International Journal of Sports Physiology and Performance, 2021, 16, 557-564
https://doi.org/10.1123/ijspp.2020-0071

Human Kinetics
ORIGINAL INVESTIGATION

Preseason Training Improves Perception of Fatigue and Recovery From a Futsal Training Session

Carolina Franco Wilke, Samuel P. Wanner, Eduardo M. Penna, André Maia-Lima, Weslley H.M. Santos, Flávia C. Müller-Ribeiro, Thiago T. Mendes, Rubio S. Bruzzi, Guilherme P. Ramos, Fábio Y. Nakamura, and Rob Duffield

Purpose: To compare the posttraining recovery timeline of elite Brazilian futsal athletes before (Pre-PS) and after 10 weeks of the preseason (Post-PS) period of high-intensity technical–tactical training. ***Methods:*** At the start (n = 13) and at the end of the preseason (n = 7), under-20 male futsal players undertook fitness testing for maximal aerobic power, the countermovement jump (CMJ), and the 10-m sprint with change of direction. Furthermore, at both Pre-PS and Post-PS, the players participated in a training session where performance and psychophysiological measures were recorded before, immediately, 3, 24, and 48 hours postsession. The measures included CMJ, 10-m sprint, creatine kinase, Total Quality Recovery Scale, and Brunel Mood Scale. Effect size (ES) analyses compared fitness and posttraining recovery values for each parameter at Pre-PS versus Post-PS. ***Results:*** Only trivial ES (−0.02 to 0.11) was evident in maximal aerobic power, CMJ, and 10-m sprint at Post-PS compared with Pre-PS. For the timeline of recovery, only trivial and small ESs were evident for the 10-m sprint (−0.12 to 0.49), though CMJ recovery was improved at 3 hours (0.87) and 48 hours (1.27) at Post-PS and creatine kinase was lower at 48 hours (−1.33) at Post-PS. Perception of recovery was improved in Post-PS at 3 hours (1.50) and 24 hours postsession (0.92). Furthermore, perception of effort was lower immediately after the session (−0.29), fatigue was lower at 3 hours (−0.63), and vigor responses were improved in all postseason assessments (0.59 to 1.13). ***Conclusion:*** Despite minimal changes in fitness, preseason training attenuated players' perception of effort and fatigue and improved their recovery profile following a high-intensity technical–tactical training session.

Keywords: CMJ, fitness, indoor soccer, performance, team sport, TQR

Futsal match demands lead to high physical and physiological strain[1] alongside increased inflammation and muscle damage.[2] To adequately prepare players, preseason training programs involve 8 to 10 sessions per week,[3] creating a condensed weekly schedule whereby appropriate posttraining recovery is difficult yet important to ensure readiness to perform.[4] However, knowledge of the posttraining recovery timeline in futsal is limited.[5,6] In addition, cross-sectional studies have shown that individual physical capacities (eg, aerobic) may affect the postexercise recovery timeline.[5,7,8] However, investigation of training effect on recovery in ecologically valid settings remains sparse.

Recovery is a multifactorial phenomenon in which central and peripheral factors interact to allow the return of performance, physiological, or perceptual perturbations to near baseline values.[9] Regarding postmatch recovery in futsal, a previous study[10] reported decreased countermovement jump (CMJ) and 10-m sprint speed at 5 hours postmatch. Postmatch decrements in CMJ and repeated-sprint ability were also observed,[6] returning to prematch values within 24 hours, despite muscle soreness still remaining increased. These studies suggest recovery times are shorter for futsal matches than other team sports,[8,11] likely due to lower external loads.[4] However, futsal players perform a higher number of training sessions in each microcycle during the in-season.[3] Therefore, understanding the timeline of posttraining recovery is important to orient the prescription of load and recovery for optimal player readiness, though it is yet to be investigated.

Importantly, recovery timelines vary according to players' characteristics, such as physical capacity and training exposure.[12,13] Johnston et al[8] reported rugby league players with higher aerobic power exhibited lower postmatch impairment followed by faster peak power recovery in CMJ and plyometric press-up. Albeit interesting, individual factors related to aerobic power (eg, age, performance level)[14] underlying such cross-sectional studies limit inferences on the effect of training on recovery. The preseason training period in team sports is used to develop physical performance due to in-season congested schedules, and it has been shown to be effective for high-level futsal athletes.[3,15] Collectively, it seems reasonable to infer that increased training exposure may benefit postexercise recovery in futsal, though supporting evidence remains limited.

Accordingly, the aims of this study were (1) to characterize the 48-hour recovery timeline of physical performance and psychophysiological parameters of under-20 (U20) futsal athletes after a typical high-intensity technical-tactical training session and (2) to investigate whether a preseason training period improves recovery

Wilke, Wanner, Penna, Maia-Lima, Santos, Müller-Ribeiro, Mendes, Bruzzi, and Ramos are with the Exercise Physiology Laboratory, School of Physical Education, Physiotherapy and Occupational Therapy, Universidade Federal de Minas Gerais, Belo Horizonte, Brazil. Wilke and Duffield are with the Sport and Exercise Discipline Group, Faculty of Health, University of Technology Sydney, Sydney, NSW, Australia. Wilke is also with the Unified Center for Identification and Development of High-Performance Athletes (CUIDAR), Clube de Regatas do Flamengo, Rio de Janeiro, Brazil. Penna is also with the Universidade Federal do Pará, Castanhal, Brazil. Mendes is with the Universidade Federal do Maranhão, Pinheiro, Brazil. Ramos is also with the Brazilian Football Confederation (CBF), Rio de Janeiro, Brazil. Nakamura is also with the Universidade Federal da Paraíba, João Pessoa, Brazil, and the Dept of Medicine and Aging Sciences, "G. d'Annunzio" University of Chieti-Pescara, Chieti-Pescara, Italy. Wilke (carol_wilke@hotmail.com) is corresponding author.

from a high-intensity futsal training session using a multiparameter recovery assessment.

Materials and Methods

Participants

After receiving an explanation of all procedures, 13 male U20 futsal players from a professional Brazilian club provided informed consent and were cleared to participate by the team's medical physician. The study was approved by the Federal University of Minas Gerais' Ethics Committee (50166015.9.0000.5149). During the preseason, 6 players were excluded from the sample after leaving the team due to technical proficiency or personal/career reasons. Therefore, we acknowledge the underpowered nature of the data analysis with 13 (age 18.8 [1.0] y, body mass 67.2 [8.5] kg, and stature 174 [7] cm) and 7 (age 18.7 [0.7] y, body mass 65.0 [5.5] kg, and stature 174 [6] cm) players for the first and second objectives, respectively.

Methodology

Study Design. Following 6 to 8 weeks of an off-season break, national-level U20 futsal players underwent anthropometric and maximal aerobic power (VO_2max) measurements at the start of preseason (Pre-PS) and again after 10 weeks of preseason (Post-PS). Within 7 days, the players undertook a high-intensity technical–tactical training session followed by 48-hour postsession recovery assessments. Physical, physiological, and perceptual markers were assessed before, immediately, 3, 24, and 48 hours after the respective Pre-PS and Post-PS testing sessions. Both sessions occurred in the morning, on a standard 38 × 20-m indoor futsal court.

Participant Characterization. Anthropometry and VO_2max were measured at Pre-PS and Post-PS at the same time of the day. Stature, body mass (MF100; Filizola, São Paulo, Brazil), and skinfold (Lange, skinfold caliper; Beta Technology, Santa Cruz, CA) assessments were followed by an incremental test to determine VO_2max, maximal heart rate (HR_{max}), and ventilatory threshold (VT).[16] On a treadmill (HPX 380; Total Health, Jaboticabal, Brazil) at a 1% gradient, initial speed was set at 6 $km{\cdot}h^{-1}$, increased by 1.0 $km{\cdot}h^{-1}{\cdot}min^{-1}$ until volitional fatigue.[5] Oxygen consumption and heart rate (HR) (RS801; Polar Electro Oy, Kempele, Finland) were measured continuously. A rating of perceived exertion (RPE)[17] was provided at the end of each stage and the end of the exercise. The spirometer ($K4b^2$; COSMED, Rome, Italy) was calibrated before each test according to the manufacturer's instructions. The highest 30-second value on the respective variable was considered to be the VO_2max and HR_{max}. Due to technical malfunctions, 6 out of the 7 players completed this test Pre-PS and Post-PS.

Recovery Training Session. High-intensity 70-minute technical–tactical training sessions were performed on the third and 12th weeks of the preseason. To ensure ecological validity, they were conducted by the coaches, aiming at (1) a high-intensity technical–tactical training session and (2) replicating the Pre-PS intensity at Post-PS, irrespective of tactical content (Table 1).

To monitor training load, the players wore a Global Positioning Satellite device coupled with a triaxial accelerometer with a sampling frequency of 100 Hz (SPI ProX2; GPSports Systems, Canberra, Australia), with appropriate reliability,[18] and a compatible HR receiver (Polar Electro Oy). External training load was assessed by player load (PL),[19] and internal training load was assessed by the HR- and RPE-derived parameters. The mean HR was calculated as a percentage of HR_{max} (%HR_{max}), and the training impulse (TRIMP) was calculated according to the Edwards method.[20] The individual RPE values were used as an indication of intensity, and the session RPE (sRPE) values were used as an overall internal load index (RPE × sessions' duration).[17]

Recovery Timeline Characterization. Upon arrival for the training session, the baseline assessments included a capillary blood sample collection for analysis of creatine kinase (CK) concentration (Reflotron; Roche, Basel, Switzerland; intraessay coefficient of variation [CV] < 3%).[21] Then, the players answered a wellness questionnaire including (1) perceived sleep quantity and quality (1 = very bad and 5 = very good); (2) a total quality recovery scale (TQR),[22] previously reported as being sensitive to weekly training accumulation[23]; and (3) a Portuguese version of the Brunel Mood

Table 1 Description of the Training Sessions Held Pre-PS and Post-PS for Characterization of the 48-Hour Recovery Timeline

Pre/Post	Field players involved	Court size	Duration	Rules
Pre-PS				
1	4 × 4	Full-court	21 min + 34 min with 8-min interval in between	Similar rules to an official match Free time and number of player substitutions allowed Short (30–120 s) pauses during each block for instructions
Post-PS				
1	6 × 3	Half-court	15 min	Similar rules to an official match
2	2 × 1 followed by 3 × 2, 3 × 3, and 4 × 4	Full-court	5 min	The team that started with the ball possession had to make a fast attempt to score a goal. Irrespective of the result (scored or not), either the goalkeeper or the coaching staff made a quick ball reposition to the opposite team, who should perform a counterattack as fast as possible. This sequence was repeated 4 times without interval. Each time, more players were added to the activity.
3	4 × 4	Full-court	7 min	Similar rules to an official match
4	2 × 1 followed by 3 × 2, 3 × 3 and 4 × 4	Full-court	5 min	Same as activity 2

Abbreviations: Pre-PS, before preseason; Post-PS, after 10 weeks of preseason.

Scale (BRAMS), from which vigor and fatigue were analyzed (Cronbach $\alpha = .79–.85$).[24]

A 15-minute warm-up, composed of different running speeds, change of direction, and futsal-specific drills, was followed by CMJ and a 20-m sprint test with change of direction. For the CMJ, the players performed hip and knee flexion up to approximately 90°, followed by a rapid hip and knee extension to achieve the highest possible height, while maintaining hands on their waist. Four jumps were performed on a force platform (Ergo System, Globus, Codogné, Italy) interspersed by 15 seconds, and the mean jump height was used for analyses. Previous studies have shown high reliability in the CMJ test (ie, CV = 2.8% and intraclass correlation coefficient = .98).[25] A 20-m sprint test with 180° change of direction at 10 m, based on the 505 test (ICC between .87 and .99),[26] was used to evaluate the players' ability to accelerate, decelerate, and change direction. The time to complete 10 and 20 m were measured by timing gates (Multisprint; Hidrofit, Belo Horizonte, Brazil) positioned at the start/finish line and at 10 m. Due to a technological malfunction, only the first 10-m times were used for analysis, and this test is referenced as the 10-m test.

Following the baseline measurements, the training session was undertaken. Immediately after the session, the players repeated the CMJ and 10-m tests and provided a blood sample to determine the CK concentration. Approximately 15 minutes after the session, they reported RPE and BRAMS. To determine the recovery timeline for each variable, all procedures adopted prior to the beginning of the training session were repeated 3, 24, and 48 hours after. During this period and 48 hours prior to the sessions, no recovery interventions or training sessions were performed, and the participants were instructed to record their diet and abstain from alcohol, caffeine, and high-intensity exercises.

Preseason Training. The training schedules during the preseason included 1 technical–tactical session per day, from Monday to Saturday. Training was usually performed in the morning, on one of the 3 courts available at the training facilities: 36 × 20, 31 × 19, or 25 × 15 m. The technical–tactical sessions' duration was approximately 90 minutes and included activities aimed at the development of team shape, technical, and decision-making skills. In addition, 5 friendly matches were performed. The weekly routines also included 3 strength-training sessions per week, usually in the afternoon. The sessions were composed of general upper body, lower body, and core exercises aimed at hypertrophy and strength.

The training loads in all technical–tactical sessions were monitored, as described earlier. Furthermore, between 15 and 20 minutes following the sessions, the players reported RPE. The training load parameters (PL, $\%HR_{max}$, TRIMP, and sRPE) were calculated for each session.

Statistical Analysis

To characterize the timeline of recovery following a high-intensity training session, data from the Pre-PS were used. After verifying the data distribution using the Shapiro–Wilk test, normally distributed variables (CMJ, 10 m, and vigor; mean [SD]) were analyzed using a repeated-measures 1-way analysis of variance with respective partial eta squared (η_p^2) for the analysis of ES, followed by the Tukey post hoc test, when applicable, to determine changes over the course of recovery (immediately, 3-, 24-, and 48-h post). Nonnormally distributed variables (CK, TQR, and fatigue; median [interquartile interval]) were compared using the Friedman test with respective Kendall W for the analysis of ESs, followed by the Wilcoxon post hoc test, when applicable. The magnitude of effect for pairwise comparisons was analyzed using Cohen d with 95% confidence interval. The magnitude of d was qualitatively interpreted using the following thresholds: <0.2, trivial; 0.2 to 0.6, small; 0.6 to 1.2, moderate; 1.2 to 2.0, large; 2.0 to 4.0, very large; and >4.0, nearly perfect.[27]

Due to the low sample size, the magnitude of differences of baseline measures and training load at Pre-PS and Post-PS, as well as from the percentage change from the baseline at each time (immediately, 3-, 24-, and 48-h post) between Pre-PS and Post-PS was analyzed using Cohen d. The latest analysis was performed, adding individual differences in sRPE (Post-PS − Pre-PS) as a covariate in the comparisons with an acknowledgment of a possible impact of this parameter on players' recovery, using an online-available spreadsheet.[28]

Results

Characterization of Posttraining Recovery Timeline

Training Load. The Pre-PS training session duration was 68 minutes, during which, PL was 559 (92) AU. The mean HR was 81 (4) $\%HR_{max}$, and TRIMP was 229 (23) AU. The mean RPE was 6.1 (1.7), resulting in a sRPE of 413 (113) AU.

Recovery Timeline. Relative to the baseline values (Figure 1), no significant differences over time were observed in the CMJ ($P = .957$; $\eta_p^2 = .336$) and 10 m ($P = .655$; $\eta_p^2 = .490$) performances throughout the 48-hour recovery period. Significant changes were observed in CK ($P < .001$; $W = 0.642$), TQR ($P = .003$; $W = 0.353$), vigor ($P < .001$; $\eta_p^2 = .520$), and fatigue ($P < .001$; $W = 0.776$). Specifically, CK increased immediately post ($P = .001$; $d = 0.48$; 95% CI, 0.19 to 0.79), remaining increased at 3 hours ($P = .001$; $d = 1.03$; 95% CI, 0.38 to 1.68), 24 hours ($P = .003$; $d = 1.14$; 95% CI, 0.35 to 1.93), and 48 hours compared with the baseline ($P = .024$; $d = 0.60$; 95% CI, 0.05 to 1.15). The players' perceived recovery (TQR) decreased 3-hour postsession ($P = .001$; $d = -2.06$; 95% CI, −3.42 to −0.71), then increased at 24 hours, showing similar values to the baseline up to 48-hour postsession ($P = .387$; $d = -0.33$; 95% CI, −1.13 to 0.48 and $P = .178$; $d = -0.65$; 95% CI, −1.67 to 0.37; respectively). The vigor scores decreased immediately ($P < .001$; $d = -1.57$; 95% CI, −2.48 to −0.67), 3 hours ($P < .001$; $d = -1.70$; 95% CI, −2.67 to −0.73), and 24 hours after the session ($P = .020$; $d = -0.69$; 95% CI, −1.31 to −0.07), returning to the baseline 48-hour postsession ($P = .156$; $d = -0.41$; 95% CI, −1.02 to 0.20). Fatigue increased immediately after the session ($P = .001$; $d = 2.42$; 95% CI, 1.17 to 3.67) and remained increased at 3 hours ($P = .002$; $d = 1.96$; 95% CI, 0.80 to 3.11), though it was similar to the baseline at 24 hours ($P = .776$; $d = -0.04$; 95% CI, −0.53 to 0.45) and 48 hours ($P = .232$; $d = -0.21$; 95% CI, −0.64 to 0.21).

Effect of Preseason Training on Recovery

Training Load During the Preseason. During the 10-week preseason, the team performed 54 technical–tactical sessions, including 5 friendly matches (6 [1] sessions per week and 46 [9] sessions per player). The mean duration was 91 (19) minutes, in which PL was 670 (174) AU or 7.8 (2.1) $AU \cdot min^{-1}$. Such an external load resulted in a mean HR of 74 (7) $\%HR_{max}$, RPE of 4.1 (1.2) AU, and sRPE of 373 (139) AU. The mean TQR during this period was 13.8 (1.1).

Anthropometry and Physical Performance Responses to Preseason Training. When comparing the 7 players who completed Pre-PS and Post-PS, only trivial ESs ($d = -0.02$ to 0.11) were observed in body composition and physical capacity (Table 2).

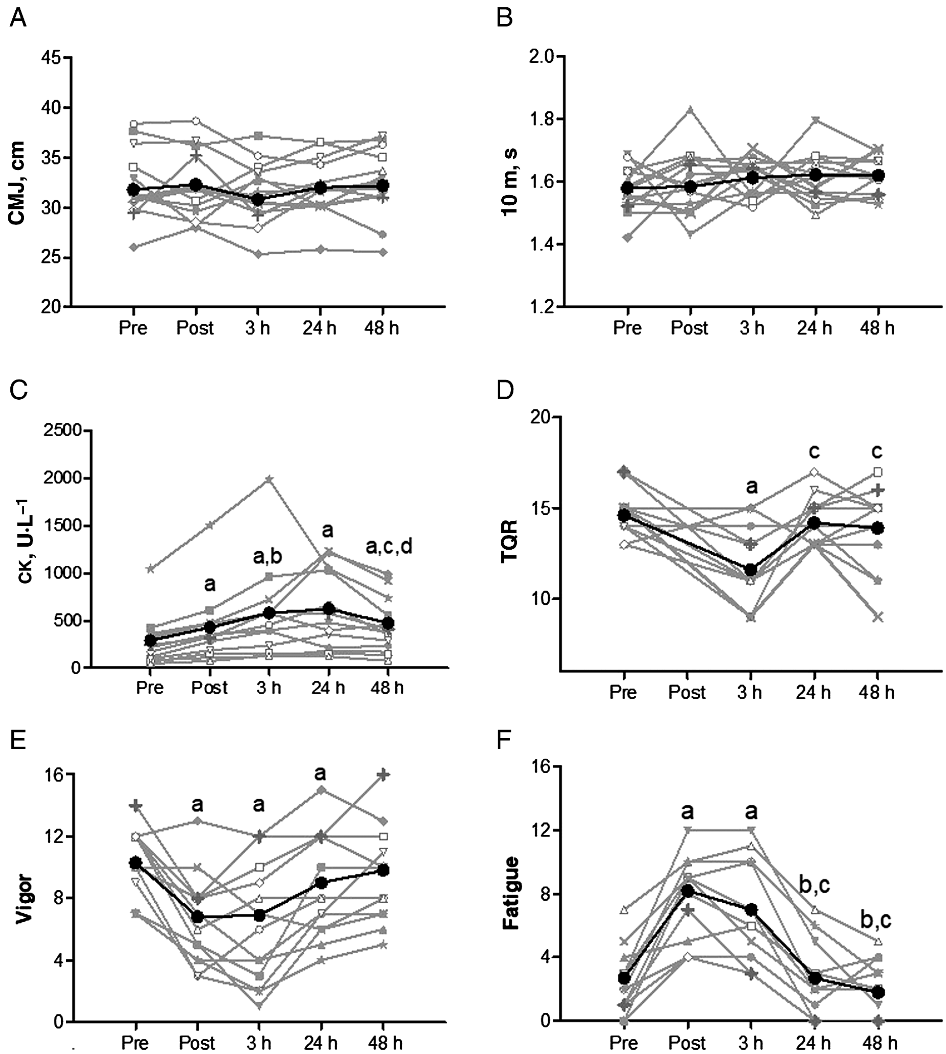

Figure 1 — Timeline of recovery markers after a technical–tactical futsal training session. Gray lines represent individual data, and black lines represent mean values. (A) CMJ high, (B) 10-m time, (C) CK concentration, (D) TQR, (E) vigor (BRAMS), and (F) fatigue (BRAMS). BRAMS indicates Brunel Mood Scale; CK, creatine kinase; CMJ, countermovement jump; TQR, Total Quality Recovery Scale. [a] Different from presession. [b] Different from postsession. [c] Different from 3-hour postsession. [d] Different from 24-hour postsession.

Table 2 Anthropometric Measures and Physical Performance of Players Pre-PS and Post-PS (n = 7)

Parameter	Pre-PS	Post-PS	ES	95% CI	Magnitude of effect
Body mass, kg	65.0 (5.5)	66.8 (6.4)	0.10	−0.02 to 0.21	Trivial
%Body fat	5.2% (2.3%)	6.0% (3.5%)	0.11	−0.12 to 0.35	Trivial
VO_2max, ml $O_2 \cdot kg^{-1} \cdot min^{-1}$	52.6 (3.5)	52.8 (3.5)	0.10	−0.14 to 0.33	Trivial
$\%VO_2max$ at VT	47% (13%)	53% (12%)	0.10	−0.05 to 0.24	Trivial
CMJ, cm	32.6 (4.2)	32.3 (4.2)	−0.02	−0.15 to 0.10	Trivial
10 m, s	1.57 (0.10)	1.58 (0.07)	0.02	−0.15 to 0.20	Trivial

Abbreviations: CI, confidence interval; CMJ, countermovement jump; ES, effect size; Post-PS, after 10 weeks of preseason; Pre-PS, before the preseason; VO_2max, maximal aerobic power; VT, ventilatory threshold. Note: Data are expressed as mean (SD).

Pre-PS Versus Post-PS. With respect to the baseline assessments (Table 3), trivial effects existed for most variables ($d = -0.63$ to 0.27), though there was a small effect ($d = -0.23$) for lower vigor scores in the Post-PS compared with Pre-PS. The training session performed Post-PS was 5 minutes shorter than the Pre-PS, with a small effect for the time players spent in action (time played; ie, excluding time between activities and substitutions). Differences between the respective sessions for PL, PL per minute, $\%HR_{max}$, time spent above $80\%HR_{max}$, and TRIMP presented only trivial effects ($d = -0.09$ to 0.10). However, RPE and sRPE presented small effects for lower values at Post-PS compared with Pre-PS. Therefore, to acknowledge a possible impact on players'

Table 3 Baseline and Training-Load Measures From the Testing Training Session Performed Pre-PS and Post-PS (n = 7)

Parameter	Pre-PS	Post-PS	ES	95% CI	Magnitude of effect
Pretraining measures					
Creatine kinase, $U \cdot L^{-1}$	216 (136)	227 (168)	0.03	−0.32 to 0.37	Trivial
TQR	14.9 (1.7)	14.1 (1.8)	−0.13	−0.35 to 0.09	Trivial
Vigor	10.6 (2.7)	8.6 (4.5)	−0.23	−0.46 to 0.00	Small
Fatigue	2.6 (2.3)	2.9 (1.3)	0.04	−0.25 to 0.32	Trivial
Sleep hours	7.2 (0.6)	6.8 (1.3)	−0.18	−0.72 to 0.36	Trivial
Sleep quality	3.6 (0.8)	3.6 (0.9)	0.00	−0.19 to 0.19	Trivial
Training load					
Duration, min	68 (0)	63 (2)	—	—	—
Time played, min	28 (2)	26 (3)	−0.27	−0.72 to 0.18	Small
Player load, AU	596 (102)	534 (111)	−0.09	−0.26 to 0.08	Trivial
Player load/min, AU	9.0 (1.6)	9.0 (1.9)	−0.01	−0.18 to 0.16	Trivial
$\%HR_{max}$	81% (4%)	80% (4%)	−0.06	−0.30 to 0.18	Trivial
Time >80%HR_{max}, min	35.9 (7.7)	30.1 (4.5)	−0.02	−0.44 to 0.40	Trivial
TRIMP, AU	228 (23)	204 (20)	0.10	−0.66 to 0.86	Trivial
RPE	6.0 (1.4)	4.4 (1.4)	−0.29	−0.51 to −0.07	Small
Session RPE, AU	408 (111)	280 (94)	−0.35	−0.61 to −0.09	Small

Abbreviations: AU, arbitrary units; CI, confidence interval; ES, effect size; $\%HR_{max}$, percentage of maximal heart rate; Post-PS, after 10 weeks of preseason; Pre-PS, before the preseason; RPE, rating of perceived exertion; TQR, Total Quality Recovery Scale; TRIMP, training impulse. Note: Data are expressed as mean (SD).

recovery, individual differences in sRPE (Post-PS – Pre-PS) were further used as a covariate in the comparisons between the Pre-PS and Post-PS recovery timelines.

Recovery Timeline. Figure 2 shows the percentage difference in the pretraining values during the respective recovery timelines for Pre-PS and Post-PS. The CMJ changes from the baseline presented a moderate effect for better results at Post-PS than Pre-PS at 3-hour posttraining ($d = 0.87$; 95% CI, 0.20 to 1.55) and a large effect for better results at 48-hour posttraining ($d = 1.27$; 95% CI, 0.52 to 2.02). The ESs for changes in the 10-m performance immediately, 3 hours, and 24 hours after the session were only trivial (d between −0.12 and −0.05) and small at 48 hours ($d = 0.49$; 95% CI, 0.24 to 0.73) between Pre-PS and Post-PS. The postsession change from the baseline in CK concentration showed a large effect to be higher in Post-PS ($d = 1.18$; 95% CI, 0.15 to 2.20), though it was lower at 48-hour posttraining compared with Pre-PS ($d = -1.33$; 95% CI, −2.04 to −0.63). There was a large effect for a smaller decrease in TQR at 3 hours postsession at Post-PS compared with Pre-PS ($d = 1.50$; 95% CI, 0.75 to 2.25) and a moderate effect for a higher subsequent increase in TQR at Post-PS ($d = 0.92$; 95% CI, −0.01 to 1.84). The increase in fatigue was also lower at 3-hour postsession at Post-PS compared with Pre-PS ($d = -0.63$; moderate; 95% CI, −1.02 to −0.25), though differences from the baseline were higher at 48 hours ($d = 0.73$; moderate; 95% CI, −0.67 to 2.14). Changes from the baseline in vigor were improved (moderate ES) in Post-PS at all time points (d between 0.59 and 1.13).

Discussion

This study describes the recovery timeline after high-intensity futsal-specific training and, then, the influence of preseason training on recovery. At the start of the season, physical performance assessed by the CMJ and 10-m sprint was not impaired postsession, whereas the perception of recovery, fatigue, and vigor were worse in the hours posttraining, returning to the baseline within 24 hours. In addition, increases in CK showed moderate effects up to 24-hour posttraining. At the end of the preseason, despite limited fitness-based improvements in lower-body power, speed, or aerobic power, an improved recovery timeline existed following a training session of similar load. Specifically, despite a greater increase in CK immediately after training, a faster return to the baseline was evident at the end of the preseason. Furthermore, perceptual responses were improved at Post-PS up to 24 hours (TQR) and 48 hours (vigor). These results provide an initial context for the role of sport-specific training exposure to aid posttraining recovery.

The training sessions used to compare the recovery timelines before and after the preseason showed high-training loads, as evidenced by higher PL per minute, $\%HR_{max}$, and RPE, considering the loads in this preseason program. In addition, despite the training activities not being identical at Pre-PS and Post-PS, the loads were similar, as evidenced by the trivial ES in external load (ie, PL) and cardiovascular demand. Such absence of difference also aligns with a previous study, showing similar internal loads between different futsal-specific training activities.[29] However, the players perceived the session as less intense (ie, lower RPE for similar external load), which supports the notion that exposure to training may improve the perception of the load,[30] and in turn, perhaps tolerance to fatigue.[13]

Regarding the recovery at Pre-PS, posttraining CMJ and 10-m performances were not impaired, differing from previous studies that reported decreases in CMJ and sprint after friendly futsal matches.[6,10] The shorter training duration in this study may have led to lower external loads and preservation of lower body force and power,[9] though such assumptions are limited, as external load was not reported in previous investigations. Differing from physical performance, CK increased substantially, remaining elevated up to 48-hour posttraining, consistent with previously reported increases in muscle damage and inflammatory markers after futsal matches.[2,31] Finally, TQR and fatigue returned to the baseline only

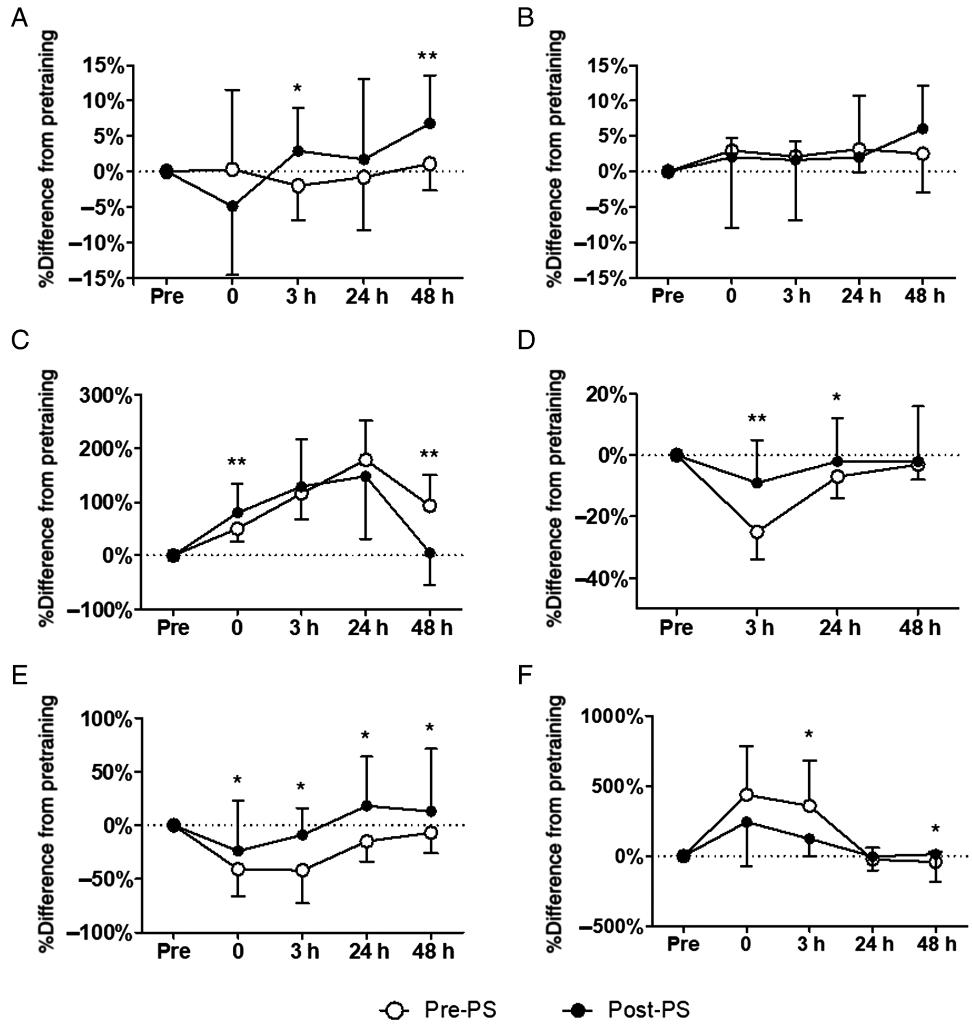

Figure 2 — Timeline of recovery markers after technical–tactical futsal training sessions held at the start (Pre-PS) and end (Post-PS) of preseason. Data are presented as percentage change from pretraining values (mean [SD]). (A) Countermovement-jump high, (B) 10-m time, (C) creatine kinase concentration, (D) Total Quality Recovery Scale, (E) vigor (BRAMS), and (F) fatigue (BRAMS). *Moderate effect size compared with Pre-PS. **Large effect size compared with Pre-PS. BRAMS indicates Brunel Mood Scale; Pre-PS, before the preseason; Post-PS, after 10 weeks of preseason.

after 24 hours. The fact that the players reported worse readiness in the hours posttraining despite the absence of performance decrements agrees with the multifactorial nature of perceptual parameters[22] and suggests that other factors than those measured herein were affected. Despite incongruent timelines between performance, physiological, and perceptual measures, recovery of the futsal players after high-intensity training seems evident by 48 hours.

The preseason internal training loads during the 10 weeks were similar to the previously reported values for individual sessions (≈74% HR_{max}, TRIMP ≈ 153, RPE ≈ 5, and sRPE ≈ 300–500 AU).[29] The maintenance of the jump and sprint performance was also consistent with former investigations in futsal,[3,15] which may be explained by the high number of aerobically dominant technical–tactical training sessions and the focus on hypertrophy rather than power/speed in the gym in the current program. However, such training characteristics would expectedly improve players' VO_2max and/or VT, which were not observed through the incremental treadmill test. This can be partially explained by its lack of specificity[8] to futsal demands, since performance in on-court tests has been shown to improve after futsal preseason.[15] Consequently, following this 10-week preseason program designed at team technical–tactical proficiency, the players' physical capacities were not demonstrably improved.

When accounting for the reduced sRPE at Post-PS, improved changes from the baseline in CMJ (3- and 48-h postsession) and CK (at 48 h) were evident compared with Pre-PS. Despite no explicit fitness changes, preseason training still resulted in improved neuromuscular recovery profiles in the futsal players. Previously, Johnston et al[8] observed that athletes with higher 3-repetition maximum squat and Yo-Yo Intermittent Recovery Test Level 1 performance exhibited a faster CMJ return to the baseline and smaller increases in CK following a rugby league match. While similar improved recovery is evident in both studies, the cross-sectional nature of the study by Johnston et al[8] and the absence of both a strength test and a control group here make an interpretation of the underpinning factors difficult. In addition, exposure to exercise without fitness changes has been reported to decrease muscle damage following subsequent eccentric training sessions in acute settings (repeated bout effect),[32] though such a rationale in ongoing training is speculative. Therefore, it is feasible that either unmeasured fitness improvement or greater tolerance to training due to exposure mediates the improved Post-PS recovery profiles.

The players also exhibited positive changes in the recovery timeline of perceptual markers after the preseason. Interestingly, the attenuated perception of load immediately postsession was followed by the players perceiving themselves readier to perform 3 hours (improved TQR, fatigue, and vigor), 24 hours (TQR and vigor) and 48 hours (vigor) after training, despite performing similar external and internal loads. Given that RPE can be influenced by individuals' reference of "maximal effort,"[33] it is also possible that similar absolute loads appear easier due to the preseason exposure to high loads. Posttraining perceptual results also align with the improved neuromuscular recovery responses and reinforce the argument of improved tolerance to load following training, partially via the improved psychological ability to tolerate high-intensity efforts.[13]

Understanding athletes' responses to training in ecologically valid settings is paramount to improving recovery strategies. However, it also presents limitations related to the uncontrolled environment, including the exposure to unexpected data loss, limitation to one experimental situation, and the inability to include a control group. In this study, although 13 players were recruited, the data of only 7 could be analyzed to address the second objective, increasing the odds of errors and limiting our findings to the population studied herein. Furthermore, the fact that training sessions performed for recovery timeline assessments were not identical at Pre-PS and Post-PS included a cofactor (ie, sRPE) to the effect of the preseason training in the recovery timeline. Taking this into account, we included the one variable that differed between Pre-PS and Post-PS as a covariate in our analysis, though we acknowledge that kinematic and cognitive differences may also be present.

Practical Applications

Despite the distinct postsession timeline between parameters, recovery of the futsal players after high-intensity training seems evident by 24 to 48 hours. Based on the improved recovery of CK, fatigue, and recovery perception after the preseason, appropriate training exposure and accumulation may improve tolerance to fatigue and recovery later in the season. Furthermore, given that physical performance responses were not affected by the training session or the 10 weeks of preseason, we suggest considering fitness tests other than CMJ and 10 m to infer recovery, or laboratory-based VO_2 and VT to infer training status in futsal players.

Conclusions

In summary, after a high-intensity technical–tactical training session performed at the start of the season, the U20 players' physical performance showed only minimal changes; the markers of perceived recovery and mood returned to the baseline after 3 hours, and CK remained elevated up to 48-hour postsession. Ten weeks of futsal-specific preseason training attenuated the players' perception of effort and fatigue and improved the recovery of power, muscle damage, and vigor markers' up to 48 hours after a training session with comparable load, irrespective of the maintenance of VO_2max, VT, 10 m, and CMJ performances. Future studies are encouraged to address which factors mediate improvements in athletes' recovery profile following a training period.

Acknowledgments

The authors are grateful to Minas Tênis Clube for allowing the development of this research, the coaching staff for having embraced the project, and the players for their participation. S.P.W. was supported by Fundação de Amparo à Pesquisa de Minas Gerais (FAPEMIG; APQ-02953-16). This study was financed in part by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior—Brazil (CAPES)—Finance Code 001. C.F.W. and A.M.-L. received PhD fellowships and R.S.B. received a master fellowship, whereas F.C.M.-R. received a postdoctoral fellowship from CAPES.

References

1. Rodrigues VM, Ramos GP, Mendes TT, et al. Intensity of official futsal matches. *J Strength Cond Res*. 2011;25(9):2482–2487. PubMed ID: 21869629 doi:10.1519/JSC.0b013e3181fb4574
2. de Moura NR, Borges LS, Santos VC, et al. Muscle lesions and inflammation in futsal players according to their tactical positions. *J Strength Cond Res*. 2013;27(9):2612–2618. PubMed ID: 23249823 doi:10.1519/JSC.0b013e31827fd835
3. 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(10):2815–2826. PubMed ID: 24662230 doi:10.1519/JSC.0000000000000461
4. De Oliveira Bueno MJ, Caetano FG, Pereira TJ, et al. Analysis of the distance covered by Brazilian professional futsal players during official matches. *Sports Biomech*. 2014;13(3):230–240. PubMed ID: 25224298 doi:10.1080/14763141.2014.958872
5. Wilke CF, Fernandes FAP, Martins FVC, et al. Faster and slower post-training recovery in futsal: multifactorial classification of recovery profiles. *Int J Sports Physiol Perform*. 2019;14(8):1089–1095. PubMed ID: 30702357 doi:10.1123/ijspp.2018-0626
6. Moreira A, Costa EC, Coutts AJ, Nakamura FY, Da Silva DA, Aoki MS. Cold water immersion did not accelerate recovery after a futsal match. *Revista Brasileira de Medicina do Esporte*. 2015;21(1):40–43. doi:10.1590/1517-86922015210101578
7. Tomlin DL, Wenger HA. The relationship between aerobic fitness and recovery from high intensity intermittent exercise. *Sports Medicine*. 2001;31(1):1–11. PubMed ID: 11219498 doi:10.2165/00007256-200131010-00001
8. Johnston RD, Gabbett TJ, Jenkins DG, Hulin BT. Influence of physical qualities on post-match fatigue in rugby league players. *J Sci Med Sport*. 2015;18(2):209–213. PubMed ID: 24594214 doi:10.1016/j.jsams.2014.01.009
9. Minett GM, Duffield R. Is recovery driven by central or peripheral factors? A role for the brain in recovery following intermittent-sprint exercise. *Front Physiol*. 2014;5:24. PubMed ID: 24550837 doi:10.3389/fphys.2014.00024
10. Tessitore A, Meeusen R, Pagano R, Benvenuti C, Tiberi M, Capranica L. Effectiveness of active versus passive recovery strategies after futsal games. *J Strength Cond Res*. 2008;22(5):1402–1412. PubMed ID: 18714251 doi:10.1519/JSC.0b013e31817396ac
11. Silva JR, Rumpf MC, Hertzog M, et al. Acute and residual soccer match-related fatigue: a systematic review and meta-analysis. *Sports Med*. 2018;48(3):539–583. PubMed ID: 29098658 doi:10.1007/s40279-017-0798-8
12. Helgerud J, Engen LC, Wisloff U, Hoff J. Aerobic endurance training improves soccer performance. *Med Sci Sports Exerc*. 2001;33(11):1925–1931. PubMed ID: 11689745 doi:10.1097/00005768-200111000-00019
13. Zghal F, Cottin F, Kenoun I, et al. Improved tolerance of peripheral fatigue by the central nervous system after endurance training. *Eur J*

Appl Physiol. 2015;115(7):1401–1415. PubMed ID: 25681110 doi:10.1007/s00421-015-3123-y
14. Alvarez JC, D'Ottavio S, Vera JG, Castagna C. Aerobic fitness in futsal players of different competitive level. *J Strength Cond Res*. 2009;23(7):2163–2166. PubMed ID: 19855347
15. Nogueira FC, de Freitas VH, Nogueira RA, Miloski B, Werneck FZ, Bara-Filho M. Improvement of physical performance, hormonal profile, recovery-stress balance and increase of muscle damage in a specific futsal pre-season planning. *Revista Andaluza de Medicina del Deporte*. 2018;11(2):63–68. doi:10.1016/j.ramd.2015.11.008
16. Amann M, Subudhi AW, Foster C. Predictive validity of ventilatory and lactate thresholds for cycling time trial performance. *Scand J Med Sci Sports*. 2006;16(1):27–34. PubMed ID: 16430678 doi:10.1111/j.1600-0838.2004.00424.x
17. Foster C, Florhaug JA, Franklin J, et al. A new approach to monitoring exercise training. *J Strength Cond Res*. 2001;15(1):109–115. PubMed ID: 11708692
18. Kelly SJ, Murphy AJ, Watsford ML, Austin D, Rennie M. Reliability and validity of sports accelerometers during static and dynamic testing. *Int J Sports Physiol Perform*. 2015;10(1):106–111. PubMed ID: 24911138 doi:10.1123/ijspp.2013-0408
19. Boyd LJ, Ball K, Aughey RJ. The reliability of MinimaxX accelerometers for measuring physical activity in Australian football. *Int J Sports Physiol Perform*. 2011;6(3):311–321. PubMed ID: 21911857 doi:10.1123/ijspp.6.3.311
20. Edwards S. *The Heart Rate Monitor Book*. Kempele, Finland: Polar CIC; 1993.
21. Howatson G, Milak A. Exercise-induced muscle damage following a bout of sport specific repeated sprints. *J Strength Cond Res*. 2009;23(8):2419–2424. PubMed ID: 19826279 doi:10.1519/JSC.0b013e3181bac52e
22. Kentta G, Hassmen P. Overtraining and recovery. A conceptual model. *Sports Med*. 1998;26(1):1–16. PubMed ID: 9739537
23. Wilke CF, Wanner SP, Santos WHM, et al. Influence of faster and slower recovery-profile classifications, self-reported sleep, acute training load, and phase of the microcycle on perceived recovery in futsal players. *Int J Sports Physiol Perform*. 2020;15(5):648–653. PubMed ID: 31896076 doi:10.1123/ijspp.2019-0201
24. Rohlfs ICPM, Terry PC, Rotta TM, et al. Development and initial validation of the Brazil Mood Scale. Presented at: 43rd Annual Australian Psychological Society Conference (APS 2008): Psychology Leading Change; September 23–27, 2008; Hobart, Australia.
25. Markovic G, Dizdar D, Jukic I, Cardinale M. Reliability and factorial validity of squat and countermovement jump tests. *J Strength Cond Res*. 2004;18(3):551–555. PubMed ID: 15320660
26. Altmann S, Ringhof S, Neumann R, Woll A, Rumpf MC. Validity and reliability of speed tests used in soccer: a systematic review. *PLoS One*. 2019;14(8):e0220982. PubMed ID: 31412057 doi:10.1371/journal.pone.0220982
27. Hopkins WG, Marshall SW, Batterham AM, Hanin J. Progressive statistics for studies in sports medicine and exercise science. *Med Sci Sports Exerc*. 2009;41(1):3–13. PubMed ID: 19092709 doi:10.1249/MSS.0b013e31818cb278
28. Hopkins WG. Spreadsheets for analysis of controlled trials, crossovers and time series. *Sportscience*. 2017;21:1–4.
29. Wilke CF, Ramos GP, Pacheco DA, et al. Metabolic demand and internal training load in technical–tactical training sessions of professional futsal players. *J Strength Cond Res*. 2016;30(8):2330–2340. PubMed ID: 26808850 doi:10.1519/JSC.0000000000001321
30. Hogarth LW, Burkett BJ, McKean MR. Influence of Yo-Yo IR2 scores on internal and external workloads and fatigue responses of tag football players during tournament competition. *PLoS One*. 2015;10(10):e0140547. PubMed ID: 26465599 doi:10.1371/journal.pone.0140547
31. de Moura NR, Cury-Boaventura MF, Santos VC, et al. Inflammatory response and neutrophil functions in players after a futsal match. *J Strength Cond Res*. 2012;26(9):2507–2514. PubMed ID: 22067240 doi:10.1519/JSC.0b013e31823f29b5
32. Hyldahl RD, Chen TC, Nosaka K. Mechanisms and mediators of the skeletal muscle repeated bout effect. *Exerc Sport Sci Rev*. 2017;45(1):24–33. PubMed ID: 27782911 doi:10.1249/JES.0000000000000095
33. Borg GA. Psychophysical bases of perceived exertion. *Med Sci Sports Exerc*. 1982;14(5):377–381. PubMed ID: 7154893 doi:10.1249/00005768-198205000-00012