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ORIGINAL SCIENTIFIC PAPER

Within-season Adaptations in Physical, Physiological and Technical-tactical Performance of Experimented Futsal Players

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Abstract

This study analysed the seasonal variations in futsal players' physical, physiological, and technical–tactical performance. Eight senior futsal players from the same team were monitored at three time points in the season (beginning of the preseason, middle of the first half of the season, and middle of the second half of the season). A progressive and intermittent shuttle-running test (the futsal intermittent endurance test) was applied to collect the following variables: maximum velocity, distance covered, total distance covered, test duration, initial heart rate, peak heart rate, peak blood lactate concentration, and rating of perceived exertion. In addition, different match-performance variables were assessed during a simulated futsal match (goals scored, shots on goal, successful passes, balls lost, balls recovered, and goals conceded). Results indicated that the physiological variables of initial heart rate ($p<.001$, $\eta2=.862$) and peak blood lactate concentration ($p=.001$, $\eta2=.640$) significantly varied over the course of the season. However, no significant differences were found in the physical and technical–tactical variables. This study has implications for sport practitioners; specifically, it emphasizes that preseason and in-season training load periodization enhances the physiological fitness of top-level futsal players, although their physical and technical–tactical performance remained relatively stable.

Keywords: *workload, heart rate, lactic acid, team sports, season variance*

Introduction

Scholars have shown increasing interest in investigating futsal-related topics as a means of generating scientific and applied knowledge for coaches and practitioners (Spyrou et al., 2020). One of the most prevalent topics of investigation involves analyzing the physical demands of match play. Futsal has been described as a strenuous sport and is characterized by intermittent and high-intensity efforts and frequent multidirectional sprints, jumps, and impacts, requiring substantial energy from the aerobic and anaerobic systems (Barbero-Alvarez et al., 2008; Castagna et al., 2009; Moore et al., 2014; Ribeiro et al., 2020; Spyrou et al., 2020). A special feature of futsal is the unlimited number of player substitutions, which contributes to maintaining match intensity and pace at a high level and ultimately increases the match's physical demands (Castagna et al., 2009; Ribeiro et al., 2021). Therefore, understanding how to maintain or improve the physical parameters of players is a critical issue, as futsal players should be able to successfully perform during a long competitive season of roughly 8–9 months.

Futsal preseason features high training loads, which are intended to develop several physical capacities concomitantly and elevate player performance levels (Miloski et al., 2016; Rabelo et al., 2016; Lago-Fuentes et al., 2020). By contrast,

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the in-season period is mainly devoted to technical–tactical content, with maintenance of a generally stable training load (Miloski et al., 2016; Rabelo et al., 2016; Lago-Fuentes et al., 2020; Mateus et al., 2021). This logical variation of training scope might lead to seasonal changes in players' fitness and technical–tactical performance. Accordingly, the analysis of seasonal variations in player performance customarily involves three key periods of the season: preseason, midseason, and end of season (Clark et al., 2008; Oliveira et al., 2013). Studies have clearly demonstrated that the physical capacities that determine performance are improved over the preseason and are generally maintained throughout the competitive season (Oliveira et al., 2013; Miloski et al., 2016). Further, occasionally, declines in some of these capacities may be observed towards the end of the season (Clark et al., 2008; Mara et al., 2015).

Although variations in the fitness components are acknowledged, the evidence on how technical–tactical skills change over the course of a competitive season of futsal is inadequate. The existence of such a gap in the literature is somewhat surprising, given that physical fitness is just one of several variables that influence players' performance; the combination of different performance variables is widely recognized as the determinant of successful performance (Travassos et al., 2012; Mohammed et al., 2014). In line with this reasoning, a crucial feature of players' overall performance is the link between their physical fitness and technical–tactical skills (Mohammed et al., 2014; Moore et al., 2014; Milanez et al., 2020). For instance, a lower activity profile resulting from a lack of conditioning has been associated with more technical errors (Rampinini et al., 200; Milanez et al., 2020). Furthermore, players with poor physical fitness face difficulties in continually performing explosive movements, which leads to predictable game play and a consequent inability to disrupt opponents' tactics (Sampaio et al., 2014; Coutinho et al., 2018).

To better understand futsal players' development under such demanding training and competitive scenarios, longitudinal coverage of the physical adaptations and match-related technical performance variations throughout the competitive season would therefore be a fruitful approach. As previously mentioned, the literature has mainly been devoted to studying physical fitness over the course of a season while neglecting possible indirect and interactive effects on technical–tactical performance. Pursuing such a line of investigation may provide a deeper understanding of the interaction between physical and tactical–technical performance and thus empower coaches and practitioners to implement critical adaptations to their training programs, thereby increasing their effectiveness. Therefore, the present study is a first attempt to explore the seasonal variations in futsal players' physical, physiological, and technical–tactical performance. We hypothesized that significant improvements in physical and physiological variables would be initially observed during the preseason and then stabilize over the season (Oliveira et al., 2013; Miloski et al., 2016). Additionally, we envisioned that a training environment aimed at improving individual and collective performance would enhance players' technical–tactical performance (Travassos et al., 2012a; Travassos et al., 2012b; Oppici et al., 2018).

Materials and Methods

Participants

Eight experienced outfield futsal players volunteered to participate in the study (age, 24.5±5.17 years; height, 175±6.12 cm; weight, 69.7±8.4 kg). Criteria for inclusion were applied to ensure players had previous experience in playing futsal in national championship leagues (i.e. minimum experience of 5 years), and participants were exposed to four training sessions per week (lasting approximately 100 min each). No players presented a history of injury or muscle disorders in previous 6 months. All players were informed of the study purpose and potential risks before giving their written informed consent for participation. The study protocol conformed to the recommendations of the Declaration of Helsinki and was approved by and followed the guidelines of the local institutional research ethics committee (CEUBI-Pj-2018-029).

Design and procedures

Evaluation procedures were distributed across three time points within a competitive season (M1, beginning of the preseason; M2, middle of the first half of the season; M3, middle of the second half of the season). The selection of the timing for testing followed previous research (Oliveira et al., 2013) and was arranged for the convenience of the team's coach. Participants were randomly assigned to perform physical and match testing on different days. Physical measures were assessed in the second training session of a weekly microcycle that did not include any formal competition, and match-related variables were assessed on the following day. All the tests were completed on the same day of the week (i.e. physical: Tuesday; technical: Wednesday), at the same time of day (6:00–8:00 p.m.), and at an indoor facility where the players typically engaged in their weekly training. On testing days, subjects completed an individual warm-up consisting of jogging, static and dynamic stretching, short sprints, and general exercises involving ball control.

Measurements

Physical performance was evaluated using the futsal intermittent endurance test (FIET), which entails shuttle running performed at progressively increasing speed until exhaustion (Castagna & Barbero-Alvarez, 2010). The test comprises three shuttle-running bouts of 45 m (3×15 m) interspersed with 10 s of active recovery. After each 8×45 m, the players were allowed to rest for 30 s. For the FIET, the initial speed was 9 km/h, and speed increments during the first 9×45-m bouts were 0.33 km/h, successively shifting to 0.20 km/h every 45 m until exhaustion (Castagna & Barbero-Alvarez, 2010). The test ends when participants do not reach the finish line before the timer sounds in two consecutive runs.

One week before testing, participants were familiarized with the testing equipment and procedures. Physical performance was determined on the basis of the following measures directly retrieved from the shuttle-running test: (i) maximum velocity reached (km/h), (ii) total distance covered (m), and (iii) test duration. Additionally, we evaluated (iv) initial heart rate (bpm) and (v) peak heart rate (bpm) using the Polar system (Polar Team System, Polar Electro, Kempele, Finland), (vi) peak blood lactate concentration (mmol/L) using a Lactate Pro 2 analyser (Arkray, Kyoto, Japan), and the (vii) rating of perceived exertion using the Borg Scale, with scores ranging from 6 to 20 (Borg, 1982).

Players' technical–tactical performance was evaluated by conducting a simulated futsal match (GK+4 vs. 4+GK) on a regular-sized futsal pitch. The match was 10 min in duration, interspersed with a 5-min recovery period. To ensure the teams were evenly matched, the players were divided on the basis of their skills, according to the coach's perception of their passing ability, ball control, shooting, and game knowledge. All the match situations were video recorded (a pair of cameras was positioned on each side of the goals) and downloaded to a computer to register the match performance statistics by using a video analysis system (PickleSports, Portugal). This software allows for the selection of key performance indicators and the generation of detailed performance statistics regarding individuals' and team performances. The match performance indicators were goals scored, shots on goal, successful passes, balls lost, balls recovered, and goals conceded (Santos et al., 2020).

Statistical analysis

First, a Shapiro–Wilk test was used to confirm the normal distribution of data ($p>0.05$). Descriptive statistics (mean, standard deviation, and 95% confidence interval) were reported. A univariate one-way repeated-measures analysis of variance (ANOVA) was then conducted to compare the effect of the timing of testing on the physical, physiological, and match performance indicators. No violations of the assumption of sphericity were detected. Effect sizes were computed on the basis of partial eta-squared ($\eta2$) values and interpreted in accordance with Ferguson (2009): without effect if $0<\eta2<0.04$, minimum effect if $0.04<\eta2<0.25$, moderate effect if $0.25<\eta2<0.64$, and strong effect if $\eta2>0.64$. Whenever data were (i) significant ($p\leq0.05$) with a medium/moderate or large/strong effect size ($\eta2>0.25$), this was reported as a 'meaningful variation', and where the data were (ii) significant (≤0.05) with a small effect size ($\eta2\leq0.25$), it was reported as a 'significant variation'. Post hoc Bonferroni's tests were used to make a pairwise comparison between the levels of the within-participant factor, namely the timing of testing (Winter, 2008). All the analyses were conducted using SPSS (version 23.0. Armonk, NY: IBM Corp), with the significance level being set at $p<0.05$.

Results

No significant differences were found for the physical-related variables between the different time points of evaluation (maximum velocity, $F(2,14)=1.21$, $p=.328$, $\eta2=.147$; total distance covered, $F(2,14)=1.61$, $p=.235$, $\eta2=.187$; and test duration, $F(2,14)=1.89$, $p=.187$, $\eta2=.213$).

However, the analysis of physiological variables revealed significant differences in initial heart rate between the different time points of evaluation ($F(2,14)=43.77$, $p<.001$, $\eta2=.862$). A posteriori comparison indicated that participants exhibited a larger initial heart rate at M1 (61.5±3.21) that significantly decreased over time (M2, 57.38±3.25; M3, 55.13±1.06). Significant differences were also observed in peak blood lactate concentration between the different time points of evaluation ($F(2,14)=12.45$, $p=.001$, $\eta2=.640$). A posteriori comparison demonstrated that participants exhibited a high peak blood lactate concentration at M1 that significantly decreased at M2 (M1, 11.49±1.82; M2, 6.99±1.95) and then stabilized with no differences between the second and third time points (M3, 9.13±2.51). Further analysis revealed no significant differences in peak heart rate ($F(2,14)=1.85$, $p=.194$, $\eta2=.209$) or perceived exertion ($F(2,14)=2.00$, $p =.172$, $\eta2=.222$; Fig. 1).

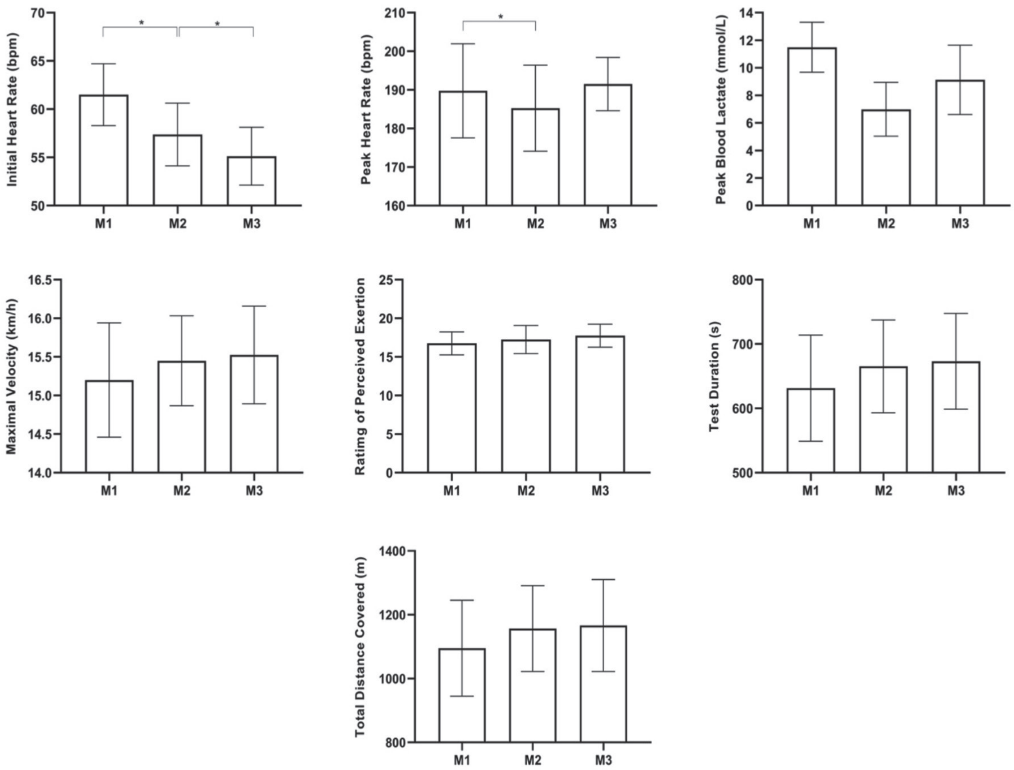

FIGURE 1. Descriptive values (mean and standard deviation) of physical and physiological variables.

With regard to players' technical–tactical performance, no significant differences were observed across the variables of goals scored ($F(2,14)=0.13$, $p=.876$, $\eta2=.019$), shots on goal ($F(2,14)=1.94$, $p=.180$, $\eta2=.217$), successful passes ($F(2,14)=1.67$, $p=.224$, $\eta2=.192$), balls lost ($F(2,14)=0.86$, $p=.444$, $\eta2=.109$), balls recovered ($F(2,14)=1.64$, $p=.23$, $\eta2=.190$), and goals conceded ($F(2,14)=0.88$, $p=.44$, $\eta2=.111$).

Table 1. Mean and standard deviation of physical, physiological and match-related performance variables

Variables	Moment 1	Moment 2	Moment 3
Maximal velocity reached	15.20(0.69)	15.45(0.55)	15.53(0.59)
Total distance covered	1095(140.51)	1156.88(125.82)	1166.25(134.53)
Test duration	631.38(82.49)	665.25(72.21)	673.13(74.53)
Initial heart rate	61.50(3)	57.38(3.04)	55.13(2.80)
Peak heart rate	189.75(11.40)	185.25(10.43)	191.50(6.44)
Peak blood lactate concentration	11.49(1.70)	6.99(1.83)	9.13(2.35)
Rating of perceived exertion	16.75(1.39)	17.25(1.71)	17.75(1.39)
Goals scored	0.88(1.05)	0.63(1.11)	0.75(0.66)
Shots on goal	3.13(1.62)	4.75(2.49)	2.75(1.64)
Successful passes	15.50(4.56)	19(3.61)	19.13(5.06)
Ball lost	5.00(2.45)	3(1)	2.88(1.62)
Ball recovery	2(1.12)	2.13(1.76)	3.25(0.97)
Goals conceded	3(1)	2.50(0.50)	3(1)

Discussion

This study examined futsal players seasonal physical, physiological, and technical–tactical adaptations at three different time points in the season (i.e. beginning of the preseason, middle of the first half of the season, and middle of the second half of the season). The results demonstrated that certain physiological variables such as initial heart rate and peak blood lactate concentration, which were evaluated through the FIET test, significantly varied through the season. The players' initial heart rate progressively decreased from the first to the last time point of evaluation, and the blood lactate concentration significantly decreased from the first to the second time point but then stabilized.

Amongst the physiological variables, only initial heart rate and peak blood lactate concentration exhibited significant variations, presenting higher values at the preseason time point compared to the in-season time points. This evidence may reflect the relatively poor fitness level of players of team sports that typically feature a preseason period. In fact, at the beginning of the season, coaching staffs tend to follow a periodization strategy where training loads tend to be higher for conditioning purposes. Previous research has corroborated this convention, reporting significant differences in the total weekly training load between the first and subsequent microcycles of professional female and male futsal teams (Miloski et al., 2012; Lago-Fuentes et al., 2020). For instance, Miloski et al. (2012) found larger training load (i.e. total weekly training load), monotony, and strain values in the preparatory period than in the competitive period. These training load dynamics are designed to induce an imbalance in the players' homeostasis to improve their physical fitness and enable them to achieve the desired performance level in competitions.

Initial heart rate values in the FIET progressively decreased over the season. Futsal has been consistently characterized as a high-intensity match sport that places heavy demands on both the aerobic and anaerobic systems. Additionally, players are required to perform high-intensity movements such as sprinting and tackling on an intermittent basis (Naser et al., 2017). Players covered almost a quarter of the total distance in the FIET at high intensity. The high-intensity and intermittent match profile is further supported by a work-to-rest ratio of approximately 1:1 (Barbero-Alvarez et al., 2008). That the initial heart rate in the FIET decreased from 61.5 bpm to 55.1 bpm from the initial to the last time point of evaluation may suggest that the training program induced relevant cardiorespiratory and mitochondrial adaptations, both at central and peripheral levels. A wealth of evidence indicates that the aerobic system provides the main source of energy (Makaje et al., 2012) and also contributes to removing blood lactate, which is critical, given the metabolic acidosis effects of high-intensity exercise and its detrimental influence on player performance (Glänzel et al., 2020). Therefore, the observed decrease in initial heart rate within the season may signal optimization of the aerobic system as a result of the training process.

In the present study, blood lactate concentration significantly decreased from the preseason to the middle of the first half of the season and then stabilized in the middle of the second half of the season. Blood lactate concentration is a solid indicator of the contribution of anaerobic glycolysis to overall performance in team sports (Krustrup et al., 2006). Previous research has reported peak BLac values of 12.6±2.3 mmol/L and 12±2.9 mmol/L, respectively, for the FIET and treadmill protocols (Castagna & Barbero-Alvarez, 2010). Our results accord with the findings of Castagna and Barbero-Alvarez (2010), especially the values observed in the preseason (11.49±1.82 mmol/L). Existing research has also provided additional insights into blood lactate variation during an official futsal match, with the results demonstrating that the BLac concentration of futsal players tends to rise from the beginning of a match to half-time and then stabilizes at the end of the match (Arslanoğlu et al., 2014). The present study corroborates previous research by highlighting the high-intensity nature of a futsal match and the predominant role of anaerobic metabolism. This study provides additional insight into how the BLac concentration of futsal players tends to stabilize throughout the season, which can be interpreted as a physiological adaption to training stimuli. In particular, improved capacity of the aerobic system to remove blood lactate may have contributed to the lower values observed at the second and third evaluations. Although tentative, such evidence was ascertained while not jeopardizing the capacity of the anaerobic pathway to support player performance given the high-intensity and intermittent physiological profile of futsal match play.

Surprisingly, no significant improvement in distance covered and test duration variables was observed. In this context, Oliveira et al. (2013) documented performance improvements in the repeated sprint ability (RSA) and Yo-Yo intermittent recovery test from the preseason to the in-season period. Worth noting is the fact that the FIET is a futsal-oriented high-intensity test, whereas the RSA and Yo-Yo are not. Hence, additional evidence is needed to determine the within-season sensitivity of both specific and general physical fitness tests to the performance of elite futsal players.

In futsal matches, players experience an informationally rich and time-contrived environment that requires accurate decision-making regarding when and where to move, pass, shoot, and recover ball possession (Travassos, Araújo, et al., 2012; Travassos, Duarte, et al., 2012). Furthermore, players with poor physical fitness struggle to consistently perform explosive actions and consequently technical–tactical performance is also impacted (Milanez et al., 2020; Rampinini et al., 2008). Unexpectedly, in the present study, the match performance variables did not change between the time points in analysis. Possibly, as a result of their high expertise, the participating players may have a superior level of technical and tactical skills that is not directly affected by their physical fitness. In addition, the stability observed in the physical-related variables may also suggest that the players experienced a degree of change in their physiological capacity to perform while co-adapting their perceptual and motor behaviours. Further research is required to understand the relationship between the different physical, physiological, and technical–tactical components and the specific thresholds that may generate bidirectional impacts on performance.

Our study has some limitations that should be noted. Due to the small sample size and the specificity of the players' technical–tactical performance evaluation task, further research involving larger cohorts is needed to clarify the within-season variations in match performance and whether they are closely related to physical variables. Further research should also be conducted over the course of a season by considering players' performance in competitive matches. Furthermore, future studies should incorporate a wide range of variables (session rating of perceived exertion, distance covered, accelerations, decelerations, speed thresholds, collective variables) to provide a comprehensive understanding of performance fluctuations across a season.

The results obtained in this study may provide guidance for the monitorization of futsal players performance across the season. In particular, sport coaches and practitioners may utilize heart rate and peak blood lactate measures as potential indicators of fitness levels, especially at the preseason time point. By this means, a solid performance basis may be created to sustain an optimal level of performance over the in-season period. In addition, the design of periodization strategies may be critically informed by a multidimensional spawn of information involving physical, physiological, and technical–tactical measures in order to induce favourable performance adaptations.

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Conflicts of Interest
The authors declare no conflict of interest.

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