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Seasonal changes in physical performance and heart rate variability in high level futsal players

Running subject head: Futsal training and fitness

Abstract

The aim of this study was to determine the changes in physical performance and resting heart rate variability (HRV) in professional futsal players during the pre-season and in-season training periods. Eleven athletes took part in the study (age = 24.3 ± 2.9 years; height = 176.3 ± 5.2 cm; weight = 76.1 ± 6.3 kg), and performed a repeated-sprint ability (RSA) test [6 x 40 m (20 + 20 m with a 180º change of direction) sprints separated by 20 s of passive recovery] and Yo-yo intermittent recovery test level 1 (Yo-yo IR1) at three different moments (M1 = beginning of pre-season; M2 = end of pre-season; M3 = mid in-season). The HRV indices were assessed at the same moments. After the short pre-season (3-week), mean RSA time (RSA_{mean}) (M1 = 7.43 ± 0.2 s; M2 = 7.24 ± 0.2 s; $P = 0.003$), decrement in RSA performance ($RSA_{decrement}$) (M1 = 6.7 ± 0.3%; M2 = 5.0 ± 0.9%; $P = 0.001$), and Yo-yo IR1 distance (M1 = 1.244 ± 298 m; M2 = 1.491 ± 396 m; $P = 0.002$) were significantly improved ($P < 0.05$). During the in-season (i.e. M3), performance in Yo-yo IR1 and RSA_{mean} were maintained. In contrast, RSA_{best} (M2 = 6.89 ± 0.2 to M3 = 6.69 ± 0.3; $P = 0.001$) was improved and $RSA_{decrement}$ (M2 = 5.0 ± 0.9% to M3 = 6.6 ± 0.9%; $P = 0.001$) was impaired. At M2, there was an increase in HRV vagal-related indices compared with M1 that was maintained at M3. In conclusion, after a short pre-season, futsal players improved their RSA and Yo-yo IR1 performance with concomitant improvements in HRV. These indices were maintained during the in-season period while RSA_{best} was improved and $RSA_{decrement}$ impaired. Frequent monitoring of these performance and HRV indices may assist with identification of individual training adaptations and/or early signs of maladaption.

Key-Words: Indoor soccer, cardiac autonomic control, intermittent fitness testing.

Introduction

Similar to soccer [32, 40], and other team sports [21, 43, 45], futsal (5-a-side indoor soccer) is an intermittent, high-intensity, team sport. However, due to the smaller court dimensions, the unlimited number of substitutions, and the inclusion of attacking and defensive tasks, competitive futsal players are required to perform relatively more sprints and high-intensity activities throughout a game [6, 23]. Players consequently experience fatigue across the halves [6, 23], and the ability to repeat high-intensity efforts and to resist fatigue is paramount to the physical performance of futsal players.

Repeated-sprint ability (RSA) and aerobic capacity, as assessed by intermittent progressive field tests (e.g., Yo-yo Intermittent Recovery Test level 1 – Yo-yo IR1 [3] or the Futsal Intermittent Endurance Test – FIET [19], therefore appear to be important physical fitness attributes to compete at a high standard. Besides aerobic capacity, intermittent field tests also involve neuromuscular and metabolic aspects (e.g., lower-limb muscle power and blood buffering capacity) which determine performance in team sports [11, 41]. To date, most studies have reported improvements in these important fitness components following pre-season training in team-sport athletes [3, 29]. However, while it is relatively easy to improve these fitness components during the pre-season, it is not known whether elite futsal players are able to maintain, or improve RSA and aerobic capacity during the competition season when the majority of the training time is devoted to tactics and training loads are reduced [30]. In soccer, it has been reported that RSA is impaired and performance in the Yo-yo IR1 is maintained during the competitive season [3, 29]. Identification of pre-season and in-season fitness changes in competitive futsal players may assist in training optimization for enhanced performance and help in detecting critical periods for improvements of key physical fitness components.

In addition to the standard assessment of RSA and Yo-yo IR1 performance, other monitoring tools such as resting and post-exercise heart rate variability (HRV), a non-invasive assessment of cardiac autonomic modulation, have been documented in response to the training and competitive loads of soccer [10, 17]. For instance, post-exercise (5-min submaximal running at 9 $km \cdot h^{-1}$) HRV has been reported to track the aerobic performance (Vam-Eval field running test) of highly-trained, young soccer players during a competitive season [17]. Athletes with greater vagal HRV improvements during the season exhibited greater improvement in the Vam-Eval test performance. Subsequently, HRV indices may reflect positive changes in parallel to the improvement in Yo-yo IR1 test performance and high-intensity intermittent activity in futsal players. This concomitant improvement may provide an important and simple monitoring tool for training optimization in futsal and other team sports, avoiding the need of frequent maximal testing.

The aim of this study was to determine the changes in physical performance (RSA and Yo-yo IR1) and resting HRV in professional futsal players during the pre-season and in-season training periods. It was hypothesized that significant improvements in these variables would be observed initially during the pre-season, and that performance in the Yo-yo IR1 would be maintained during the season, while RSA would be impaired. Further, we hypothesized that HRV would improve in parallel to distance covered during the Yo-yo IR1.

Methods

Participants

Fifteen male futsal players (age: 24 ± 2.9 years; body mass: 75.2 ± 6.1 kg; height: 175.9 ± 5.2 cm; BMI: 24.3 ± 1.8 kg/m^2) competing in the Brazilian National Division League agreed to take part in this study after reading and signing a written consent form. They were all free from injury and chronic health problems at the commencement of the study, and the procedures adopted were approved by the Institutional Ethics Committee and performed in accordance with the ethical standards of the IJSM [28].

Experimental design

The futsal players of the same team were evaluated on three occasions (February, March and May) over the 2011 competitive season. Following a ~2 months off-season period, the athletes undertook their first evaluation at the beginning of the pre-season period (M1). Each evaluation consisted of the following schedule: Day 1) medical screening and anthropometric assessment in the morning (9:00-11:00h); Day 2) resting heart rate variability measurements and RSA test in the afternoon (15:00-17:00h); Day 3) Yo-yo IR1 test in the morning (9:00-11:00h). The second evaluation was carried out at the end of a short (3 weeks) pre-season (M2) with the third evaluation performed in the middle of the regular season (i.e. ~3 months after finishing the pre-season, M3). All running tests were performed in a gymnasium with a hardwood surface that was familiar to the team athletes, with players clothed with light training uniforms and futsal shoes.

Pre-season and in-season training

The 3-week pre-season consisted of a standardized training schedule (as exemplified in Table 1) with the main objective to improve players' physical, tactical and technical skills. Athletes undertook two training sessions per day with the first consisting of speed, RSA, and continuous and interval-based runs aiming to improve aerobic and anaerobic fitness. The second daily training session consisted of technical and tactical activities such as small sided games. There were two friendly games during the pre-season. During the season, the team had regular competitive matches (2-3 per week for a total of 15 matches over the observation period). Moderate activities or passive rest were implemented during the in-season period, intending to assist with recovery from matches and travel (as exemplified in Table 1). The remaining training sessions were aimed at maintaining the fitness components developed during the short pre-season using predominantly court activities (with technical/tactical predominance). The competitive season included a 4-week period without matches where athletes undertook activities of greater training intensity (4 weeks before M3). Over the pre-season, training loads were quantified by the session-rating of perceived exertion (RPE) method [26, 38]. Players were asked to rate how hard the training session was using the scale proposed by Foster et al. [26] 15 min after its end. This individual RPE value was multiplied by the training session duration.

***** Insert Table 1*****

Resting cardiac autonomic analysis

At the beginning of the second day of testing, indirect cardiac autonomic modulation was assessed by HRV during the 10-min resting period with athletes seated and breathing spontaneously [8]. HRV was analyzed in final 5-min period with all RR intervals visually inspected, and ectopic beats (<3%) and artifacts manually removed and replaced by interpolation of adjacent RR intervals. RR interval recordings were obtained from each athlete with a portable heart rate monitor (Polar® RS800, Kempele, Finland) at a sampling rate of 1000 Hz. The RR recordings were downloaded via accompanying Polar software (Polar® Pro Trainer, Kempele, Finland) and exported for later analysis of time and frequency domain measures of HRV by Kubios v 2 Heart Rate Variability software (Biosignal Analysis and Medical Imaging Group at the Department of Applied Physics, University of Kuopio, Kuopio, Finland). As the HRV data collection was performed in the afternoon, the athletes were instructed to avoid any exercise in the respective morning, and to follow their habitual sleep habits and diet for breakfast and lunch during the training days.

In the time domain, three indices were calculated: the mean RR interval (RRmean), the root-mean-square difference of successive normal RR intervals (RMSSD), which reflects vagal modulation; and the standard deviation of all normal RR intervals (SDNN), which comprises both sympathetic and vagal cardiac modulations. In the frequency domain, oscillations of RR intervals were split into the low-frequency (LF: 0.04 - 0.15 Hz) and high frequency bands (HF: >0.15 to 0.40 Hz) using the fast Fourier transform (FFT) algorithm of 1024 points, 50% overlap and Welch's periodogram method. Absolute values were expressed in ms^2, while normalized units were calculated as the area of the frequency band minus the very low frequency modulations (<0.04Hz) and expressed in relation to all modulations ≤0.40 Hz. The HF band reflects vagal modulation while the LF band indicates both sympathetic and parasympathetic influences. The ratio of the LF to HF (LF/HF) bands was also examined as an indicator of sympathovagal balance [47].

Repeated-sprint ability (RSA)

Before the RSA test, athletes performed a standardized 5-min warm-up of progressive runs and accelerations that were administered by the team's physical trainer. The RSA test consisted of 6 x 40 m (20 + 20 m with a 180º change of direction) sprints separated by 20 s of passive recovery [29, 40]. The athlete started 0.5 meter behind the start line which was marked by a photocell (Multisprint®, Hidrofit®, Brazil). Before starting, the athletes were instructed to run as fast as possible to the end of the 20 m course, which was marked with two cones, then perform a quick change in direction (180º) and run in the direction of the start line. Following each sprint, athletes decelerated and walked to the starting line in readiness for the subsequent sprint. Five seconds prior to the next sprint, the athletes assumed the starting position and a 3-s regressive countdown was provided to commence their sprint. The best (RSA_{best}) and mean sprint time (RSA_{mean}) were recorded as the performance indices. The percent sprint decrement ($RSA_{decrement}$) was calculated according to the following equation proposed by Fitzsimons et al.[25]:

$$100 - (\text{total time}/\text{ideal time} \times 100)$$

Where ideal time = 6 x RSA_{best}.

The coefficients of variation for RSA_{mean}, RSA_{best} and $RSA_{decrement}$ have been reported as 0.8, 1.3 and 30.2%, respectively, for soccer players [29]. Further, RSA_{mean} has been reported to be highly correlated with distance performed at high intensity during soccer games (r= - 0.69) [40] and to be capable of discriminating player performance (e.g. amateur vs. elite, forward vs. fullback [2]. To our knowledge, only a few studies examining RSA with futsal players have been conducted. These studies showed that RSA_{mean} is correlated with VO_2max as determined by the Léger-Lambert field test [4] and that both RSA_{mean} and RSA_{best} are better in futsal players than in handball and basketball players [5].

Yo-yo intermittent recovery test level 1 (Yo-yo IR1)

The Yo-yo IR1 test was performed on the same indoor court as the RSA test. A similar warm-up to that undertaken before the RSA test was conducted prior to the Yo-yo IR1 test. The Yo-yo IR1 consisted of repeated 20 m runs back and forth between two markers with a progressive increase in speed which was governed by an audio player. Between each 40 m bout, the athlete recovered with 10 s jogging (shuttle runs of 2 x 5 m). The test consists of 4 running bouts at 10-13 $km\cdot h^{-1}$ (0-160 m) and another 7 runs at 13.5-14 $km\cdot h^{-1}$ (160-440 m). From this point on it continues with stepwise 0.5 $km.h^{-1}$ speed increments after every 8 running bouts. The test was completed when the athlete reached voluntary exhaustion or failed to maintain the running pace in synchrony with the audio recording (i.e. failed to achieve the markers twice in the same stage). The Yo-yo IR1 course lines were marked with cones 20 m apart with additional cones set at 5 m behind the starting line for use during recovery. The athletes wore heart rate monitors (Polar RS800, Kempele, Finlandia) to record the final heart rate attained in the test. The coefficient of variation for Yo-yo IR1 performance has been reported as 4.9% [32]. Performance in the Yo-yo IR1 is significantly correlated with the distance covered at high intensity during youth and adult soccer match play (r = 0.71-0.77) [20, 32] and with total distance covered during youth handball games (r = 0.88) [43].

Statistical analysis

Data are presented as mean (SD). Comparisons of seasonal values of performance and HRV were performed using one-way ANOVA for repeated measures. Post-hoc differences in performance and HRV were assessed using pairwise comparisons with a Bonferroni correction. Due to the non-normal distribution, HF and LF in absolute units were transformed using a natural logarithm to allow for parametric statistics to be used. However, the respective results are presented as non-transformed mean values. The effect size (d) and 95% confidence interval of all changes was calculated and interpreted as proposed by Hopkins (www.sportsci.org/resource/stats): < 0.2: Trivial; 0.2 – 0.6: Small; 0.6 – 1.2: Moderate; > 1.2: Large. In order to obtain the possible relationships between the variables the relative changes (Δ%) of all performance and VFC indices were calculated between the moments and assessed via Pearson correlation or Spearman's rank (ρ) correlation coefficient when variables were not normally distributed. The level of significance adopted was $P < 0.05$ with all analyses performed with SPSS 17.0 for Windows software (SPSS Inc).

Results

Participants and training loads

Of the 15 athletes who began the pre-season training period, four did not complete the study due to injury. Additionally, one player exhibited significant artifacts during the HR recordings and was subsequently removed from the HRV analyses. Hence, the results for performance were obtained from 11 (24.3 ± 2.9 years; 176.3 ± 5.2 cm) athletes while the HRV results were obtained from 10 athletes. The body mass and body mass (BMI) index of the 11 athletes were constant throughout pre-season and in-season (Mass: M1 = 76.1 ± 6.3 kg; M2 = 76.3 ± 7 kg; M3 = 77.2 ± 6.4 kg, $P > 0.05$; BMI: M1 = 24.5 ± 1.6 $kg.m^{-2}$; M2 = 24.5 ± 1.9 $kg.m^{-2}$; M3 = 24.8 ± 1.83 $kg.m^{-2}$, $P > 0.05$).

During the 3-week pre-season there was no difference ($P = 0.13$) in training loads measured by session-RPE between the first (4345 ± 496 a.u.) and the second weeks (3884 ± 428 a.u.). However, the training load accumulated in third week (2674 ± 880) was lower than those accumulated in the first ($P = 0.005$) and second ($P = 0.004$) weeks. There was no significant relationship between the total training loads accumulated and the Δ% changes in performance or HRV indices between M1 and M2. Unfortunately, we have no data concerning training loads accumulated during the in-season period.

Performance responses

The RSA performance during pre- and in-season is presented in Table 2. There was a significant improvement in RSA_{mean} from M1 to M2 ($P = 0.003$), which was maintained at M3 ($P = 0.01$). The RSA_{best} was significantly improved at M3 compared with M1 (P = 0.006) and M2 (P = 0.02). The $RSA_{decrement}$ improved (i.e., decreased) significantly at M2 (P = 0.001) compared with M1 but then returned to higher (i.e. worse) values at M3. Moderate ES were noticed in RSA_{mean} between M1 and M2, in RSA_{best} between M2 and M3, and in $RSA_{decrement}$ between M1 and M3. Large ES were noticed in RSA_{mean} and RSA_{best} between M1 and M3, and in $RSA_{decrement}$ between M1 and M2, and between M2 and M3.

***** Insert Table 2*****

There were no differences in maximal HR values obtained during the Yo-yo IR1 at M1 (191 ± 7.1 bpm), M2 (188 ± 5.7 bpm) or M3 (192 ± 5.9 bpm). The Yo-yo IR1 performance improved significantly from M1 (1,244 ± 298 m) to M2 (1,491 ± 396 m; P = 0.002) and remained elevated for M3 (1,465 ± 270 m; P = 0.007). The Yo-yo IR1 change was rated as moderate for M2 [0.77 (95% CI of 0.42 – 1.11)] and M3 [0.69 (95% CI of 0.31 – 1.07] compared with M1 and trivial for M3 compared with M2 [-0.08 (95% CI of -0.57 – 0.41)]. The relative change (Δ%) in the Yo-yo IR1 performance was moderately correlated with the relative change in RSA_{mean} between M1 and M2 (r = 0.58; $P < 0.05$ [95% CI: 0.03 – 0.98]). No other significant correlations were identified.

Autonomic responses

Table 3 summarizes the HRV pre- and in-season values for the futsal players. Compared with M1, values for the RRmean (P = 0.003), RMSSD (P = 0.001) and HF (P = 0.03) were significantly greater at M2, with ES for changes ranging from small to large (Table 3). At M3, all HRV indices were similar to the values at M1 and M2, with ES for changes ranging from trivial to moderate (Table 3).

***** Insert Table 3*****

Discussion

This is the first study to track sport-specific fitness and cardiac autonomic regulation during the pre-season and in-season training of elite futsal players. Our results showed that high-intensity intermittent running endurance and RSA_{mean} were improved in response to the short pre-season, along with positive changes in selected HRV indices (e.g. RRmean, RMSSD and HF). During the in-season, most performance components were maintained at the level achieved at the end of pre-season with improvement registered only for RSA_{best}, in contrast with our first hypothesis. These results demonstrate that most physical performance indices (except RSA_{best}) and HRV can be quickly improved during the pre-season preparation but are not further changed during the competitive season, highlighting the need of well-designed pre-season training in order to optimize fitness gains.

In the present study, both RSA_{mean} and $RSA_{decrement}$, but not RSA_{best}, were improved in response to the short, non-experimental, futsal pre-season. Similar improvements in RSA indices have previously been reported in response to training modes such as repeated sprints and high-intensity intermittent runs [14, 15, 24, 44], strength training [9], and small-sided games [13]. These RSA improvements are also similar to those observed during the soccer pre-season, a period during which Impellizzeri et al. [29] found a substantial decrease (-2.2%) in RSA_{mean}, likely substantial decrease (-1%) in RSA_{best}, and very likely (22.7%) worsening of $RSA_{decrement}$. While we did not observe an improvement in RSA_{best} during the pre-season, this discrepancy may be related to the comparatively short (three weeks) pre-season used for the futsal team compared to the two-month pre-season in the study by Impellizzeri et al. [29]. This suggests that while RSA_{mean} and $RSA_{decrement}$ can be improved in a relatively short time, a longer training period is required to improve RSA_{best}. Alternatively, we can speculate that a pre-season with more sprint training sessions and less aerobic training could have had improved RSA_{best}. However, this type of program is not a common training practice in futsal and other team sports.

Afterwards, only small RSA_{mean} change was noticed during the in-season months. In contrast, significant improvement was noticed in RSA_{best}. These results do not reflect those obtained in studies involving professional soccer players. For instance, Impellizzeri et al. [29] reported a likely impairment (0.8%) from the early to mid-season in RSA_{mean}, while trivial change was noted from mid to end-season. Similarly, RSA_{best} was impaired (0.9%) from early to mid-season and maintained from mid to end-season. These contrasting results in comparison to ours may be attributed to the differences in the competitive soccer and futsal match characteristics, which constitute a substantial part of the physical stimulus leading to adaptations during this period [46]. Futsal involves relatively more high-intensity activities compared to soccer [6], including sprints. This greater training stimulus for futsal may explain why the current players maintained their RSA_{mean} and improved their RSA_{best} during the competitive season.

The $RSA_{decrement}$ was reduced at M2 compared to M1, suggesting a reduction of fatigability during repeated sprinting during pre-season, which may explain, at least in part, the improvement in RSA_{mean}. However, at M3, $RSA_{decrement}$ returned to the baseline values. While at first glance this result may suggest an increased fatigability in comparison to M2, it is more likely that the increase in $RSA_{decrement}$ is a mathematical artifact of the improved RSA_{best} at this time. For instance, a positive correlation has previously been reported between initial power output and power decrement during repeated-sprint protocols similar to ours [37]. In addition, Racinais et al. [39] observed that although $RSA_{decrement}$ was greater in the afternoon than in the morning, this could be explained by the greater initial power output in the afternoon. Thus, caution is required when interpreting training-induced changes in $RSA_{decrement}$ when there are concurrent alterations in RSA_{best}.

The changes in RSA performance are likely to be explained by different mechanisms between M1-M2 and M2-M3. For example, between M1 and M2 there was an improvement in RSA_{mean} due to a reduction in $RSA_{decrement}$. This can possibly be explained by metabolic adaptations to the short pre-season. In fact, the relative improvement in RSA_{mean} was significantly correlated with Yo-yo IR1 performance increase ($r = 0.58$). As these performance tests share some similar metabolic determinants [3, 27] we can speculate that the short pre-season was capable of improving aerobic power, phosphocreatine resynthesis or blood buffering capacity. Alternatively, the ability to quickly change direction by improving specific coordination and neuromuscular activation may have also played a role [12]. However, at M3 the RSA_{mean} was maintained despite an impaired $RSA_{decrement}$. Due to improvement in RSA_{best}, it can be speculated that the maintenance of RSA_{mean} at M3, compared with M2, may have resulted from improved muscle activation/coordination with consequent improvement in muscle power at M3 [42].

In the present study, there was a 20% change in Yo-yo IR1 performance from M1 to M2. This is smaller both in absolute and relative terms to the results of Barbero-Álvarez and Barbero-Álvarez [7] who reported a distance of 1875 ± 285 m in the beginning of the pre-season and 2400 ± 293 m (28% of increase) at the end of a 7-week pre-season in elite futsal players. Consistent with these results, Krustup et al. [32] reported a 25% increase of Yo-yo IR1 distance (1760 ± 59 m to 2211 ± 70 m) during pre-season in elite professional soccer players. The smaller changes observed in our study can most likely be attributed to the shorter pre-season duration compared to other studies. Surprisingly, our players' the Yo-yo IR 1 performance was modest compared to European counterparts and may reflect national differences in competition as we have consistently observed similar Yo-yo IR 1 performances in elite Brazilian futsal players (unpublished observations).

During the in-season, no further change in Yo-yo IR 1 performance was observed compared to the end of pre-season. This is consistent with the findings of Krustrup et al. [32] and others [3], and suggests that improvements in Yo-yo IR1 performance should be emphasized during the early preparatory phases of the training periodization since no expressive adaptations on the ability to perform intermittent exercise are expected during the competition season.

Consistent with our finding regarding changes in Yo-yo IR1 performance, the vagal-related HRV indices were increased in our futsal players after the pre-season period, and remained stable during the in-season. The absence of cardiac autonomic modulation adaptations during the competition period in our study is in agreement with the recent results of Mazon et al. [36], who reported no changes in supine and tilt-induced HRV indices in volleyball players after 12 weeks of in-season training following the "selective loads periodization model". It thus appears that in team sports, athletes have a tendency to experience positive modifications of their autonomic regulation during the early phases of yearly training programs, and then maintain the indices afterwards due to attainment of threshold values above which adaptation responses cannot be further observed [33].

Although prior research has shown positive effects of regular training on resting HRV in endurance athletes [22, 34], to our knowledge, this is the first study to report changes in the resting cardiac autonomic activity during the pre-season and competition season in team-sport athletes. These effects can be related to adaptations of various systems, including the central nervous system. In an animal model, Mastelari et al. [35] have shown that the HF (nu) improved from 26.4 ± 6.9 to 88.9 ± 2.4 after aerobic physical training (swimming), and that this improvement was abolished when the trained animals received a microinjection of nitric oxide inhibitor in the paraventricular nucleus (PVN). These results suggest that the training alters the PVN function by modifying the nitric oxide activity. The occurrence of PVN adaptations, as well as other physiological adaptations (e.g., hemodynamic changes [18] leading to improvement of HRV) may help to explain our results but further research is required, especially in humans.

Despite there are no previous reports showing the effects of training on resting cardiac autonomic control in team-sport athletes, the HRV measured in the post-exercise recovery has been shown to improve after training in team-sport athletes [17, 18]. Buchheit et al. [17] have shown that athletes who improved recovery of vagal-related HRV indices after short submaximal exercise (i.e., 5-min at 9 km·h^{-1}) had greater likelihood to experience a substantial improvement in the final velocity obtained during the Vam-Eval test. More recently, Buchheit et al. [18] reported that during one week of training during the in-season period, elite soccer players showed a gradual increase in the short-term variability of R-R intervals (Poincaré plot) measured during the post-exercise recovery period. After completing the one week training camp the athletes also improved Yo-yo IR1 test performance. However, the Yo-yo IR1 improvement (%) was not related to the relative changes in short-term variability of RR intervals. These results are in accordance with ours that failed to show any relationship between the changes in Yo-yo IR1 performance and the changes in resting HRV indices, but showed that these variables had a similar temporal pattern (i.e. improvement after the pre-season with no further changes during in-season).

One possible limitation by applying HRV analyses during the afternoon in athletes is that the measurement may be influenced by activities performed during the morning. However, the athletes were instructed to avoid any exercise on the respective morning scheduled for data collection. Hence, as the HRV during the rest days has shown little circadian influence [1], we believe that this bias was minimized in the present study. Future studies should also consider applying HRV recovery from submaximal exercise [16] in addition to resting measurements, in order to verify which one is more sensitive to training effects.

In conclusion, after a short pre-season period, futsal players improved RSA_{mean}, $RSA_{decrement}$ and Yo-yo IR1 performance. These alterations were accompanied by positive changes in resting HRV indices. During the in-season period, there was an increase in RSA_{best} performance, concomitant with a worsening of $RSA_{decrement}$ to baseline levels; the worsening of $RSA_{decrement}$ during the competitive period can most likely be attributed to the concomitant improvement in RSA_{best}. The HRV, Yo-yo IR1 and RSA_{mean} results achieved at the end of pre-season were all maintained during the in-season period. It is possible that a longer pre-season period, with greater control of training loads [38] and stress-recovery balance [31], may improve performance and better prepare futsal players for the competition season.

Practical applications

Futsal coaches and physical trainers can monitor fitness changes during the pre- and in-season periods using field tests that provide complementary information on the players' performance. The RSA and Yo-yo IR1 tests appear to be sensitive to the quick improvements in performance occurring during the pre-season period. Improvements in RSA_{mean}, $RSA_{decrement}$ and distance covered in the Yo-yo IR1 test, parallel the improvement in cardiac autonomic control during the pre-season. In contrast, maintenance of these indices occurs during the in-season period with frequent monitoring of these indices potentially able to detect individual training adaptations and/or early indication of non-functional overreaching or overtraining. Physical trainers should be aware that RSA_{best} can be enhanced during the competitive season possibly due to the physical demands placed by the matches, which elicit several sprinting activities. This improved RSA_{best} can be accompanied by increased $RSA_{decrement}$ that may not necessarily reflect increased fatigue.

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Table 1: Typical weekly training program for Futsal players (Week 3 and Week 5).

	Day						
	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Pre-season							
Morning	Muscular power in the gym	Moderate intensity interval training	Repeated sprint	Muscular strength	Muscular power in the gym	Low intensity aerobic activities	Rest
Afternoon	Technical/Tactical	Technical/Tactical	Technical/Tactical	Small sided games	Technical/Tactical	Friendly game	Rest
In-season							
Morning	Tactical	Travel	Technical/Tactical	Technical/Tactical	Rest	Lower body muscular power	Technical/Tactical
Afternoon	Rest	Regenerative activities	Travel	Rest	Regenerative activities	Technical/Tactical	-
Night	Match	-	-	Match	-	-	-

Table 2: Repeated-sprint Ability (RSA) performance at the beginning of the pre-season period (M1), at the end of a 3-week pre-season (M2) and in the middle of the regular season (M3) for futsal players. (n = 11).

	M1	M2	M3	M1 vs M2 ES [95% CI] – Rating	M1 vs M3 ES [95% CI] – Rating	M2 vs M3 ES [95% CI] – Rating
Yo-yo IR1 (m)	1244 (298)	1491 (396)*	1465 (270)*	0.77 [0.42 – 1.11] Moderate	0.69 [0.31 – 1.07] Moderate	-0.08 [-0.57 – 0.41]
RSA_{mean} (s)	7.43 (0.2)	7.24 (0.2)*	7.13 (0.3)*	-0.95 [-1.40 – -0.50] Moderate	-1.52 [-2.40 – -0.64] Large	-0.57 [-1.16 – 0.02] Small
RSA_{best} (s)	6.93 (0.2)	6.89 (0.2)	6.69 (0.3)*#	-0.19 [-0.50 – 0.12] Trivial	-1.20 [-1.84 – -0.51] Large	-1.01 [-1.62 – -0.39] Moderate
$RSA_{decrement}$ (%)	6.7 (0.3)	5.0 (0.9)*	6.6 (2.4)	-1.8 [-2.71 – 0.89] Large	0,02 [-1,44 – 1.48] Trivial	1.82 [0.39 – 3.25] Large

Values are presented as mean (SD). * $P < 0.05$ compared with M1. # $P < 0.05$ compared with M2. CI: confidence interval. ES: effect size. Criteria used to interpret the magnitude of the ES were: < 0.2 trivial, > 0.2 – 0.6 small, > 0.6 – 1.2 moderate, > 1.2 large.

Table 3: Cardiac autonomic responses at the beginning of the pre-season period (M1), at the end of a 3-week pre-season (M2) and in the middle of the regular season (M3) for futsal players (n = 10).

	M1	M2	M3	M1 vs M2 ES [95% CI] – Rating	M1 vs M3 ES [95% CI] – Rating	M2 vs M3 ES [95% CI] – Rating
RRmean (ms)	808 (124.1)	880 (112.9)*	872 (85.7)	0.53 [0.28 – 0.78] Small	0.47 [-0.23 – 1.17] Small	-0.06 [-0.60 – 0.48] Trivial
RMSSD (ms)	33 (16.8)	48 (20.8)*	42 (12.9)	0.80 [0.51 – 1.09] Moderate	0.49 [-0.15 – 1.12] Small	-0.31 [-0.98 – 0.35] Small
HF (ms^2)	234 (210)	614 (146)*	496 (90)	0.86 [0.55 – 1.1.17] Moderate	0.67 [0.23 – 1.11] Moderate	-0.19 [-0.47 – 0.09] Trivial
LF (ms^2)	1240 (150)	1808 (70)	1458 (77)	0.46 [0.02 – 0.90] Small	0.20 [-0.49 – 0.88] Small	-0.26 [-0.72 – 0.19] Small
HF (nu)	18 (9.3)	28 (14.4)	28 (13.6)	0.94 [-0.03 – 1.91] Moderate	0.96 [0.09 – 1.83] Moderate	0.02 [-0.96 – 1.00] Trivial
LF (nu)	82 (9.3)	72 (14.4)	72 (13.6)	-0.94 [-1.91 – 0.03] Moderate	-0.96 [-1.83 – -0.09] Moderate	-0.02 [-1 – 0.96] Trivial
LF/HF Ratio	7 (5.7)	4 (3.1)	4 (3.4)	-0.48 [-0.9 – -0.07] Small	-0.46 [-1 – 0.08] Small	0.02 [-0.24 – 0.27] Trivial

Values are presented as mean (SD). * $P < 0.05$ compared with M1. CI: confidence interval. ES: effect size. Criteria used to interpret the magnitude of the ES were: < 0.2 trivial, > 0.2 – 0.6 small, > 0.6 – 1.2 moderate, > 1.2 large.