow difficult to propose in a real soccer pregame scenario, we

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investigated the effect of an easy (EASY) exercise protocol that is mainly focused on explosive strength/power, with no/light loads and minimal equipment. Anecdotally, EASY exercise is already used by some strength and conditioning coaches in the pregame morning, as it is believed to promote the priming effect with no resulting fatigue; however, this speculation still needs to be confirmed with controlled research studies. Considering its applicability and the absence of information on its effects, we included this condition in the present research and we hypothesized that EASY exercise performed in the morning, besides being less demanding than RSR, could positively affect afternoon performance in young elite soccer players.

Methods

Design

A randomized, counterbalanced crossover design was implemented for this study, which was conducted immediately after the end of the first half of the season. Familiarization with all the test procedures took place before the beginning of data collection. Players completed 3 different morning protocols (RSR, EASY, and control [CON]) on 3 different days, separated by at least 48 hours of recovery. The sequence of the exercise was established a priori using a randomization plan (http://www.randomization.com). The participants underwent the same test battery to assess hormone levels, body temperature, mood, quadriceps neuromuscular function, jump, and sprint performance both in the morning and in the afternoon of each day, while the rate of perceived exertion (RPE), motivation, and endurance performance were assessed only once per day (Figure 1). All the evaluations were conducted in the same indoor gym at the same time of the day to minimize possible circadian-related effects. Moreover, the same controlled dietary intake was adopted during the days of the tests, and the subjects were asked to avoid physical activity and caffeine intake in the 24 hours preceding each condition and during the data collection.

Subjects

A total of 12 young male soccer players (age = 17 [1] y, height = 1.78 [0.06] m, mass = 69 [4] kg, playing position: 3 defenders, 4 midfielders, 5 strikers) from an Italian Serie A club participated in this study. All of them had at least 6 years of experience in playing soccer at the competitive level. They were used to training 5 times per week and playing 1 match per week during the competitive season. Before starting the data collection, the players were asked to complete the questionnaire of Horne and Östberg Self-Assessment version[13] to assess if their chronotypes were "intermediate" (n = 10), "moderate morning" (n = 1), or "moderate evening" (n = 1). The players or the parents of the underage players provided written informed consent before participating in the study. The study was approved by the Independent Institutional Review Board of Mapei Sport Research Center according to the Declaration of Helsinki. All the subjects were free from injury and illness at the time of the study.

Exercise Conditions

In the RSR condition, the players performed 6 all-out shuttle sprints over a distance of 20 + 20 m, with a 180° change of direction and 20 seconds of recovery between each sprint.[5,14] In the EASY condition, the players completed 4 × 12 fast half squats with an overload of 10 kg (weight disc plate; TechnoGym, Cesena, Italy), performed as fast as possible, with 20 seconds of recovery between each set. Immediately after, they performed 6 × 5-m speed ladder drills followed by all-out shuttle sprints over a distance of 10 + 10 m, with a 180° change of direction and 20 seconds of recovery. No morning exercise was undertaken in the CON condition, and the players were instructed to avoid physical activity after the tests conducted in the morning.

Measurements

Hormone Levels and Body Temperature. Blood testosterone and cortisol concentrations were assessed upon arrival. Blood collection and sample management were carried out following

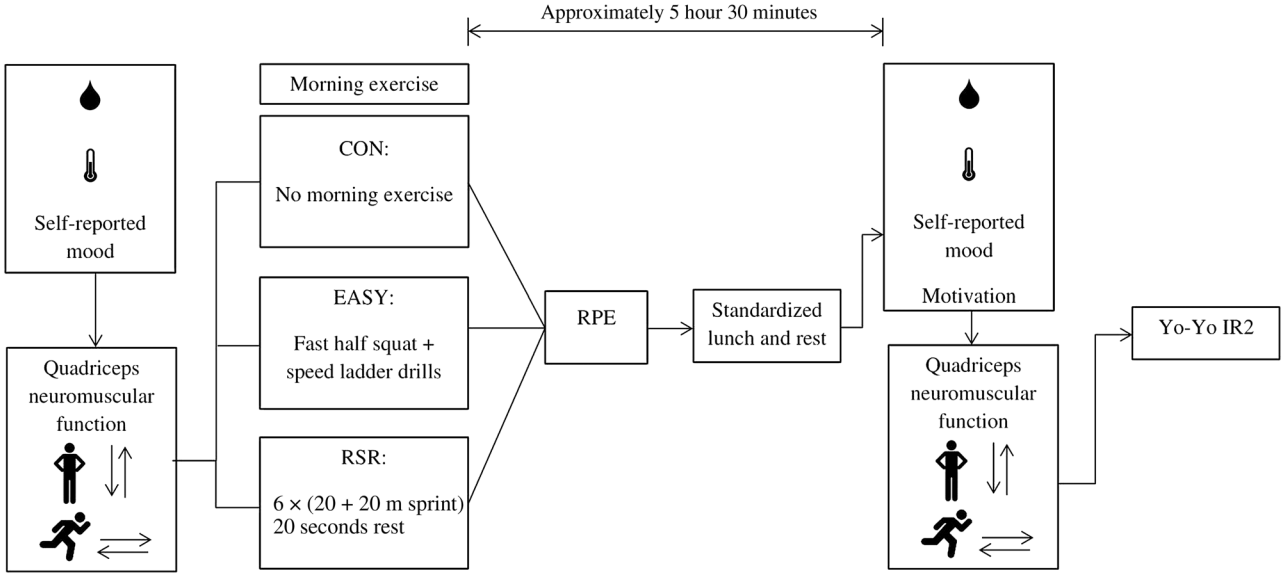

Figure 1 — Schematic representation of the study protocol. indicates blood samples; , ear temperature; , countermovement jump; , sprint; CON, control; EASY, easy exercise; RSR, repeated-sprint running; RPE, rating of perceived exertion; Yo-Yo IR2, Yo-Yo Intermittent Recovery level 2 test.

laboratory practice for the preanalytical phase of sports biochemistry and hematology tests.[15] Blood was drawn from the athletes via venipuncture in the antecubital vein early in the morning, just after wake-up (approximately 08:30 AM) and later in the afternoon. The samples were collected into 8-mL plastic serum gel tubes (Vacutest Kima S.R.L., Arzergrande, Italy) that were allowed to clot for 30 minutes and then were spun at 3000 g for 10 minutes at room temperature. Within 2 hours, the serum was aliquoted into 1.5-mL plastic cryogenic tubes and frozen at −20°C for no more than 3 months, until analysis. After thawing, all samples were assayed in the same analytical run on the Centaur XP automated analyzer (Siemens Healthineers AG, Munich, Germany) using the dedicated chemiluminescence immunoassay kits. Siemens centaur cortisol and testosterone assays are competitive immunoassays that use direct chemiluminescent technology (coefficient of variation were 4.0% for cortisol and 4.7% for testosterone).

Body temperature was assessed with an infrared aural thermometer (Braun Thermoscan IRT 4520; Braun, South Boston, MA).[16] Three measurements per side were conducted, and the mean temperature of the 6 measurements was retained.

Quadriceps Neuromuscular Function. Quadriceps neuromuscular function (right side) was evaluated in isometric conditions, with the subject comfortably seated on the chair of a custom-developed dynamometer. The dynamometer consists of a modified leg extension machine equipped with a load cell (range: 0–500 daN, sensitivity: 2.008 mV/V, S500; Studio AIP Srl, Varese, Italy) connected to a data acquisition system (BIOPAC MP 100; BIOPAC System, Inc, Santa Barbara, CA). The force signal was amplified, filtered, converted to torque using the lever arm length (0.4 m), and subsequently stored into a personal computer (sampling rate: 1000 Hz) using a dedicated software. The knee joint was positioned at 90° of flexion, and the trunk–thigh angle was approximately 100°. The lever arm of the dynamometer was strapped to the leg above the lateral malleolus via Velcro straps.

The assessments consisted of a series of voluntary and/or electrically-stimulated contractions of the knee extensor muscles for the quantification of maximal voluntary contraction (MVC) torque, voluntary activation, voluntary rate of torque development (RTD), and doublet contractile properties. The subjects were first familiarized with electrical stimulation procedures, and supramaximal current intensity was carefully and individually determined using a common procedure.[17] Transcutaneous electrical stimuli (pulse duration: 1 ms) were delivered using a constant-current stimulator (Digitimer DS7AH; Digitimer Ltd, Hertfordshire, United Kingdom) connected to 2 self-adhesive electrodes (femoral triangle-gluteal fold configuration). The players completed a standardized warm-up consisting of 3 voluntary contractions of 5 seconds at 25%, 50%, and 75% of their estimated MVC torque. They were then asked to perform two 5-second MVC separated by 2-minute rest periods, without any concern for the RTD. Supramaximal paired stimuli were manually delivered 2 to 3 seconds after the onset of the contraction to evoke a superimposed doublet response, and then at rest, 1 to 2 seconds after each MVC, to evoke a potentiated doublet response.[18] MVC torque was defined as the highest torque attained either before or after the superimposed response. The peak torque associated to the superimposed and resting doublet responses were used to estimate voluntary activation according to the formula of Allen et al.[19] We also quantified the following contractile properties from the resting doublet response: doublet peak torque, RTD, and rate of torque relaxation. RTD and rate of torque relaxation were calculated as the highest slope of the torque–time curve during the contraction and relaxation phase, respectively. For all the variables, the best of the 2 trials was retained. Finally, voluntary RTD was quantified according to recent guidelines.[20] Briefly, the subjects were asked to perform 5 "as fast and hard as possible" short contractions (approximately 1 s) separated by approximately 30 seconds, with strong verbal encouragement. Any contraction not attaining at least 80% of the MVC torque or with an evident countermovement was discarded.[20] The average RTD of the 3 best contractions was retained.

RPE, Self-Reported Mood, and Motivation. The RPE was assessed with the Borg CR10 scale at the end of the morning sessions, as an indicator of overall load.[21] The Brunel Mood Scale (BRUMS)[22] was used to assess mood both in the morning and in the afternoon, before the beginning of the assessments and after the blood samples. Even though the BRUMS contains 6 subscales (anger, confusion, depression, fatigue, tension, and vigor), with 4 items per subscale, in the present study, we only considered the fatigue and vigor subscales. The items were answered on a 5-point Likert-type scale (0 [not at all], 1 [a little], 2 [moderately], 3 [quite a bit], and 4 [extremely]). Motivation was measured only in the afternoon immediately after the BRUMS, using the validated scales for intrinsic and extrinsic motivation.[23] Each subscale consists of 7 items on a 5-point Likert-type scale, with the same anchor described for the BRUMS. At the end of the last day of data collection, the players were also asked to indicate their preferred protocol (EASY, RSR, and CON). More specifically, they were asked to choose the condition that allowed them to achieve their best performance in the tests of the afternoon, according to a subjective and general feeling.

Jump and Sprint Performance. After a standardized, approximate 5-minute warm-up consisting of low-intensity running, dynamic mobility drills, and 3 countermovement jumps while keeping arms akimbo, the players performed 6 maximal countermovement jumps with arms akimbo separated by approximately 30 seconds on a force platform (sampling rate: 500 Hz, Type 2822A1-1; Kistler Group, Winterthur, Switzerland). The mean of the 3 best values of jump height and peak power output was retained.

After 2 submaximal trials as a warm-up, the players completed 2 all-out shuttle sprints of 20 + 20 m, interspersed with 2 minutes of rest.[2] Running time was measured with a photocells system (Polifemo; Microgate, Bolzano, Italy), with the best sprint time considered as the main outcome. The players were asked to adopt the split-standing starting technique.

Endurance Performance. During the afternoon, the players performed the Yo-Yo Intermittent Recovery level 2 test (Yo-Yo IR2).[24] This test consists of repeated 20-m shuttle runs at a progressively increasing speed controlled by an audio track, with 10 seconds of recovery between each shuttle run. When the participant failed to reach the finishing line twice, the distance covered was recorded. The heart rate data were also collected throughout the test (Polar Team,[2] Kempele, Finland), and the maximal heart rate was retained.

Statistical Analysis

Descriptive results are reported as means (SD). The data analysis was conducted using the magnitude-based decision method with the Hopkins spreadsheet.[25] All data were first log-transformed to reduce bias due to nonuniformity error.[25] The post-only crossover and pre–post crossover were the 2 Excel spreadsheets used to run the statistical analyses.[26] The first spreadsheet was used to compare the data obtained both in the morning and in the afternoon within

every experimental condition and the data collected only once in every experimental condition, while the second spreadsheet was used to compare the differences in the changes between pairs of conditions. The practical significance of the changes was also assessed by calculating the Cohen *d* effect size.[27] The following threshold values were considered for the effect size: 0 to 0.2 = trivial, 0.2 to 0.6 = small, 0.6 to 1.2 = moderate, 1.2 to 2.0 = large, > 2.0 = very large. The magnitude-based decision analyses were conducted using the smallest worthwhile change, which was obtained by multiplying the between-subjects SD by 0.2. The qualitative probabilistic terms were assigned using the following scale: <0.5%, almost certainly not; <5%, very unlikely; <25%, unlikely; 25% to 75%, possibly; >75%, likely; >95%, very likely; >99.5%, almost certainly. The magnitude was considered unclear if the confidence intervals overlapped the positive and negative thresholds.[25,26]

Results

Hormone Levels and Body Temperature

Within-condition variations are reported in Table 1, while standardized differences in the changes between conditions are shown in Figure 2. In all the conditions, a substantial reduction in hormone concentrations was observed from morning to afternoon. The within-day decrease in blood testosterone concentration was *possibly* attenuated in RSR compared with CON and *likely* attenuated in RSR compared with EASY. On the other hand, blood cortisol concentration was *likely* more reduced in EASY compared with CON. Body temperature naturally increased during the day, with no clear differences between the 3 conditions.

Quadriceps Neuromuscular Function

Within-condition variations and standardized differences in the changes between conditions are reported in Table 1 and Figure 2, respectively. Neither MVC torque nor voluntary activation showed any differences within and between conditions. Voluntary RTD was *possibly* improved after EASY and *possibly* decreased after RSR. Voluntary RTD changes were *likely* negative when comparing RSR with EASY. Doublet peak torque was *possibly* improved after CON, while it remained stable following RSR and EASY. Moreover, CON had a *possibly* positive effect on doublet RTD, whereas it remained stable after EASY and was *likely* negatively reduced following RSR. As a consequence, doublet RTD changes were *likely* compared with EASY, *very likely* compared with CON, and negatively reduced after RSR. No substantial changes were detected for doublet rate of torque relaxation within different conditions, and only a *possibly* negative effect was identified after RSR was compared with CON.

RPE, Self-Reported Mood, and Motivation

The RPEs at the end of the morning sessions were *almost certainly* different in the 2 exercise conditions (RSR: 5.03 [1.24]; EASY: 4.29 [0.69]) compared with CON (2.92 [0.79]), and RPE was also *likely* higher after RSR compared with EASY.

When comparing the afternoon to morning BRUMS data, the level of fatigue was *likely* lower only following EASY, while vigor was *possibly* and *likely* lower after CON and EASY, respectively (Table 1). Task-dependent motivation was *likely* lower after RSR compared with CON and EASY, while task-independent motivation was *possibly* higher only following EASY compared with CON

Table 1 Variables Measured in the Morning and in the Afternoon by Condition

	CON		EASY		RSR	
Measurement	**Morning**	**Afternoon**	**Morning**	**Afternoon**	**Morning**	**Afternoon**
Hormone levels and body temperature						
Testosterone, ng·mL^{-1}	6.5 (1.4)	4.2 (1.5)^{d}↓	6.7 (1.3)	4.1 (1.1)^{d}↓	6.1 (1.7)	4.2 (0.9)^{d}↓
Cortisol, ng·mL^{-1}	154 (36)	91 (22)^{d}↓	159 (46)	84 (34)^{d}↓	157 (46)	81 (40)^{d}↓
Ear temperature, °C	36.4 (0.3)	36.7 (0.2)^{c}↑	36.2 (0.3)	36.7 (0.4)^{c}↑	36.5 (0.3)	36.7 (0.3)^{c}↑
Quadriceps neuromuscular function						
MVC torque, N·m	283 (70)	276 (58)	288 (69)	287 (65)	280 (74)	279 (78)
VA, %	87.8 (7.5)	87.1 (8.8)	86.9 (11.1)	85.4 (11.4)	85.8 (9.3)	85.4 (11.2)
Voluntary RTD, N·m^{-1}·s^{-1}	4780 (1386)	4801 (1258)	4786 (1224)	5089 (1419)^{a}↑	4735 (1177)	4508 (1396)^{a}↓
Doublet PT, N·m	68.0 (6.9)	69.3 (6.6)^{a}↑	71.3 (7.5)	70.9 (7.9)	70.1 (8.3)	69.4 (8.4)
Doublet RTD, N·m^{-1}·s^{-1}	1602 (331)	1673 (264)^{a}↑	1675 (272)	1765 (503)	1677 (246)	1549 (275)^{b}↓
Doublet RTR, N·m^{-1}·s^{-1}	1029 (314)	1039 (308)	1048 (355)	1036 (362)	1037 (355)	994 (310)
Self-reported mood, AU						
Fatigue	2.83 (2.12)	2.75 (1.36)	3.50 (2.47)	2.17 (1.80)^{b}↓	4.17 (3.71)	4.17 (3.13)
Vigor	8.42 (2.75)	7.58 (3.06)^{a}↓	7.92 (2.57)	7.08 (3.82)^{b}↓	7.42 (2.94)	7.17 (3.16)
Jump and sprint performance						
CMJ height, cm	45.7 (2.8)	46.5 (3.5)^{a}↑	45.7 (3.6)	46.3 (4.4)^{a}↑	45.2 (4.0)	45.4 (3.9)
CMJ PPO, W·kg^{-1}	53.1 (5.4)	54.1 (4.6)^{a}↑	53.0 (5.4)	54.5 (5.4)^{b}↑	53.3 (6.1)	53.4 (5.8)
Sprint time, s	7.10 (0.17)	7.04 (0.22)^{a}↓	7.13 (0.19)	7.05 (0.20)^{b}↓	7.15 (0.20)	7.06 (0.18)^{b}↓

Abbreviations: CMJ, countermovement jump; CON, control; EASY, easy exercise; MVC, maximal voluntary contraction; PPO, peak power output; PT, peak torque; RSR, repeated-sprint running; RTD, rate of torque development; RTR, rate of torque relaxation; VA, voluntary activation. Note: Data are presented as mean (SD). According to magnitude-based decision, differences from morning were rated as follows: [a]possibly, [b]likely, [c]very likely, [d]almost certain, ↑ higher, ↓ lower, compared with the same condition in the morning.

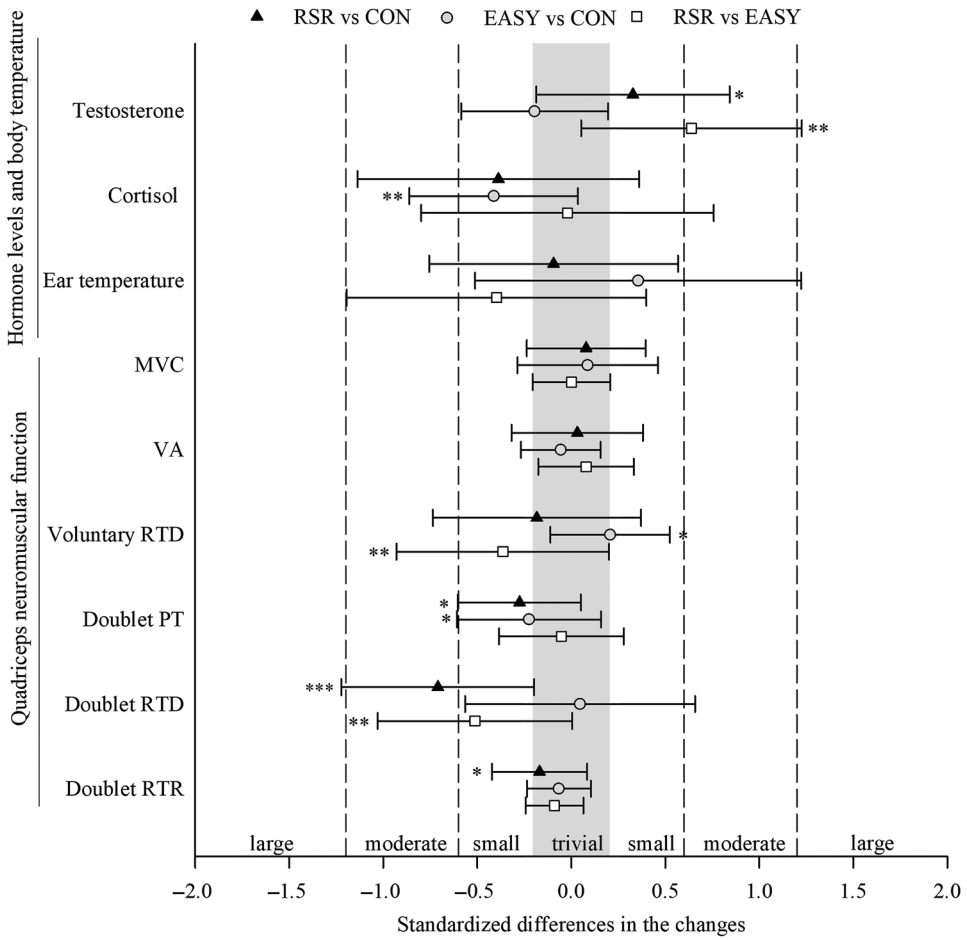

Figure 2 — Standardized differences between afternoon versus morning changes among the different conditions and relative 90% confidence limits for blood parameters, temperature, and self-reported mood (fatigue and vigor). CON indicates control; EASY, easy exercise; MVC, maximal voluntary contraction; PT, peak torque; RSR, repeated-sprint running; RTD, rate of torque development; RTR, rate of torque relaxation; VA, voluntary activation. *Possibly, **likely, ***very likely.

(Table 2). Most of the players (n = 9) subjectively rated EASY as the condition they preferred (n = 2 for RSR and n = 1 for CON).

Jump, Sprint, and Endurance Performance

Jump height and peak power output were *possibly to likely* increased following CON and EASY (Table 1). However, the differences between conditions were trivial to small (Figure 3). Sprint performance was *possibly to likely* improved in all the experimental conditions (Table 1), with trivial differences between pairs of conditions (Figure 3).

A *possibly* longer distance was reached in Yo-Yo IR2 following EASY compared with CON, with a *possibly* higher maximal heart rate recorded during the test (Table 2). Furthermore, the Yo-Yo IR2 distance after RSR was *possibly* lower compared with CON and *very likely* lower compared with EASY (Table 2).

Discussion

The main findings of the present study were that RSR exercise performed in the morning had a somehow detrimental effect on afternoon physical performance in young elite soccer players, while the EASY priming exercise seemed to positively influence afternoon performance.

The RSR priming exercise was previously found to attenuate the circadian testosterone decline, which typically occurs in the afternoon.[5] However, the effect in the present group of young soccer players was less notable compared with this previous study[5] (testosterone decline was approximately 31% vs approximately 12% in our study). This can be partially explained by interstudy differences in the mean age and training level of the participants.[5] In fact, testosterone levels have already been found to be better related with performance in subjects with relatively high strength levels.[28] Even if maximal voluntary strength of the knee extensor muscles was not affected in our present study, RSR negatively impacted voluntary RTD (ie, explosive strength) and led to some signs of peripheral fatigue (as doublet RTD was impaired), at least for the quadriceps muscle. Furthermore, it is possible that neuromuscular fatigue of the knee extensors caused by RSR prevailed over the positive effects, resulting from the attenuated reduction in testosterone levels. However, it is difficult to discuss these findings in relation with other studies because no neuromuscular evaluations were previously conducted.

Although rugby players showed an increase in vertical jump height (approximately 4%) following RSR,[5] we did not observe

Table 2 Variables Measured in the Afternoon by Condition

Measurement	CON	EASY	RSR	RSR vs CON	EASY vs CON	RSR vs EASY
Motivation, AU						
Task-dependent motivation	11.8 (6.4)	12.2 (7.0)	10.0 (7.5)	–0.26 (0.30)[b]↓	0.05 (0.33)	–0.31 (0.35)[b]↓
Task-independent motivation	20.3 (4.5)	21.0 (4.8)	20.5 (3.7)	0.05 (0.26)	0.16 (0.15)[a]↑	–0.10 (0.30)
Endurance performance						
Distance covered, m	693 (162)	740 (162)	650 (173)	–0.25 (0.39)[a]↓	0.27 (0.35)[a]↑	–0.52 (0.33)[c]↓
Maximal heart rate, bpm	191 (9)	192 (9)	189 (10)	–0.12 (0.56)	0.17 (0.14)[a]↑	–0.29 (0.46)[a]↓

Abbreviations: AU, arbitrary units; bpm, beats per minute; CON, control; EASY, easy exercise; RSR, repeated-sprint running. Note: Data are presented as mean (SD). According to magnitude-based decision, differences were rated as follows: [a]possibly, [b]likely, [c]very likely, ↑ higher, ↓ lower. Effects sizes are reported with 90% confidence limits.

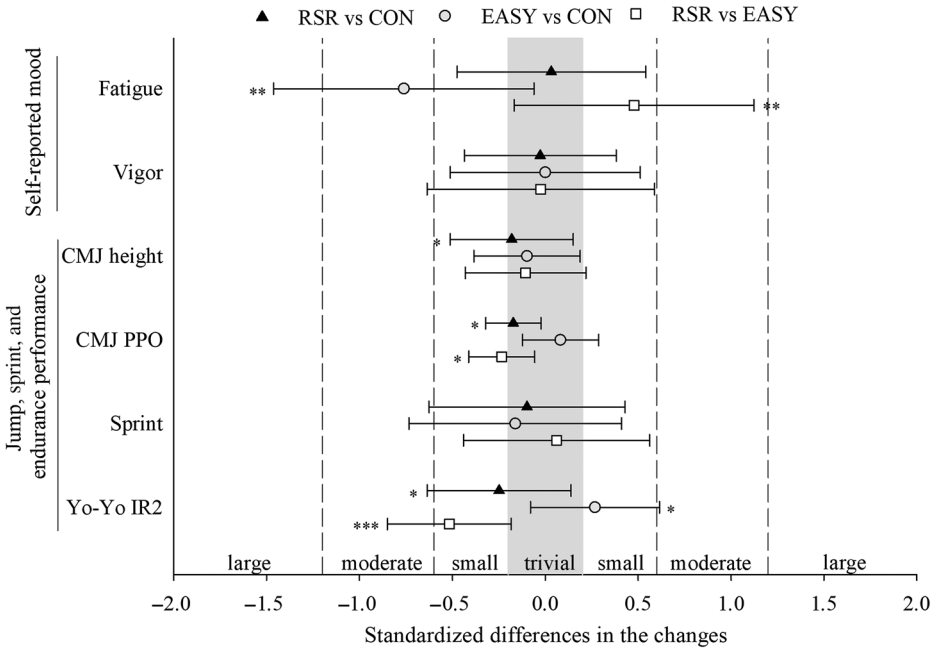

Figure 3 — Standardized differences between afternoon versus morning changes among the different conditions and relative 90% confidence limits for maximal voluntary contraction, voluntary activation, peak torque, rate of torque development, rate of torque relaxation, CMJ, and PPO. CMJ indicates countermovement jump; CON, control; EASY, easy exercise; PPO, peak power output; RSR, repeated-sprint running. *Possibly, **likely, ***very likely.

the same result in our group of young soccer players, perhaps due to fatigue. Conversely, the lack of decrement in sprint performance following RSR could be ascribed to the specificity of the task, since priming activity has been suggested to be specific to the characteristics of the subsequent performance.[1,3,4] In fact, RSR negatively impacted vertical jump and intermittent running endurance (Yo-Yo IR2) performance but not the sprinting task. The shorter Yo-Yo IR2 distance detected following RSR was likely due to neuromuscular fatigue of the knee extensors[29] and/or low motivational levels.[12]

The longer Yo-Yo IR2 distance covered in the EASY condition might be ascribed to higher motivational levels, reduced cortisol levels (likely indicating lower stress levels[9]), and enhanced quadriceps contractile properties (as witnessed by doublet RTD results). All together, these changes, accompanied by the absence of neuromuscular fatigue of the knee extensors, may have contributed to a better muscular and overall attitude to perform. As suggested by the differences in RPEs between the conditions, the effort associated to EASY could not have not been intense enough to elicit an effect on testosterone, whose levels have already been shown to increase following high-intensity exercise.[1] It is therefore remarkable that, subjectively, the players preferred the EASY exercise modality, suggesting a potential and powerful placebo effect affecting afternoon physical activity. Taken as a whole, the results of our current study suggest that an exercise protocol like EASY, performed in the morning, could be a good strategy to optimize afternoon performance in young elite soccer players, as it resulted in better overall outcomes than no exercise. On the other hand, RSR exercise seemed to be too demanding to promote specific performance enhancements in the afternoon.

The present study has some limitations that merit consideration. In this research, testosterone was not measured through saliva samples, which have already been shown to be more sensitive to exercise, but with the use of blood samples.[30] The different measurement techniques (saliva vs blood) and forms of testosterone (free vs total) could well have produced different testosterone variations following the same exercise protocol (RSR) in the different studies.[5] However, because total and free testosterone variations have been found to be similar following sprint exercise, similar results might have been expected with these 2 measurements.[31] The performance in the Yo-Yo IR2 test is mainly related to the peak distance of high-intensity running in a 5-minute period during the match.[24] As a consequence, this endurance performance index could not reflect the actual overall demands of a 90-minute football match. Moreover, training sessions and official competitions have different psychological demands. In addition, the daily schedule selected for this research was similar to previous investigations,[3–5] as it could well represent the real scenario of the soccer match day, but we acknowledge that different time intervals could produce different results. Finally, the psychological outcomes of the present study should be carefully considered when preparing a real competition because aspects such as self-reported fatigue, vigor, and motivation may be different on the day of an official match.

Practical Implications

In young elite soccer players, priming exercise performed in the morning could represent a strategy to optimize afternoon performance. In particular, an exercise combination like EASY seems to be effective to enhance physical performance and also players' motivation while avoiding the occurrence of neuromuscular fatigue. It appears particularly important to avoid excessively demanding exercise sessions (such as RSR) on a day game to prevent the occurrence of neuromuscular fatigue and a concomitant impact on self-reported motivation. Furthermore, studies should determine whether these results can be extended to other cohorts of soccer players, including professional and female players.

Conclusions

We investigated the effects of different types of morning exercises on afternoon performance in young elite soccer players. With a time interval of approximately 5 hours 30 minutes between the morning priming activity and the afternoon performance evaluation, the exercise combination that best improved both physical and psychological variables was EASY, since it was less demanding and subjectively better accepted by young soccer players than RSR.

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