Morning priming exercise strategy to enhance afternoon performance in young elite soccer players

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Abstract

Purpose: To compare the effects of different modalities of morning (AM) priming exercise on afternoon (PM) physical performance with the associated hormonal and psychophysiological responses in young soccer players.

Methods: In a randomized counterbalanced crossover-design, twelve young soccer players completed three different AM conditions on three different days: repeated sprint running (RSR, 6x40-m), easy exercise (EASY, 4x12 fast half squats, 6 speed ladder drills, 20-m sprints) and control (CON, no exercise). Blood testosterone and cortisol concentrations were assessed upon arrival (~08:30) and ~5h 30min 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 a day, while rate of perceived exertion, motivation and the Yo-Yo intermittent recovery Level 2 test (Yo-Yo IR2) were assessed once in a day.

Results: Compared to CON, RSR 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 had an unclear effect on testosterone (-3.3%), resulted in lower self-reported fatigue (-31.0%) and cortisol (-12.9%) together with possible positive effect on rate of torque development (+4.3%) and Yo-Yo IR2 (+6.5%) compared to CON.

Conclusions: Players' testosterone levels were positively influenced by RSR, but this did not translate into better physical function as both muscular and endurance performance were reduced. EASY seemed to be suitable to optimize physical performance and psychophysiological state in young soccer players.

Key words: priming exercise, delayed potentiation, soccer match day

Introduction

Soccer's match days anecdotally include light activities in the morning when the kick off 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 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 effectiveness and suitable exercise type[1,3-8]. Semi-professional 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 x 40 m with 20 s of recovery) was an effective priming strategy to improve afternoon sprint performance[5]. In contrast, young elite rugby sevens players showed no improvement in sprint ability 2 hours after a 30-min session consisting of accelerations, small-sided games and 2 x 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 with different expressions of strength and power and also with 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 psycho-physiological 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 pre-match period, while also investigating the psycho-physiological 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 pre-game scenario, we 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 pre-game 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 three different morning protocols (RSR, EASY and control [CON]) on three different days separated by at least 48 h of recovery. The sequence of the exercise was established a priori using a randomization plan (http://www.randomization.com). 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 rate of perceived exertion (RPE), motivation and endurance performance were assessed only once a 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 subjects were asked to avoid physical activity and caffeine intake in the 24 h preceding each condition and during data collection.

Figure 1

Subjects

Twelve young male soccer players (age 17 ± 1 years, 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 competitive level. They were used to train five times and to play one match per week during the competitive season. Before starting data collection, 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 Centre 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, players performed 6 all-out shuttle sprints over a distance of 20+20 m with a 180° change of direction and 20 s of recovery between each sprint[5,14]. In the EASY condition, players completed 4x12 fast half squats with an overload of 10 kg (weight disc plate, Technogym, Italy), performed as fast as possible with 20 s of recovery between each set. Immediately after, they performed 6x5 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 s of recovery. No morning exercise was undertaken in the CON condition, and 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 was carried out following laboratory practice for the pre-analytical phase of sports biochemistry and hematology tests[15]. Blood was drawn from athletes via venipuncture in the antecubital vein, early in the morning just after wake-up (~08:30 AM) and later in the afternoon. Samples were collected into plastic 8-mL serum gel tubes (Vacutest Kima, Arzegrande, Padua, Italy) that were allowed to clot for 30 min, and then spun at 3000 g for 10 min at room temperature. Within 2 hours, 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 six 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 A.I.P., Varese, Italy) connected to a data acquisition system (BIOPAC MP 100; BIOPAC System, Inc., Santa Barbara, CA, USA). 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 in 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 (VA), voluntary rate of torque development (RTD) and doublet contractile properties. 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, Hertfordshire, UK) connected to two self-adhesive electrodes (femoral triangle-gluteal fold configuration). Players completed a standardized warm up consisting of three voluntary contractions of 5 s at 25, 50 and 75% of their estimated MVC torque. They were then asked to perform two 5-s MVC separated by 2-min rest periods, without any concern for the rate of torque development. Supramaximal paired stimuli were manually delivered 2-3 s after the onset of the contraction to evoke a superimposed doublet response, and then at rest, 1-2 s 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 (PT) associated to the superimposed and resting doublet responses were used to estimate VA according to the formula of Allen et al.[19]. We also quantified the following contractile properties from the resting doublet response: doublet PT, RTD and rate of torque relaxation (RTR). RTD and RTR 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 two trials was retained. Finally, voluntary RTD was quantified according to recent guidelines[20]. Briefly, subjects were asked to perform five “as fast and hard as possible” short contractions (~1 s) separated by ~30 s, 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 three best contractions was retained.

Rate of perceived exertion, self-reported mood and motivation

The RPE was assessed with the Borg’s 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 if the BRUMS contains six subscales (anger, confusion, depression, fatigue, tension and vigor), with four items per subscale, in the present study we only considered the fatigue and vigor subscales. Items were answered on a 5-point Likert-type scale (0: not at all, 1: a little, 2: moderately, 3: quite a bit, 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 seven 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, players were also asked to indicate their preferred protocol (EASY, RSR, CON). More specifically, they were asked to choose the condition that allowed them to achieve the best performance in the tests of the afternoon, according to a subjective and general feeling.

Jump and sprint performance

After a standardized ~5-min warm-up consisting of low-intensity running, dynamic mobility drills and three countermovement jumps (CMJ) while keeping arms akimbo, the players performed six maximal CMJ arms akimbo separated by ~30 s on a force platform (sampling rate: 500 Hz, Type 2822A1-1, Kistler, Winterthur, Switzerland). The mean of the three best values of jump height and peak power output (PPO) were retained.

After 2 sub-maximal trials as a warm-up, the players completed 2 all-out shuttle sprints of 20 + 20 m interspersed with 2 min 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, players performed the Yo-Yo Intermittent Recovery Test level 2 (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 s of recovery between each shuttle run. When the participant failed to reach the finishing line twice, the distance covered was recorded. 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 ± standard deviations (SD). Data analysis was conducted using the magnitude-based decision (MBD) method with the Hopkins' spreadsheet[25]. All data were first log-transformed to reduce bias due to non-uniformity error[25]. Post-only crossover and pre-post crossover were the two 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. Practical significance of changes was also assessed by calculating the Cohen's d effect size (ES)[27]. The following threshold values were considered for ES: 0-0.2 trivial, 0.2-0.6 small, 0.6-1.2 moderate, 1.2-2.0 large, >2.0 very large. The MBD analyses were conducted using the smallest worthwhile change (SWC), 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*; 25-75%, *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 hormones concentrations was observed from morning to afternoon. The within-day decrease in blood testosterone concentration was *possibly* attenuated in RSR compared to CON and *likely* attenuated in RSR compared to EASY. On the other hand, blood cortisol concentration was *likely* more reduced in EASY compared to CON. Body temperature naturally increased during the day with no clear differences between the three conditions.

*****Table 1 *****

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 VA 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 PT 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 to EASY and *very likely* compared to CON, negatively reduced after RSR. No substantial changes were detected for doublet RTR within different conditions and only a *possibly* negative effect was identified after RSR compared to CON.

*****Figure 2 *****

Rate of perceived exertion, self-reported mood and motivation

The RPEs at the end of the morning sessions were *almost certain* different in the two exercise conditions (RSR: 5.03 ± 1.24; EASY: 4.29 ± 0.69) compared to CON (2.92 ± 0.79) and RPE was also *likely* higher after RSR compared to EASY.

When comparing 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 to CON and EASY, while task-independent motivation was *possibly* higher only following EASY compared to CON (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).

*****Table 2 *****

Jump, sprint and endurance performance

Jump height and PPO were *possibly to likely* increased following CON and EASY (table 1). However, 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 to 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 to CON and *very likely* lower compared to EASY (table 2).

*****Figure 3 *****

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 EASY priming exercise seemed to positively influence afternoon performance.

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 to this previous study[5] (testosterone decline was ~31% vs. ~12% in our study). This can be partially explained by inter-study differences in 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 (i.e., 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 has 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 (~4%) following RSR[5], we did not observe 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, 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 the 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 two measurements[31]. The performance in the Yo-Yo IR2 test is mainly related to the peak distance of high intensity running in a 5-min period during the match[24]. As a consequence, this endurance performance index could not reflect the actual overall demands of a 90-min football match. Moreover, training sessions and official competitions have different psychological demands. Additionally, 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 bring to 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. Further 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 ~5 h 30 min between morning priming activity and 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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Table 1. Variables measured in the morning and in the afternoon by condition.

Table 2. Variables measured in the afternoon by condition.

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Figure 1. Schematic representation of the study protocol. blood samples, ear temperature, ↑↓ countermovement jump, ⇆ sprint, CON control, EASY easy exercise, RSR repeated sprint running, RPE rating of perceived exertion, Yo-Yo IR2 intermittent recovery level 2 test.

Figure 2. Standardized differences between afternoon vs morning changes among the different conditions and relative 90% confidence limits for blood parameters, temperature and self-reported mood (fatigue and vigor).

Figure 3. Standardized differences between afternoon vs morning changes among the different conditions and relative 90% confidence limits for MVC maximal voluntary contraction, VA voluntary activation, PT peak torque, RTD rate of torque development, RTR rate of torque relaxation, CMJ countermovement jump, PPO peak power output.

Table 1. Variables measured in the morning and in the afternoon by condition.

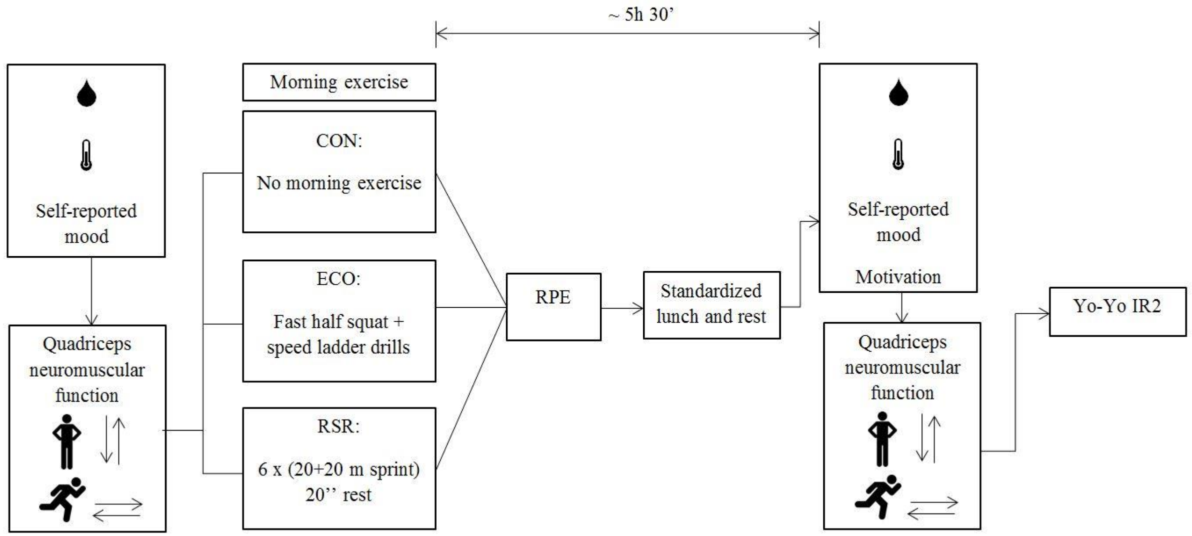
	CON		ECO		RSR	
	Morning	Afternoon	Morning	Afternoon	Morning	Afternoon
Hormone levels and body temperature						
Testosterone (ng·mL^{-1})	6.5 ± 1.4	4.2 ± 1.5****↓	6.7 ± 1.3	4.1 ± 1.1****↓	6.1 ± 1.7	4.2 ± 0.9****↓
Cortisol (ng·mL^{-1})	154 ± 36	91 ± 22****↓	159 ± 46	84 ± 34****↓	157 ± 46	81 ± 40****↓
Ear temperature (°C)	36.4 ± 0.3	36.7 ± 0.2***↑	36.2 ± 0.3	36.7 ± 0.4***↑	36.5 ± 0.3	36.7 ± 0.3***↑
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·s^{-1})	4780 ± 1386	4801 ± 1258	4786 ± 1224	5089 ± 1419*↑	4735 ± 1177	4508 ± 1396*↓
Doublet PT (N·m)	68.0 ± 6.9	69.3 ± 6.6*↑	71.3 ± 7.5	70.9 ± 7.9	70.1 ± 8.3	69.4 ± 8.4
Doublet RTD (N·m·s^{-1})	1602 ± 331	1673 ± 264*↑	1675 ± 272	1765 ± 503	1677 ± 246	1549 ± 275**↓
Doublet RTR (N·m·s^{-1})	1029 ± 314	1039 ± 308	1048 ± 355	1036 ± 362	1037 ± 355	994 ± 310
Self-reported mood						
Fatigue (au)	2.83 ± 2.12	2.75 ± 1.36	3.50 ± 2.47	2.17 ± 1.80**↓	4.17 ± 3.71	4.17 ± 3.13
Vigor (au)	8.42 ± 2.75	7.58 ± 3.06*↓	7.92 ± 2.57	7.08 ± 3.82**↓	7.42 ± 2.94	7.17 ± 3.16
Jump and sprint performance						
CMJ height (cm)	45.7 ± 2.8	46.5 ± 3.5*↑	45.7 ± 3.6	46.3 ± 4.4*↑	45.2 ± 4.0	45.4 ± 3.9
CMJ PPO (W)	3815 ± 420	3946 ± 449**↑	3825 ± 418	3913 ± 413*↑	3853 ± 494	3869 ± 484
Sprint time (s)	7.10 ± 0.17	7.04 ± 0.22*↓	7.13 ± 0.19	7.05 ± 0.20**↓	7.15 ± 0.20	7.06 ± 0.18**↓

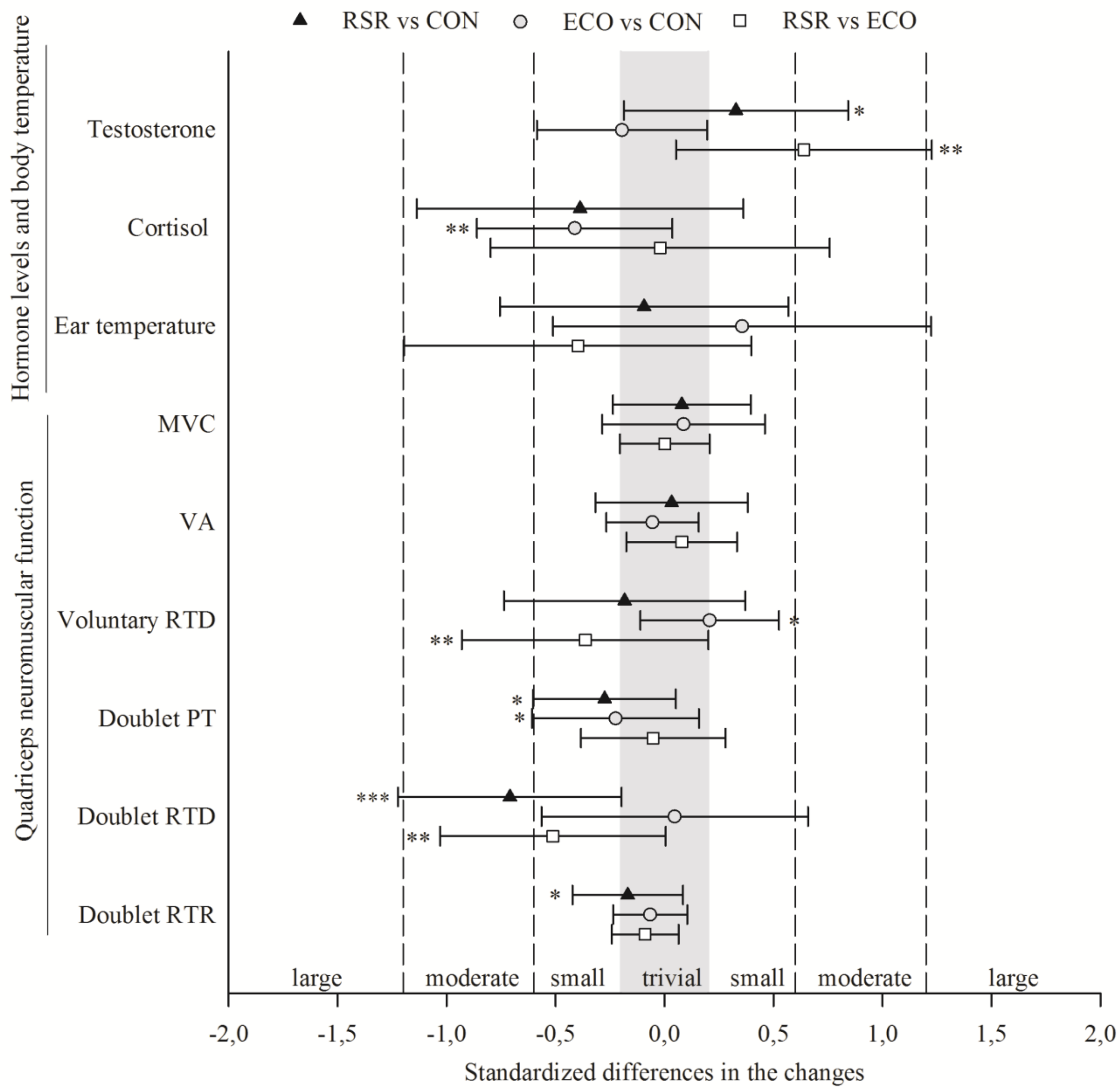
Mean data ± SD. According to Magnitude Based Inference, differences to am were rated as follow: *possibly, **likely, ***very likely, ****almost certain, ↑ higher, ↓ lower, compared to the same condition in the am. CON: control, ECO: ecological, RSR: repeated sprint running, MVC: maximal voluntary contraction, VA: voluntary activation, RTD: rate of torque development, PT: peak torque, RTR: rate of torque relaxation, CMJ: countermovement jump, PPO: peak power output.

Table 2. Variables measured in the afternoon by condition.

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

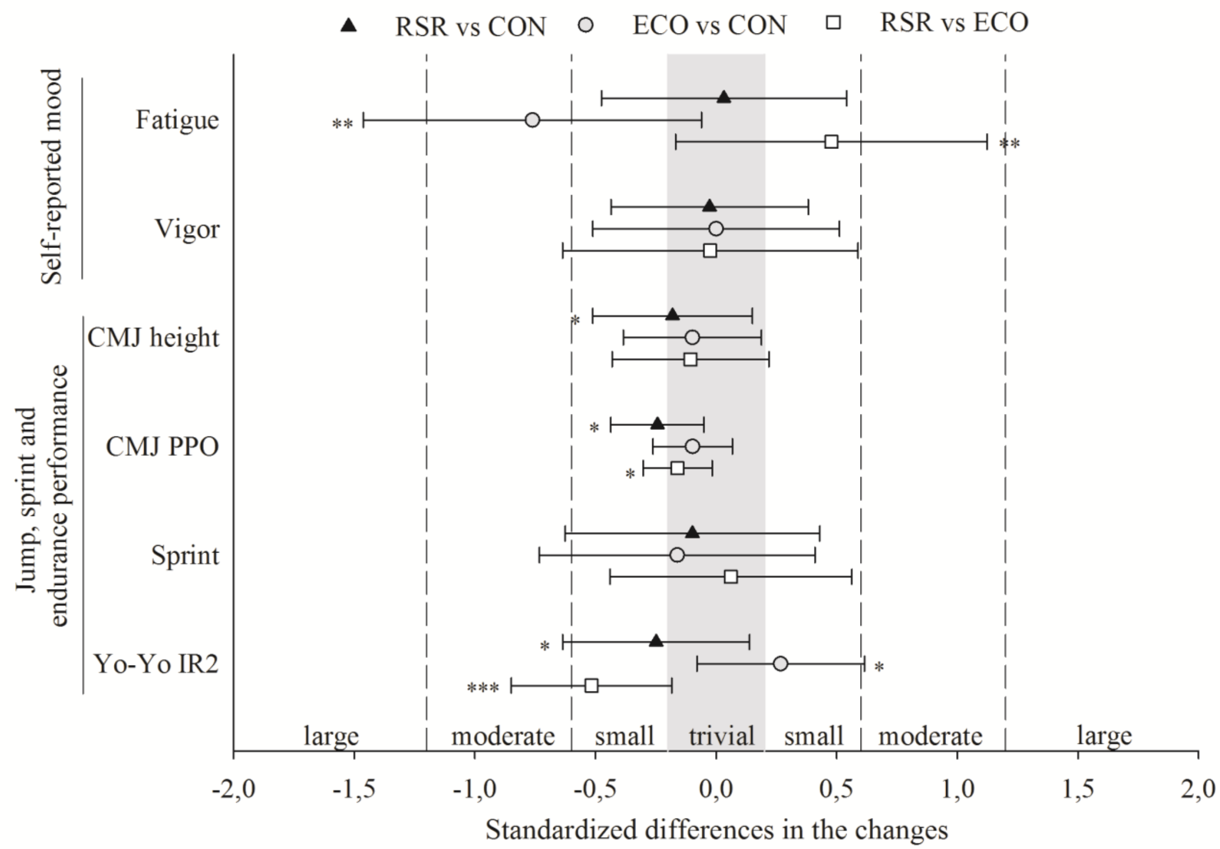
Mean data ± SD. According to Magnitude Based Inference, differences were rated as follow: *possibly, **likely, ***very likely, ****almost certain, ↑ higher, ↓ lower. Effects sizes are reported with 90% confidence limits. RPE: rate of perceived exertion, CON: control, ECO: ecological exercise, RSR: repeated sprint running.


~ 5h 30’
Self-reported mood
Quadriceps neuromuscular function
Morning exercise
CON:
No morning exercise
ECO:
Fast half squat + speed ladder drills
RSR:
6 x (20+20 m sprint) 20’’ rest
RPE
Standardized lunch and rest
Self-reported mood
Motivation
Quadriceps neuromuscular function
Yo-Yo IR2



RSR vs CON
ECO vs CON
RSR vs ECO
Hormone levels and body temperature
Quadriceps neuromuscular function
Testosterone
Cortisol
Ear temperature
MVC
VA
Voluntary RTD
Doublet PT
Doublet RTD
Doublet RTR
large
moderate
small
trivial
small
moderate
large
-2,0
-1,5
-1,0
-0,5
0,0
0,5
1,0
1,5
2,0
Standardized differences in the changes

486


RSR vs CON
ECO vs CON
RSR vs ECO
Self-reported mood
Fatigue
Vigor
Jump, sprint and endurance performance
CMJ height
CMJ PPO
Sprint
Yo-Yo IR2
**
**
*
*
*
*
*
***
large
moderate
small
trivial
small
moderate
large
-2,0
-1,5
-1,0
-0,5
0,0
0,5
1,0
1,5
2,0
Standardized differences in the changes

487