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Research article

Effects and Sustainability of a 13-Day High-Intensity Shock Microcycle in Soccer

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Abstract
The preseason in soccer is a short period of 6-8 weeks where conditional abilities, technical and tactical elements need to be trained. Therefore, time is lacking to perform long term preparation periods for different abilities, especially endurance training. There is evidence that the implementation of high-intensity shock microcycles in preseason training could be one way to improve physical performance in a short period of time. Therefore, the purpose of the present study was to examine the effects and the sustainability of a high-intensity shock microcycle on soccer specific performance. Over 2 weeks, 12 male soccer players (26.1 ± 4.5 years) performed 12 high-intensity training (HIT) sessions in addition to their usual training. Before (pre), 6 days (6d) and 25 days (25d) after training, subjects performed Counter Movement Jump (CMJ), Repeated-Sprint Ability (RSA) test and Yo-Yo Intermittent Recovery Test Level 2 (YYIR2). Mean sprint time (RSA_{Mean}) (cohen's d = -1.15), percentage decrement score (RSA_{Index}) (cohen's d = -1.99) and YYIR2 (cohen's d = +1.92) improved significantly from pre to 6d. 25d after, values showed a significant reduction for YYIR2 (cohen's d = -0.81) and small to moderate but not significant increase for RSA_{Mean} (cohen's d = +0.37) and RSA_{Index} (cohen's d = +0.7) compared to 6d values. Small but no significant increases were found for CMJ (cohen's d = +0.33) and no significant and substantial changes were found for RSA_{Best} (cohen's d = -0.07) from pre to 6d. For competitive soccer players, block periodization of HIT offers a promising way to largely improve RSA and YYIR2 in a short period of time. Despite moderate to large decreases in RSA_{Index} and YYIR2 performance in the 19 day period without HIT, values still remained significantly higher 25d after the last HIT session compared to pre-values. However, it might be necessary to include isolated high-intensity sessions after a HIT training block in order to maintain the higher level of YYIR2 and RSA_{Index} performance.

Key words: Block periodization, high-intensity training, Yo-Yo Intermittent Recovery Test, repeated-sprint ability.

Introduction

Soccer is an intermittent sport with a wide variation of movement patterns. Within these varying loads from high to lower intensities, an average of 70% of maximal oxygen uptake, blood lactate values between 2-10 $mmol \cdot L^{-1}$, a mean intensity close to the anaerobic threshold and distances of 10-12 km are covered during a match (Bradley et al., 2010; Di Salvo et al., 2009; Krustrup et al., 2006; Mohr et al., 2003; Stolen et al., 2005). These values show that the main energy demand is covered by the aerobic energy system. Although, high-intensity periods represent a small portion of the total distance covered, they are believed to be very important for the result of a soccer match (Bradley et al., 2010; Di Salvo et al., 2009). Soccer players have to perform repeated bouts of maximal exercise and need to recover quickly in between. Therefore, a high aerobic capacity is needed (Meckel et al., 2009).

There is evidence that the implementation of high-intensity training (HIT) during preseason conditioning represents a possibility to enhance aerobic capacity (Dupont et al., 2004; Helgerud et al., 2001; Hoff et al., 2002; McMillan et al., 2005; Sperlich et al., 2011; Sporis et al., 2008). In most of these studies, HIT was performed over 6-10 weeks with 2-3 training session per week (Dupont et al., 2004; Helgerud et al., 2001; Hoff et al., 2002; McMillan et al., 2005), but still little is known about the integration of HIT either in daily training sessions or in special focused training blocks.

As the preseason is quite short (6-8 weeks) and conditional abilities, technical and tactical elements need to be integrated, the traditional model of training periodization seems to be unsuitable for elite soccer training and block periodization, including HIT, might be the method of choice (Issurin, 2008). Furthermore, Baar (2006) and Nader (2006) showed that concurrent development of endurance and strength has negative effects on the development of each of the conditional abilities. By using these shock microcycle blocks with highly concentrated specialized workloads, previous studies already showed that it is possible to improve endurance performance/high-intensity running performance (Breil et al., 2010; Christensen et al., 2011; Garcia-Pallares et al., 2010; Mallo., 2011; Wahl et al., 2013). However, only three studies in soccer exist (Christensen et al., 2011; Mallo., 2011; Stöggl et al., 2010), with lacking information on soccer specific performance and especially on the sustainability of performance increases after a high-intensity training block. Therefore, the aim of the present study was to investigate the magnitude of effects and sustainability of a high-intensity shock microcycle according to block periodization in the preseason training of male semi-professional soccer players.

Methods

Subjects

12 healthy male soccer players (mean ± SD: 26.1 ± 4.5 years; 1.80 ± 0.05 m and 78.8 ± 6.5 kg) from a team of the sixth German league participated in the study. All players had more than 10 years of training experiences. Before the training intervention athletes had a break lasting 3 weeks where every player trained individually.

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During the first half of the season weekly training amount was ~6-8 h plus one game per week. All subjects were informed about the aim of the investigation and gave their written consent to participate in the study. The study protocol was performed in accordance with the declaration of Helsinki and the Ethical Committee of the university.

Design

A 13-day HIT shock microcycle, including interval running, dribbling exercises and small-sided games was conducted (Figure 1). Before (pre), 6 days (6d) after training (in order to assure sufficient recovery) and 25 days (25d) after training (in order to test the sustainability) soccer specific tests reflecting the characteristics of high-intensity match periods were carried out (Figure 1). Between the last HIT session and the 6d post diagnostic only technical drills were carried out. Between the 6d diagnostic and the 25d diagnostic normal training without any HIT session was performed. Normal training consisted of 4 training sessions per week (90 min each), with the main focus on technical/tactical drills and game specific variations. The investigation was conducted during the winter preparatory period. All tests were applied outside on a grass field. Athletes were instructed to avoid heavy exercises 24 h before testing.

Methodology

During the shock microcycle players performed 12 additional high-intensity interval sessions with two sessions performed on day 6 and 13 (Figure 1). The HIT sessions were performed as interval running, on a dribbling track or as small-sided games (SSG) all consisting of 4 x 4 min bouts separated by 3 min active recovery. Although, the effectiveness of heart rate (HR) for controlling or adjusting the intensity of a HIT session may be limited for several reasons (Buchheit et al. 2013), we chose the HR to assess the training sessions online mainly due to practicability, especially for the control of SSG and the dribbling track. HR was only measured during the first training session. The other sessions were only controlled online (Acentas, Högertshausen, Germany). If the intended heart rate of 90-95% of the individual maximal heart rate (HRmax) was too low during the online assessment of the intervals, athletes were advised to increase the intensity. To ensure the intended training intensity, the dribbling track was designed according to Hoff et al. (2002) and SSG were modified based on the findings of Hill-Haas et al. (2011). A standardized continuous 10-min warm-up was performed before all HIT sessions in each discipline.

At each of the 3 testing days (pre, 6d, 25d), players performed 3 performance tests. In order to assure constant testing conditions (22°C, 35% humidity), all tests were carried out on an indoor field. Before the tests, participants completed a 15-min warm-up of moderate running, short sprints, and stretching, followed by a 5-min rest. All performance tests were carried out in the same order starting with a Counter Movement Jump (CMJ) (coefficient of variation (CV) = 5.5%) (Marina et al., 2013). Countermovement jump height was assessed from time in flight using an Optojump photocell system (Microgate, Bozen, Italy). Players completed 3 jumps (90-sec break between each jump) using only the best try for further analysis (Brown and Weir, 2001). To assess repeated-sprint ability (RSA) the test of Bangsbo (1994) was chosen (CV = 1.8%) (Wragg et al., 2000). The test protocol consisted of seven 30-m maximum sprints including changes of direction. Following each sprint subjects performed 25 s of active recovery in order to come back to the start. Performance was determined by photoelectric cells (Sporttronic, Leutenbach-Nellmersbach, Germany) measuring best sprint time (RSA_{Best}), mean sprint time (RSA_{Mean}) and the percentage decrement score (RSA_{Index}); Calculation: Fatigue = (100 x (total sprint time / ideal sprint time)) – 100; where total sprint time = Sum of sprint times from all sprints and ideal sprint time = The number of sprints x fastest sprint time. For the assessment of high-intensity running performance, players performed the Yo-Yo Intermittent Recovery Test Level 2 (YYIR2) (CV = 9.6%) (Krustrup et al., 2006). This test consisted of two repeated 20-m runs at a progressively increased speed. Between each running bout subjects had a 10-sec rest period. The YYIR2 ended when subjective exhaustion was reached or the player failed to reach finish line twice in a row and distance covered was recorded (Krustrup et al., 2006). Before the tests, all subjects were familiarized with each of the three testing procedures. To assure that the athletes were able to perform their personal best, recovery time between each of the three tests was given.

Every morning during the shock microcycle players documented changes of person`s perceived physical state (PEPS) using a scale (Kleinert 2006). Subjects were asked to judge spontaneously to what extent 20 given adjectives coincide with their current physical feeling. Each of the four dimensions of the PEPS includes five adjectives: perceived physical energy (e.g., flabby, washed out), perceived physical fitness (e.g., well trained, strong), perceived physical flexibility (e.g., flexible, elastic), and perceived physical health (e.g., sick, injured). Subscale values of the PEPS were computed by a mean-function over all items of the belonging subscale (Kleinert 2006).

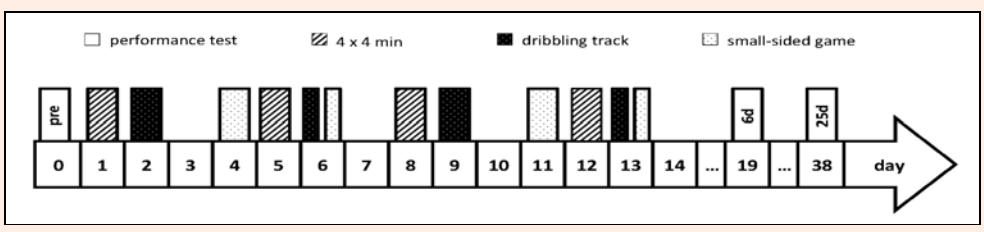

Figure 1. Arrangement of the 12 HIT sessions during the 10-day shock microcycle

Statistical analysis

For all statistical analysis of the data Statistica (Version 7.1, StatSoft Inc., USA) software package for Windows® was used. Descriptive statistics of the data are presented as means ± standard deviation (± SD). To test the two hypotheses, if a 10-day high-intensity shock microcycle improves performance variables of high- intensity match periods of soccer players and if these improvements are maintained without HIT for several weeks, ANOVA repeated-measures with Bonferroni post-hoc test was used. Statistical differences were considered to be significant for $p < 0.05$. Furthermore, the effect size "partial η^{2}" was calculated for the main time effect. The thresholds for small, moderate, and large effects were defined as 0.1, 0.25 and 0.4, respectively. Cohen's effect size (d) was calculated for the comparison of pre to 6d and 6d to 25d values. The thresholds for small, moderate, and large effects were defined as 0.20, 0.50, and 0.80, respectively.

Results

In the first session, athletes reached a mean heart rate of 183 ± 10 bpm which was 93.2 ± 2.6 % of maximal heart rate.

Post-hoc analysis showed no significant changes for CMJ (Figure 2). However, results nearly reached statistical significance from pre to 6d ($p = 0.06$), with small partial η^{2} (0.23) when considering the variations over the 3 testing sessions. Small increases were present from pre-6d (cohen's d = +0.33) and no substantial changes were present from 6d-25d (cohen's d = -0.13).

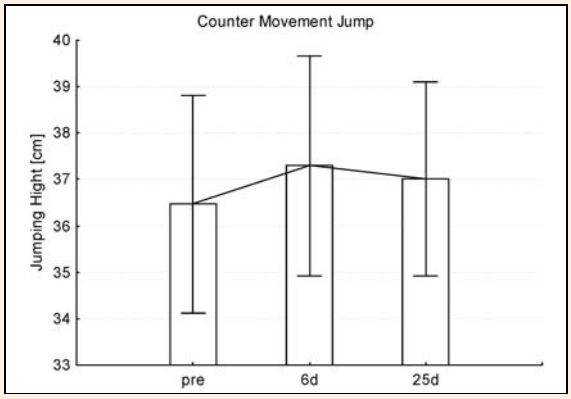

Figure 2. Changes in counter movement jump (CMJ) performance. Cohen's d (pre-6d) = 0.33; Cohen's d (6d-25d) = 0.13. Values are presented as mean ± SD.

For RSA_{Best} over-all ANOVA showed no significant changes over time ($p = 0.24$) (Figure 3a), with small partial η^{2} (0.12) when considering the variations over the 3 testing sessions. No substantial changes were present from pre-6d (cohen's d = -0.07) and from 6d-25d (cohen's d = +0.15).

For RSA_{Mean} (Figure 3b) post-hoc analysis revealed that time significantly decreased from pre to 6d after ($p < 0.001$) and remain significantly decreased 25 d after compared to pre ($p = 0.001$), with large partial η^{2} (0.64) when considering the variations over the 3 testing sessions. Large decreases were present from pre-6d (cohen's d = -1.15) and small increases were present from 6d-25d (cohen's d = +0.37).

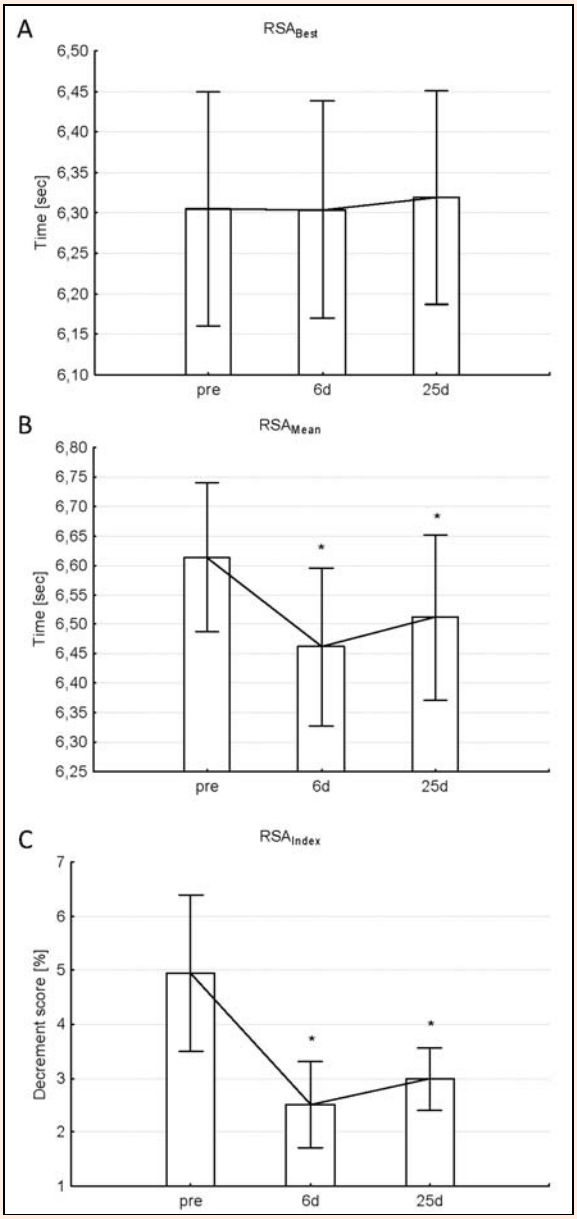

Figure 3. Changes in best sprint time (Repeated-Sprint Ability (RSA_{Best})) (a) Cohen's d (pre-6d) = 0.07; Cohen's d (6d-25d) = 0.15, mean sprint time (Repeated-Sprint Ability (RSA_{Mean})) (b) Cohen's d (pre-6d) = 1.15; Cohen's d (6d-25d) = 0.37 and the fatigue index (Repeated-Sprint Ability (RSA_{Index})) (c) Cohen's d (pre-6d) = 1.99; Cohen's d (6d-25d) = 0.7. * = significantly different to pre ($p < 0.05$). Values are presented as mean ± SD.

For the percentage decrement score (RSA_{Index}) (Figure 3c) post-hoc analysis revealed that fatigue significantly decreased 6d after compared to pre ($p < 0.001$) and remain significantly decreased 25 d after compared to pre ($p < 0.001$), with large partial η^{2} (0.71) when considering the variations over the 3 testing sessions. Large decreases were present from pre-6d (cohen's d = -1.99) and moderate increases were present from 6d-25d (cohen's d =

+0.71).

For YYIR2 post-hoc analysis revealed that the distance covered was significantly increased 6d and 25d after compared to pre (both $p < 0.001$) (Figure 4). However, values significantly decreased from 6d to 25d ($p<0.05$). Large changes were present (partial $\eta^2 = 0.73$) when considering the variations over the 3 testing sessions. Large increases were present from pre-6d (cohen's d = +1.92) and large decreases were present from 6d-25d (cohen's d = -0.81).

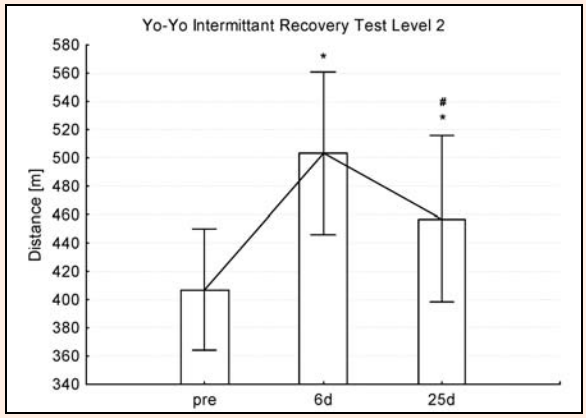

Figure 4. Changes in Yo-Yo Intermittent Recovery Test Level 2 (YYIR2) performance. Cohen's d (pre-6d) = 1.92; Cohen's d (6d-25d) = 0.81. * = significantly different to pre; # = significantly different to 6d ($p < 0.05$). Values are presented as mean ± SD.

No significant and substantial changes were found for the items perceived physical energy, perceived physical flexibility, perceived physical fitness and perceived physical health of the PEPS scale (Figure 5a-d). In addition, no significant and substantial changes in resting heart rate, weight, sleep duration and sleep quality occurred during the high-intensity shock microcycle (Figure 6a-d).

Discussion

The main findings of this investigation are 1) that a 13 day shock microcycle including 12 additional high-intensity sessions largely improved parameters (RSA_{Mean}, RSA_{Index} and YYIR2) that can impact physical performance during critical match periods in soccer and 2) that these improvements sustain on a significantly higher level, even ~ 4 weeks without any further HIT sessions. However, the effect size revealed that the 4 weeks without HIT had moderate to large decreasing effects on performance.

Improvements of the endurance performance of elite soccer players largely depend on training intensity (Baar, 2006; Bangsbo et al., 2006; Iaia et al., 2009). However, the analysis of 504 training sessions of the preseason in soccer revealed that only 8% of the training time was high-intensity exercise (>HR 4 mmol·L^{-1} blood lactate) (Castagna et al., 2011). An increase of training intensity can be realized by the implementation of HIT sessions, but still little is known about its periodization. In the

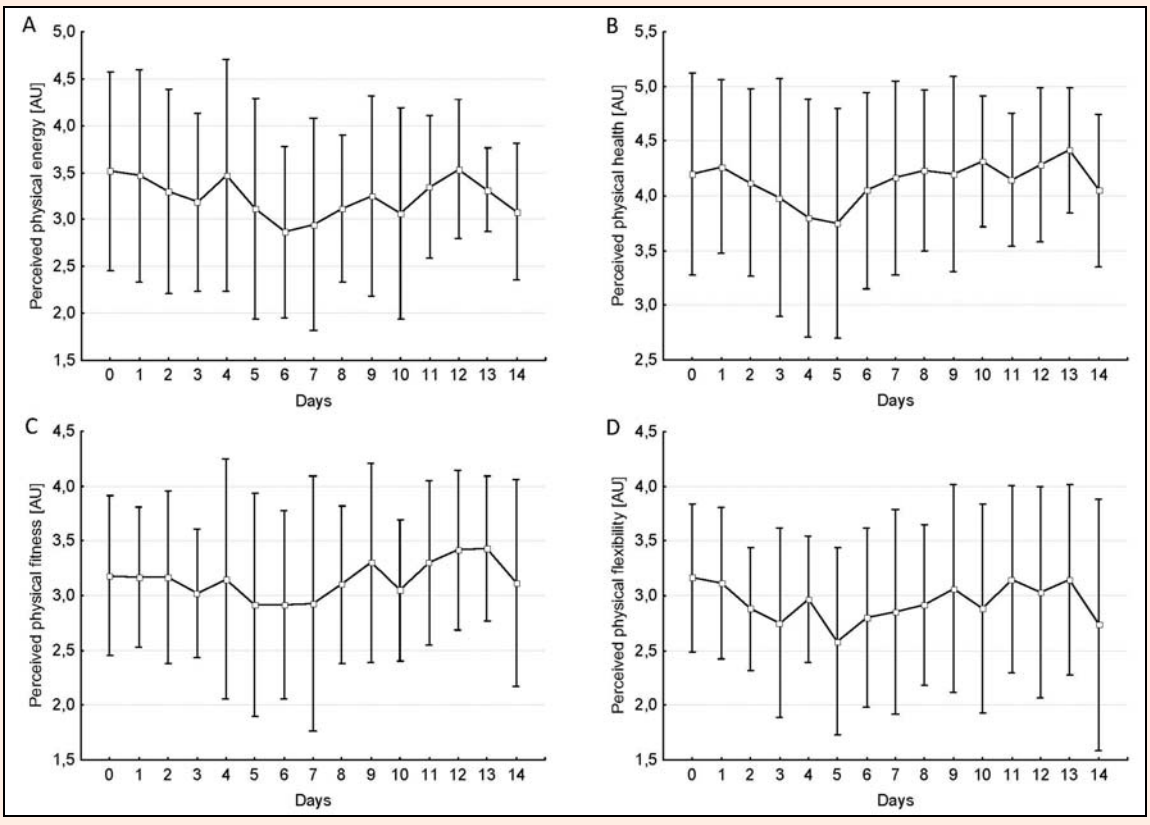

Figure 5. Changes in Perceived physical energy (a), Perceived physical health (b), Perceived physical fitness (c) and Perceived physical flexibility (d). Values are presented as mean ± SD.

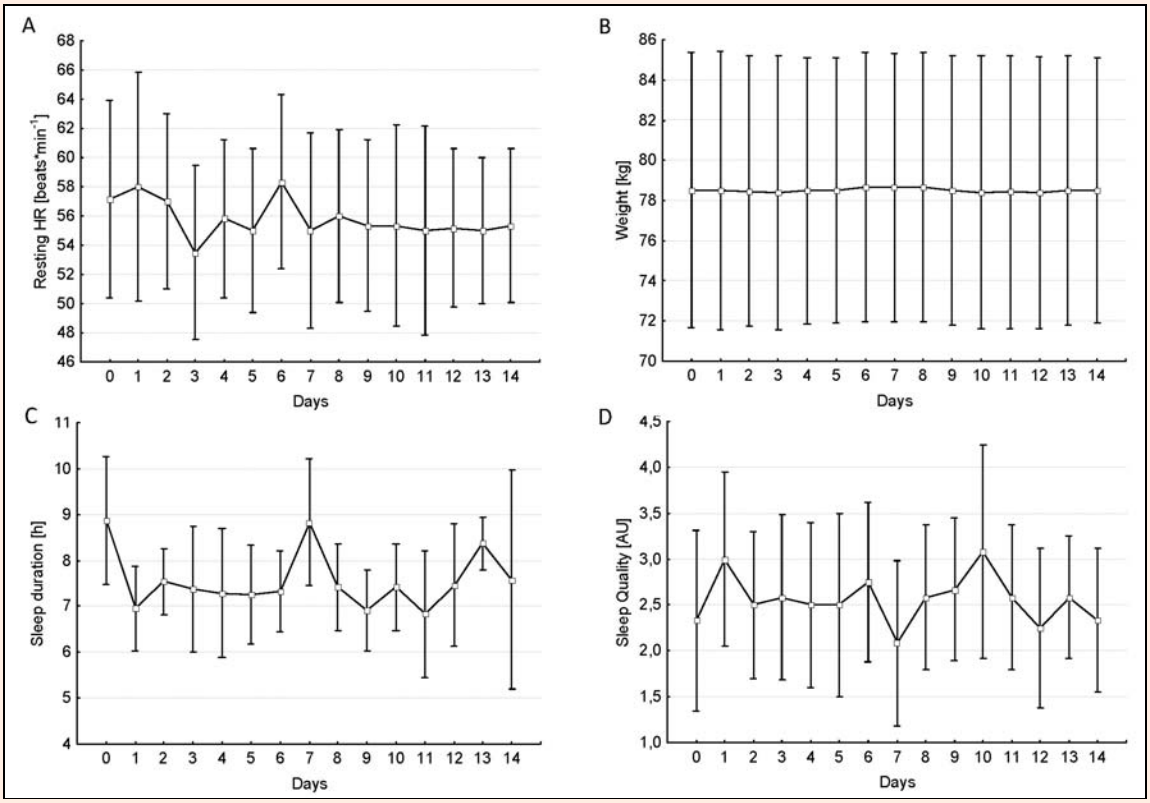

Figure 6. Changes in Resting HR (a), Weight (b), Sleep duration (c) and Sleep quality (d). Values are presented as mean ± SD.

study of McMillan et al. (2005) professional youth soccer players performed two additional HIT sessions per week over 10 weeks. Despite the high initial level, McMillan et al. (2005) found a significant improvement of maximal oxygen uptake (VO_{2max}) (cohen's d = +1.05). Sporis et al. (2008) implemented 3 HIT sessions per week in the preseason of Croatian first division soccer players, which resulted in a significant improvement (cohen's d = +0.76) in a 300-yard shuttle run. Dupont et al. (2004) showed that high-intensity training can be performed during the season with no doubt. Besides large improvements in maximal aerobic speed (cohen's d = +1.41) and 40-m sprint time (cohen's d = -1.42), the investigated team won 78% of their matches. Besides the integration of single HIT sessions, HIT shock microcycles might be another promising method to include HIT sessions in the daily training cycle. In accordance to studies of Wahl et al. (2013) with triathletes and Breil et al. (2010) with alpine skiers, the present study showed the effectiveness of a HIT shock mikrocycle to improve high-intensity running performance. In addition, two studies already investigated the effects of a shock microcycle on soccer players. Large but not significant improvements (cohen's d = +0.88) were found for YYIR2 performance after a 10-day HIT block (Christensen et al., 2011). The effects and sustainability of a HIT shock microcycle on VO_2max were investigated by Stöggl et al. (2010). During the 12-day intervention period soccer players performed 14 high-intensity sessions. The block training was followed by 4 weeks of maintenance training with one HIT session per week. VO_{2max} showed a similar trend as the YYIR2 performance of the present study, with an improvement from pre to post (cohen's d = +0.76) and a decrement (cohen's d = -0.32) after the maintenance period. In their study, even maintenance training was not able to stabilize VO_{2max} values. Due to the close relationship between VO_{2max} and YYIR2 performance, shown in previous studies (Bangsbo et al., 2008), the results of Stöggl et al. (2010) are comparable with these of the present study, despite different measured parameters. Furthermore, Rampinini et al. (2009) found that HIT improves VO_2 kinetics and identified significant relationships between RSA, VO_{2max} and VO_2-kinetics in soccer players. Although we did not measure aerobic capacity and VO_2 kinetics in the present study, it can be hypothesized that both parameters increased after the HIT shock microcycle, due to the mentioned relationships (Bangsbo et al., 2008; Rampinini et al., 2009). Consequently the enhancement of these parameters could be one explanation for the significant increase of RSA_{Mean} and RSA_{Index}, as the importance of the aerobic capacity increases progressively with the number of sprints (Spencer et al., 2005).

Despite the higher demand of the shock microcycle, HR_{Rest}, weight, sleep duration, sleep quality and PEPS-scale showed no significant and substantial changes. The fact that CMJ and sprint performance (RSA_{Best}) showed no significant and substantial changes shows that there was no overload on the neuromuscular system. The unchanged weight status is comparable to the results of Sperlich et al. (2011) and McMillan et al. (2005). Wahl et al. (2013) found significant decreases in some dimensions of the PEPS-scale, but more high-intensity sessions were performed compared to the present study. Although the risk of overreaching or even

overtraining exists, it seems that intensive sessions are needed to generate adaptations and increases in performance.

The design of the present HIT shock microcycle was able to increase performance in a short period of time. However, future studies need to prove the results with highly trained and more professional soccer players. Furthermore, the present study did not use a control group performing regular training in the preparation period and the load of the training sessions between the last HIT session and the 25d post diagnostic was not documented, which is a clear limitation and should be considered in future studies. Anyhow, the standardized improvement in performance was >0.2, which suggests that this kind of training is substantial practically to improve performance. To get a clearer idea of the sustainability, a comparison of different training regimes (e.g. single HIT sessions vs. no HIT sessions) after a HIT shock microcycle should also be investigated.

Conclusion

The present study showed that a 2-week HIT shock microcycle is a promising tool in preseason training of semi-professional soccer players to largely improve RSA_{Index} by 46% (cohen's d = -1.99), RSA_{Mean} by 2.3% (cohen's d = -1.15) and YYIR2 performance by 24% (cohen's d = +1.92) of semi-professional soccer players. Despite the decrement from 6d to 25d testing (RSA_{Index} cohen's d = +0.7; RSA_{Mean} cohen's d = +0.3; YYIR2 cohen's d = -0.81), values of the 25d testing of RSA_{Mean}, RSA_{Index} and YYIR2 remained significantly higher than pre levels (cohen's d pre-25d = -0.74 (RSA_{Mean}), -1.66 (RSA_{Index}), +0.97 (YYIR2). Therefore, it seems necessary to perform further additional HIT sessions per week. However, the exact "dose" of HIT that has to be performed to sustain the improvements still needs to be defined.

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Key points

- HIT shock microcycle increases performance in semi-professional soccer players in a short period of time.
- Despite moderate to large decreases in performance in the 19 day period without HIT, values still remained significantly higher 25d after the last HIT session compared to pre-values.
- This kind of training block increases YYIR2 performance and the ability to repeated sprints, based on the RSA_{Index}.

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