

Original article

Improvement of physical performance, hormonal profile, recovery-stress balance and increase of muscle damage in a specific futsal pre-season planning



F.C. de A. Nogueira^{a,*}, V.H. de Freitas^b, R.A. Nogueira^a, B. Miloski^c, F.Z. Werneck^d, M.G. Bara-Filho^a

^a Department of Physical Education, Federal University of Juiz de Fora, Juiz de Fora, Brazil

^b Department of Physical Education, State University of Londrina, Londrina, Paraná, Brazil

^c School of Physical Education and Sports, University of São Paulo, São Paulo, Brazil

^d Sports Centre, Federal University of Ouro Preto, Ouro Preto, Brazil

ARTICLE INFO

Article history:

Received 5 May 2015

Accepted 16 November 2015

Available online 6 September 2016

Keywords:

Sports

Athletic performance

Fatigue

ABSTRACT

Objective: The aim of this study was to verify the effects of a specific pre-season planning on physical performance, recovery-stress state, hormonal and muscle damage markers in high-level futsal players.

Method: Fifteen male futsal players, members of a high level Brazilian futsal team participated in this study. Before and after four weeks of pre-season, blood samples were collected, the Recovery Stress Questionnaire for Athletes was applied, and vertical jump tests and Yo-Yo Intermittent Recovery Level 2 tests were performed. The Internal Training Load was measured in all training sessions. Repeated measure ANOVA was used to compare the Total Weekly Training Load between different weeks. To compare the differences between pre- and post-training of all other dependent variables (except the Recovery Stress Questionnaire for Athletes scales) the Student's *t*-test and the magnitude based inference were used.

Results: The futsal pre-season improved performance in the Yo-Yo Intermittent Recovery Level 2 and Squat Jump tests. The improvement in performance tests was accompanied by an increase in testosterone, creatine kinase, testosterone/creatine kinase ratio and in the majority of the Recovery Stress Questionnaire for Athletes scales. Cortisol and the social recovery and general well-being of Recovery Stress Questionnaire for Athletes scales decreased during the futsal pre-season.

Conclusions: In summary, players improved their performance in the Yo-Yo Intermittent Recovery Level 2 and Squat Jump tests in response to a futsal pre-season. Furthermore, the Internal Training Load behavior of the futsal training promoted a favorable hormonal anabolic environment and did not promote a negative disturbance in creatine kinase or stress/recovery balance, suggesting that futsal players did not report fatigue accumulation after this pre-season design.

© 2016 Consejería de Turismo y Deporte de la Junta de Andalucía. Published by Elsevier España, S.L.U. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

Mejora del rendimiento físico, perfil hormonal, balance estrés-recuperación y aumento del daño muscular basado en la planificación específica de pretemporada en el fútbol sala

RESUMEN

Objetivo: El objetivo de este estudio fue investigar los efectos de una planificación específica de pretemporada en el rendimiento físico, el estado de estrés-recuperación, marcadores hormonales y de daño muscular en jugadores de fútbol sala de alto nivel.

Método: Quince jugadores masculinos de fútbol sala, miembros de un equipo brasileño de fútbol sala de alto nivel participaron en el estudio. Antes y después de cuatro semanas de pretemporada, se recogieron muestras de sangre, se utilizó el Cuestionario de estrés y recuperación para atletas, además de

Palabras clave:

Deportes

Rendimiento atlético

Fatiga

* Corresponding author.

E-mail address: francine_andrade@hotmail.com (F.C.d.A. Nogueira).

la realización de la prueba de salto vertical y *Yo-Yo Intermittent Recovery Test Nivel 2*. La carga interna de entrenamiento se midió en todas las sesiones de entrenamiento. Se utilizó un análisis de varianza para medidas repetidas para comparar la carga total semanal de entrenamiento entre las diferentes semanas. Para comparar las diferencias entre antes y después del entrenamiento de todas las demás variables dependientes (excepto escalas del cuestionario de estrés y recuperación para atletas), se usaron el test T de Student y la magnitud basada en la inferencia.

Resultados: La pretemporada de fútbol sala mejoró el rendimiento en el *Yo-Yo Intermittent Recovery Test Nivel 2* y en el test *Squat Jump*. La mejora en las pruebas de rendimiento fue acompañada por un aumento en los niveles de testosterona, creatina quinasa, cociente testosterona/creatina quinasa y en la mayoría de las escalas del cuestionario de estrés y recuperación para atletas. El cortisol y la recuperación social y el bienestar general del cuestionario de estrés y recuperación para atletas disminuyeron durante la pretemporada de fútbol sala.

Conclusiones: En resumen, los jugadores mejoraron su rendimiento en el *Yo-Yo Intermittent Recovery Test Nivel 2* y en el test *Squat Jump*, en respuesta a la pretemporada. Además, el comportamiento de la carga interna de entrenamiento de la pretemporada promovió un entorno hormonal anabólico favorable y no generó una perturbación negativa en la creatina quinasa o en el equilibrio estrés/recuperación, lo que sugiere que los jugadores de fútbol sala no informaron de acumulación de fatiga después de este diseño de pretemporada.

© 2016 Consejería de Turismo y Deporte de la Junta de Andalucía. Publicado por Elsevier España, S.L.U. Este es un artículo Open Access bajo la licencia CC BY-NC-ND (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

Melhoria do desempenho físico, perfil hormonal, balanço estresse-recuperação e aumento do dano muscular em um planejamento específico da pré-temporada no futsal

R E S U M O

Palavras-chave:
Esportes
Desempenho atlético
Fadiga

Objetivo: O objetivo deste estudo foi verificar os efeitos de um planejamento específico da pré-temporada no desempenho físico, estado de estresse-recuperação, marcadores hormonais e de danos musculares em jogadores de futsal de alto nível.

Método: Quinze jogadores de futsal do sexo masculino, membros de uma equipe brasileira de futsal de alto nível participaram do estudo. Antes e após quatro semanas de pré-temporada, foram coletadas amostras de sangue, foi aplicado o Questionário de Estresse e Recuperação para Atletas, além da realização de testes de saltos verticais e do *Yo-Yo Intermittent Recovery Test Nivel 2*. A carga interna de treinamento foi mensurada em todas as sessões. Para análise dos dados, foi utilizada uma análise de variância para medidas repetidas a fim de comparar a carga de treinamento semanal total entre as diferentes semanas. O teste T de Student foi realizado para comparar as diferenças entre o pré e pós de todas as outras variáveis dependentes (exceto as escalas Questionário de Estresse e Recuperação para Atletas), além da magnitude baseada em inferência.

Resultados: A pré-temporada de futsal melhorou o desempenho no *Yo-Yo Intermittent Recovery Test Nivel 2* e no teste *Squat Jump*. A melhoria nos testes de desempenho foi acompanhado por um aumento nos níveis de testosterona, creatina quinase, testosterona/creatina quinase quociente e na maioria das escalas Questionário de Estresse e Recuperação para Atletas. O cortisol e as escalas de recuperação social e bem-estar geral do Questionário de Estresse e Recuperação para Atletas diminuíram durante a pré-temporada.

Conclusões: Em resumo, os jogadores melhoraram seu desempenho no *Yo-Yo Intermittent Recovery Test Nivel 2* e no teste *Squat Jump* em resposta à pré-temporada. Além disso, o comportamento das cargas de treinamento promoveram um ambiente hormonal anabólico favorável e não geraram um distúrbio negativo na creatina quinase ou no equilíbrio estresse/recuperação, fato que sugere que os jogadores de futsal não relataram fadiga acumulada após uma pré-temporada com este desenho de periodização.

© 2016 Consejería de Turismo y Deporte de la Junta de Andalucía. Publicado por Elsevier España, S.L.U. Este é um artigo Open Access sob uma licença CC BY-NC-ND (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

Introduction

The long competitive period in a futsal team schedule leads coaches and physical trainers to impose high training loads during the short pre-season to improve players' performances.^{1,2} The high intensity demand imposed by futsal matches in addition to repeated sprints, abrupt stops, accelerations and changes of direction performed during the games³ require that players have well developed aerobic, anaerobic and neuromuscular systems. Previous studies reported that a short futsal pre-season (i.e., 3–9 weeks) improved performance in the *Yo-Yo intermittent recovery (IR) test*,^{2,4–6} VO_2max ,⁵ repeated-sprint ability,² power of the lower limbs (i.e., inferred by vertical jump test)

and speed¹ of futsal players. However, only one of the aforementioned studies⁶ reported the magnitude of the training load worked (i.e., internal training load) and the effect of this training load on psychophysiological markers, as well as in physical performance tests. In this sense, it is difficult to establish whether the effect of pre-season on performance tests was amalgamated with fatigue accumulation.

It is well established that some tools are available to quantify training load and monitor respective training induced responses in high-level athletes. The session rating of perceived exertion (session-RPE) method is a simple, cheap and valid tool to monitor internal training load (ITL) in team sports and it is commonly used in monitoring futsal training.^{1,4,5,7,8} Similarly,

Table 1
Schedule of futsal pre-season.

	Week	1	2	3	4
	Main goals	S/TT/A	S/TT/A	S/TT/An	S/TT/Sp
Strength	Number of sessions	3	3	3	2
	Effort	4 sets 8–10 RM 75–90 s			4 sets 4–6 RM 180 s
Aerobic/anaerobic lactic	Rest between sets				
	Number of sessions	4	2	2	1
	Effort	3 sets 4 × 60 s MAS 60 s walking 150 s			3 sets 3 × 30 s all out 30 s walking 150 s
Speed/power	Rest between efforts				
	Rest between sets				
	Number of sessions	0	0	0	1
	Effort	x	x	x	1 set of 8 × 10 m straight-line sprints 60–90 s passive rest 6
	Rest between sets				
Technical/tactical skills	Number of sessions	4	7	8	
	Efforts	Ball-drill exercises, small-sided games, simulated games Purpose of these exercises changed according to specific technical and tactical team necessities			
Flexibility	Number of sessions	1	1	1	1
Core		2	2	2	1
Injury prevention		1	1	1	0
Friendly matches	Number of matches	0	0	0	2

A: aerobic; An: anaerobic lactic; MAS: maximal aerobic speed; Sp: speed; S: strength; TT: technical and tactical.

the Recovery and Stress Questionnaire for Athletes (RESTQ)⁹ is a valid questionnaire often used to monitor stress and recovery in team sports.^{10–13} Biochemical variables, such as Creatine Kinase (CK), and hormonal variables such as testosterone and blood cortisol concentration are used to monitor muscle damage and disturbance in the hypothalamus–pituitary–adrenal and hypothalamus–pituitary–gonadal axis, respectively; all of them indicators of fatigue accumulation.^{12,14,15} Thus, RESTQ, CK, testosterone and cortisol are potential indicators (markers) to be used for monitoring disturbances caused by fatigue accumulation in response to a futsal pre-season.

The Yo-Yo IR test is the most commonly used physical test to assess performance in team sports such as soccer and futsal^{2,4,6,16–18} and the YYIR2 actually seems to be more responsive to futsal training than the YYIR1.⁴ Hence, more studies reporting the behavior of the YYIR2 during the futsal training period are warranted. Power of lower limb is an important factor in decisive moments of futsal games such as kicking the ball at the goal, disputing the ball and counterattacking. Vertical jump (VJ) tests (i.e., squat jump (SJ); drop jump (DJ)); countermovement jump (CMJ) tests) are physical tests frequently used to monitor changes in the physical capacity of futsal players.^{1,6} The different biomechanical, neuromuscular and elastic components involved in SJ, DJ and CMJ^{19,20} suggest that these tests can change differently in response to futsal training, indicating different adaptations in the neuromuscular system. However, to the best of our knowledge, the changes in the different VJ tests in response to specific futsal training have not yet been investigated.

Although knowledge about the behavior of psychophysiological markers and performance tests in response to the training load worked in pre-season could help coaches and physical staff to plan future training programs, physical performance and psychophysiological responses to a pre-season phase in high-level futsal players are still unclear. Thus, the main aim of this study was to verify the effects of a specific pre-season planning on physical performance, recovery-stress state and hormonal and muscle damage markers in high-level futsal players.

Method

Subjects

Fifteen male futsal players (age 28.4 ± 6.6 years, body mass 75.0 ± 6.6 kg; height 173.8 ± 5.2 cm; body fat $11.6 \pm 3.7\%$), members of a high level Brazilian futsal team, participated in this study. After presentation of the study proposal and explanation of the possible risks involved in the process, players testified voluntary participation and authorized the use and disclosure of information. The study procedures were in accordance with the international standards of human experimentation (Declaration of Helsinki), and approved by the local ethics committee (protocol n° 2501.241.2011).

Experimental design

The futsal players returned from an off-season period during which physical activities were not controlled. The training program implemented during the pre-season phase was planned by team staff (Table 1). Before and after 4-weeks of pre-season, blood samples were collected, the RESTQ was applied, and vertical jump tests and YYIR2 were performed at 9:00 a.m. after 48 h without training sessions. Players were instructed not to ingest alcohol and caffeine for 24 h prior to data collection. Players performed 10 min of warm up before the physical performance tests, consisting of stretching and jogging at a comfortable pace. The ITL was measured in all training sessions using the Session-RPE method.⁷ Players were familiarized with the RPE scale, questionnaires and physical tests performed.

Blood collection was performed by a trained nurse, respecting the principles of biosecurity required. Five ml of blood were collected from the antecubital fossa arm vein, and stored in tubes with a gel separator and taken to the laboratory to be analyzed on the same day. For CK analysis, the blood sample was centrifuged for 5 min at 3200 rpm and the serum obtained was analyzed using specialized equipment (Biochemistry 3000 BT Plus® kit with Beckman

Coulteur®). Testosterone and cortisol were analyzed using specific chemiluminescence tests, following the Bio System Kit specifications, according to the laboratory routine. The technique was developed by an Elecsys 2010 machine from Roche Diagnostics and the laboratory has a quality system certified by ABNT/INMETRO/ISO 9001/2000.

To carry out the vertical jump (VJ) tests an Ergojump carpet (Cefise®, Brazil) was used, with the analysis being performed using Jump System 1.0 software (Cefise®, Brazil). Three jump tests were performed in the following order: SJ, CMJ and DJ. For SJ, the athletes started in a squatting position with knees at approximately 90°, focusing only on the concentric phase of the movement. For CMJ, the athletes started in a standing position and then squatted and jumped at fast velocity to perform the jump with stretch-shortening cycle (SSC). The DJ started with the athlete in a standing position, at 40 cm above the Ergojump Carpet and the participants then squatted and jumped at fast velocity to perform the jump with SSC. The athletes were instructed to keep their hands on their waist. All players performed three trials for each jump test, with a 60 second interval between each attempt. The average of the best two performances was retained for analysis.

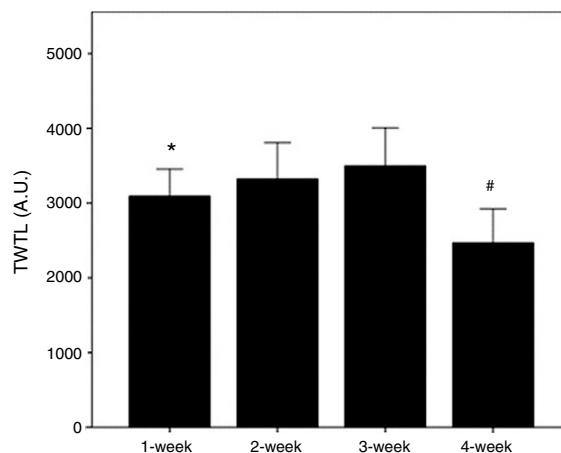
Statistical analysis

The data are presented as mean and standard deviation. The data normality was tested using the Shapiro–Wilk test. Repeated measure ANOVA was used to compare the TWTL between different weeks. To compare the differences between pre- and post-training of all other dependent variables (except the RESTQ scales) the Student's *t*-test and the magnitude based inference (MBI)²¹ were used, from which the smallest worthwhile change (i.e., $0.2 \times$ standard deviation) and 90% confidence intervals were also determined. The qualitative ranking utilized was: <1%, almost certainly not; 1–5%, very unlikely; 5–25%, unlikely; 25–75%, possible; 75–95%, likely; 95–99%, very likely; >99%, almost certain. If the positive and negative result values were both >5% the results were deemed as unclear. The MBI analyzes were conducted using a spreadsheet posted on the web-site <http://www.sportsci.org/resource/stats/SPSS> software, version 20.0 was used for all analyses.

Results

The TWTL of the four pre-season weeks is shown in Fig. 1. The TWTL of the first week was lower than that of the third week, and the TWTL of the fourth week was lower than in the other three weeks ($p < 0.01$).

The performance in the YYIR2 and SJ tests increased after pre-season ($p < 0.01$), however the CMJ and DJ did not change with training ($p \geq 0.05$). MBI analyzes demonstrated that the chances of SJ, CMJ, DJ and YYIR2 improving with training were very likely,



* Significant difference compared to week 3; # Significant difference compared to weeks 1, 2 and 3 ($p < 0.01$). TWTL = Total weekly training load; A.U. = Arbitrary units

Fig. 1. TWTL of the 4 weeks of training.

possible, unlikely, almost certain, respectively (Table 2). The CK, testosterone and testosterone/cortisol ratio (T/Cr) increased, and cortisol decreased in response to pre-season training ($p < 0.01$). The MBI analyzes showed that the chances of testosterone, cortisol, T/Cr and CK changing with training were possible, very likely, almost certain and almost certain, respectively (Table 2).

The RESTQ scales “general stress, social stress, lack of energy, physical recovery and sleep quality” did not change and the “social recovery and general well-being” scales decreased with training. All others RESTQ scales were higher after the training program ($p < 0.05$) (Figs. 1 and 2).

Discussion

The main results found in the present study were that the futsal pre-season improved performance in the YYIR2 and SJ tests. The improvement in performance tests was accompanied by an increase in testosterone, CK, T/Cr and in the majority of the RESTQ scales. Cortisol and the social recovery and general well-being RESTQ scales decreased during the futsal pre-season.

The ITL monitored during the futsal pre-season in the present study increased during the first three weeks and decreased in week fourth. Intensification of the ITL followed by a period of decrease has been reported previously in team sports.^{12,14,15,22} This training load distribution provides a moment of fatigue accumulation, and, consequently, worsening performance in physical tests^{14,15} which is followed by supercompensation and improving performance in physical tests.^{14,15,22} The improvement in physical tests, in response to training load distribution, demonstrated

Table 2
Changes in performance in physical tests and in biochemical variables during pre-season training.

Physical tests	Pre-season	Post-season	p-Value	MBI
SJ (cm)	36.31 ± 4.08	39.01 ± 4.47	0.01 [*]	98/2/0
CMJ (cm)	40.11 ± 4.73	41.13 ± 5.38	0.05	56/44/0
DJ (cm)	38.33 ± 4.75	38.21 ± 5.41	0.84	4/88/8
YYIR2 (m)	573.33 ± 193.42	762.67 ± 211.37	<0.01 [*]	100/0/0
Testosterona (pg ml ⁻¹)	14.43 ± 1.62	14.78 ± 1.43	<0.01 [*]	58/42/0
Cortisol (μg ml ⁻¹)	18.11 ± 4.17	14.61 ± 3.64	<0.01 [*]	0/1/99
T/Cr	0.85 ± 0.25	1.08 ± 0.33	<0.01 [*]	100/0/0
CK (U L ⁻¹)	221.00 ± 101.35	433.20 ± 259.81	<0.01 [*]	100/0/0

CMJ: Countermovement jump; CK: creatine kinase; DJ: drop jump; MBI: magnitude based inference; SJ: squat jump; T/Cr: testosterone/cortisol ratio; YYIR2: Yo-Yo Intermittent Recovery Test Level 2.

^{*} Post-training better than pre-training ($p < 0.05$).

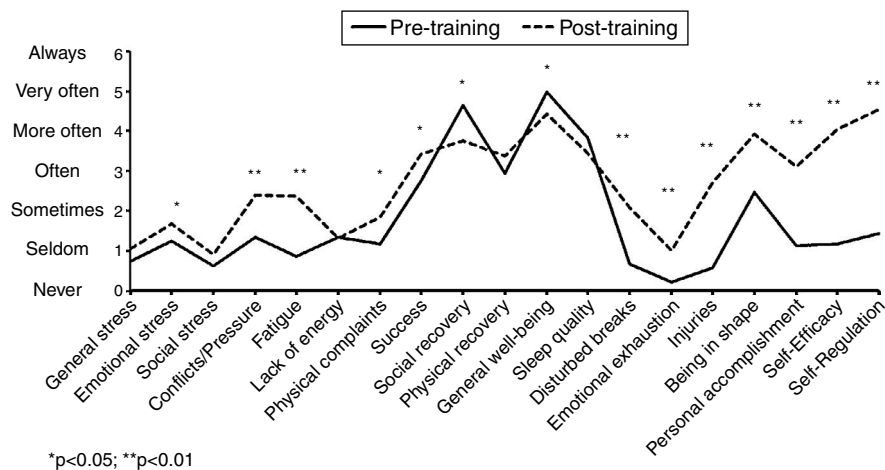


Fig. 2. The pre-training and post-training RESTQ scales.

in the present study is in accordance with the aforementioned studies.^{14,15,22}

The supercompensation phenomena reported above is a possible explanation for the higher values in the YYIR2 (~35%) found in the present study, compared with ~25% improvement previously reported in futsal and soccer players after a period of training.^{4,18} Furthermore, the high intensity characteristics of futsal training and matches, with a large contribution from the aerobic and anaerobic system, justify the improvement in the YYIR2.^{3,4} The SJ was the only neuromuscular test that significantly changed in response to the futsal pre-season. The strength training, accelerations, and other actions involved in futsal training could be responsible for the improvement in SJ in the present study as previously reported in female basketball players.²² The stress RESTQ scales (i.e., Emotional stress, conflict/pressure, fatigue, physical complaints, disturbed breaks, emotional exhaustion and injuries) increased and the recovery scales (i.e., social recovery and general well-being) decreased in response to the futsal pre-season. Furthermore, in the present study, some recovery scales (i.e., being in shape, personal accomplishment, self-efficacy and self-regulation) increased with training, suggesting that the futsal pre-season positively changed the sport specific recovery scales.

The level of increase in CK blood concentration found in the present study (i.e., 221.0–433.2 U L⁻¹) was lower than the level reported in previous studies (i.e., ~400 to ~1300 U L⁻¹) in which CK was associated with decreased performance in physical tests.^{14,15} Despite an increase in CK blood concentration, players improved their performance in the YYIR2 and SJ tests. A similar increase in CK blood concentration (i.e., ~180 to ~580 U L⁻¹) was not associated with changes in performance in the CMJ test in volleyball players after a period of training load intensification.¹² Possibly the small increase in CK reported in the present study is a physiological behavior in futsal players and does not impact on performance in physical tests. Changes in cortisol and testosterone blood concentration reflecting in a decrease in T/Cr have been reported in athletes with symptoms of fatigue accumulation.^{14,15} However, the results found in the present study showed that cortisol decreased, while testosterone and T/Cr increased in response to a futsal pre-season. Since cortisol is a catabolic and testosterone an anabolic hormone,²³ the results found suggest that the futsal pre-season promoted an anabolic environment in the players analyzed.

In summary, players improved their performance in the YYIR2 and SJ tests in response to a futsal pre-season. Despite possible improvement in the CMJ test, the futsal pre-season, without explosive training, did not promote large changes in this variable. Furthermore, the ITL behavior of the futsal training in the present

study promoted a favorable hormonal anabolic environment and did not promote a negative disturbance in CK or stress/recovery balance (i.e., RESTQ scales), suggesting that futsal players did not report fatigue accumulation after a pre-season composed of three weeks of accumulated ILT followed by one week of decreased ITL. The results found in the present study suggest that coaches and physical trainers could use an ITL distribution similar to that used in the present study aiming to improve performance in physical tests without increasing fatigue accumulation markers. Furthermore, the training load application should be accompanied by frequent monitoring of the physical performance and psychophysiological markers to ensure that the ITL distribution is appropriate to different futsal players.

Ethical disclosures

Protection of human and animal subjects. The authors declare that the procedures followed were in accordance with the regulations of the relevant clinical research ethics committee and with those of the Code of Ethics of the World Medical Association (Declaration of Helsinki).

Confidentiality of data. The authors declare that no patient data appear in this article.

Right to privacy and informed consent. The authors declare that no patient data appear in this article.

Conflicts of interest

The authors have no conflicts of interest to declare.

Acknowledgments

The authors thank the athletes and the coaching staff of the team. They also thanks the Fapemig for financial aid.

References

- Freitas VH, Miloski B, Bara Filho MG. Quantificação da carga de treinamento através do método percepção subjetiva do esforço da sessão e desempenho no futsal. *Rev Bras Cineantropom Desempenho Hum.* 2012;14:73–82.
- Oliveira RS, Leicht AS, Bishop D, Barbero-Álvarez JC, Nakamura FY. Seasonal changes in physical performance and heart rate variability in high level futsal players. *Int J Sports Med.* 2013;34:424–30.
- Castagna C, D'Ottavio S, Granda Vera J, Barbero Álvarez JC. Match demands of professional Futsal: a case study. *J Sci Med Sport.* 2009;12:490–4.

4. de Freitas VH, Pereira LA, de Souza EA, Leicht AS, Bertollo M, Nakamura FY. Sensitivity of the Yo-Yo Intermittent Recovery Test and cardiac autonomic responses to training in futsal players. *Int J Sports Physiol Perform*. 2015;10:553–8.
5. Miloski B, Moreira A, Andrade FC, Freitas VH, Peçanha T, Nogueira RA, et al. Do physical fitness measures influence internal training load responses in high-level futsal players? *J Sports Med Phys Fitness*. 2014;54:588–94.
6. Soares-Caldeira LF, de Souza EA, de Freitas VH, de Moraes SM, Leicht AS, Nakamura FY. Effects of additional repeated sprint training during preseason on performance, heart rate variability, and stress symptoms in futsal players: a randomized controlled trial. *J Strength Cond Res*. 2014;28:2815–26.
7. Foster C, Florhaug JA, Franklin J, Gottschall L, Hrovatin LA, Parker S, et al. A new approach to monitoring exercise training. *J Strength Cond Res*. 2001;15:109–15.
8. Milanez VF, Pedro RE, Moreira A, Boullosa DA, Salle-Neto F, Nakamura FY. The role of aerobic fitness on session rating of perceived exertion in futsal players. *Int J Sports Physiol Perform*. 2011;6:358–66.
9. Kellmann M, Kallus KW. Recovery-stress questionnaire for athletes: user manual. Champaign: Human Kinetics; 2001.
10. Coutts AJ, Reaburn P. Monitoring changes in rugby league players' perceived stress and recovery during intensified training. *Percept Mot Skills*. 2008;106:904–16.
11. di Fronso S, Nakamura FY, Bortoli L, Robazza C, Bertollo M. Stress and recovery balance in amateur basketball players: differences by gender and preparation phase. *Int J Sports Physiol Perform*. 2013;8:618–22.
12. Freitas VH, Nakamura FY, Miloski B, Samulski D, Bara-Filho MG. Sensitivity of physiological and psychological markers to training load intensification in volleyball players. *J Sports Sci Med*. 2014;13:571–9.
13. Freitas VH, Souza EA, Oliveira RS, Pereira LA, Nakamura FY. Efeito de quatro dias consecutivos de jogos sobre a potência muscular, estresse e recuperação percebida, em jogadores de futsal. *Rev Bras Educ Fís Esporte*. 2014;28:23–30.
14. Coutts A, Reaburn P, Piva TJ, Murphy A. Changes in selected biochemical, muscular strength, power, and endurance measures during deliberate overreaching and tapering in rugby league players. *Int J Sports Med*. 2007;28:116–24.
15. Coutts AJ, Reaburn P, Piva TJ, Rowsell GJ. Monitoring for overreaching in rugby league players. *Eur J Appl Physiol*. 2007;99:313–24.
16. Bangsbo J, Iaia FM, Krstrup P. The Yo-Yo intermittent recovery test: a useful tool for evaluation of physical performance in intermittent sports. *Sports Med*. 2008;38:37–51.
17. Krstrup P, Mohr M, Amstrup T, Rysgaard T, Johansen J, Steensberg A, et al. The yo-yo intermittent recovery test: physiological response, reliability, and validity. *Med Sci Sports Exerc*. 2003;35:697–705.
18. Krstrup P, Mohr M, Nybo L, Jensen JM, Nielsen JJ, Bangsbo J. The Yo-Yo IR2 test: physiological response, reliability, and application to elite soccer. *Med Sci Sports Exerc*. 2006;38:1666–73.
19. Bobbert MF, Gerritsen KG, Litjens MC, Van Soest AJ. Why is countermovement jump height greater than squat jump height? *Med Sci Sports Exerc*. 1996;28:1402–12.
20. Bobbert MF, Mackay M, Schinkelshoek D, Huijing PA, van Ingen Schenau GJ. Biomechanical analysis of drop and countermovement jumps. *Eur J Appl Physiol Occup Physiol*. 1986;54:566–73.
21. Batterham AM, Hopkins WG. Making meaningful inferences about magnitudes. *Int J Sports Physiol Perform*. 2006;1:50–7.
22. Nunes JA, Moreira A, Crewther BT, Nosaka K, Viveiros L, Aoki MS. Monitoring training load, recovery-stress state, immune-endocrine responses, and physical performance in elite female basketball players during a periodized training program. *J Strength Cond Res*. 2014;28:2973–80.
23. Fragala MS, Kraemer WJ, Denegar CR, Maresh CM, Mastro AM, Volek JS. Neuroendocrine-immune interactions and responses to exercise. *Sports Med*. 2011;41:621–39.