

Neuromuscular Performance Changes in Elite Futsal Players Over a Competitive Season

Konstantinos Spyrou,^{1,2,3} Pedro E. Alcaraz,^{1,3} Elena Marín-Cascales,³ Rubén Herrero-Carrasco,⁴ Daniel D. Cohen,^{5,6} and Tomás T. Freitas^{1,2,3,7}

¹UCAM Research Center for High Performance Sport, UCAM Universidad Católica de Murcia, Murcia, Spain; ²Facultad de Deporte, UCAM Universidad Católica de Murcia, Murcia, Spain; ³Strength and Conditioning Society, Rome, Italy; ⁴Research Group Murcia Soccer Federation, Murcia, Spain; ⁵Sports Science Center (CCD), Colombian Ministry of Sport (Mindeporte), Bogotá, Colombia; ⁶Masira Research Institute, University of Santander (UDES), Bucaramanga, Colombia; and ⁷NAR, Nucleus of High Performance in Sport, São Paulo, Brazil

Abstract

Spyrou, K, Alcaraz, PE, Marín-Cascales, E, Herrero-Carrasco, R, Cohen, DD, and Freitas, TT. Neuromuscular performance changes in elite futsal players over a competitive season. *J Strength Cond Res* XX(X): 000–000, 2022—A professional futsal season imposes a great amount of physiological and mechanical stress on players. The main aim of this study was to examine the changes in neuromuscular performance qualities across the season. Ten professional male players performed a 10-m sprint, standing long jumps (SLJs), and countermovement jumps (CMJs) during the competitive season (i.e., every ~5 weeks from September to January). A one-way repeated measures ANOVA with post hoc pairwise comparisons and effect sizes (ESs) were used to analyze potential differences among these assessments. A significant and large decline was found in concentric peak power ($p = 0.040$; ES = 1.24). A nonsignificant and moderate decrease was observed in sprint ability ($p = 0.155$; ES = 1.03), CMJ height ($p = 0.175$; ES = 1.00), and SLJ distance ($p = 0.164$; ES = 1.03). Regarding other CMJ kinetic variables, nonsignificant and moderate changes were found. In summary, considering the neuromuscular performance tests and variables assessed, only concentric peak power in CMJ decreased significantly across the season; however, nonsignificant decrements were observed in sprinting time, SLJ, CMJ height, and other kinetic metrics. CMJ variables during the jump-land cycle should be incorporated alongside more traditional measures (e.g., jump height) to monitor performance during the season.

Key Words: five-a-side soccer, physical capacities, fatigue, competitive period

Introduction

Futsal is a high-intensity intermittent indoor sport, with high physical, technical, and tactical demands (23,27). The typical competitive season consists of ~50 regular matches including national (i.e., League and Cup) and international (i.e., European club tournaments and National Team) competitions over a span of ~7.5 months, with a frequency of 1–3 games per week. During a single match, futsal players cover a total distance of ~4,000 m, of which ~675 m are spent running (12–18 km·h⁻¹) and ~130 m sprinting (>18 km·h⁻¹), perform ~70 high-intensity accelerations and decelerations, and complete ~170 change of direction actions (24,28). In addition, they usually complete daily or twice-a-day sessions for games' preparation, covering as much as ~10 km (on average) at high and very high intensities during a typical weekly microcycle (14). Thus, a professional futsal season imposes a large physiological and mechanical stress on athletes (23,27). For this reason, training and competition loads can lead to not only acute neuromuscular fatigue (i.e., failure of the musculoskeletal system to maintain the required force or power output) (31) but also residual (i.e., 24–72 hour after exercise (25)) and potentially chronic fatigue (i.e., overtraining syndrome) (4), throughout the season, if appropriate individual tailor-made training programs (e.g., adjusting recovery times or limiting on-court weekly distance) are not considered.

Neuromuscular performance monitoring (i.e., through jump, sprint testing, etc.) is often used as a practical tool to periodically evaluate the response to the training and competition stress that team-sport athletes are exposed to across the season (5,10). For example, decreases in countermovement jump (CMJ) performance (i.e., jump height) have been observed after soccer and rugby league matches (1,21). However, a number of studies (6,9,16) have shown that a more comprehensive analysis of kinetic variables during the jump-land cycle is needed to detect neuromuscular impairments associated with acute or residual fatigue, permitted when the test is performed with force platforms. Similarly, adaptive responses after periods of training (10,15) or detraining (6,26) may require a thorough analysis of selected CMJ metrics to identify alterations in neuromuscular status during the season that are not detected by monitoring jump height alone.

Several investigations (7,9,12,16,17,30,32) have examined neuromuscular performance at several time points during the sports season and shown that, overall, physical abilities tend to be maintained or decrease across the season. Legg et al. (17) detected trivial declines (effect size [ES] = -0.18) in CMJ performance and jump-land cycle during the competitive period in elite female basketball players. Nonetheless, there is also evidence demonstrating that physical capacities can be enhanced during the competitive period in team sports (11). For example, Gonzalez et al. (11) observed, in a sample of elite basketball players, that starters improved vertical jump power, quickness, and reaction time 17.15%, 0.29%, and 5.66% more, respectively, than

Address correspondence to Pedro E. Alcaraz, palcaraz@ucam.edu.

Journal of Strength and Conditioning Research 00(00)/1–6

© 2023 National Strength and Conditioning Association

nonstarters during the season. The variability in findings across these studies may be attributed to differences in the characteristics or demands of the sport, the level of the competition, the congestion of the competitive calendar (i.e., different number of matches per week), age (e.g., youth-amateur vs experienced), or contextual factors (e.g., player role: starters vs nonstarters) (9,11,16,32). Regarding futsal, few studies (2,22,29) have investigated potential changes in physical capacities across the season. Particularly, in professional futsal players, the influence of training and competition stress on sprint, horizontal and vertical jump performance, and CMJ kinetic variables (assessed multiple times across the competitive period) has not been examined.

Based on the above considerations, the aim of this study was to examine potential changes in speed-power-related outputs (i.e., sprint speed, standing long jump [SLJ] distance, and vertical jump height) and CMJ kinetic variables (derived from the eccentric, concentric, and landing phases) across the season in elite futsal players. Because of the prolonged and congested schedule in professional futsal, we hypothesized that performance across all metrics would decline as the season progressed.

Methods

Experimental Approach to the Problem

This longitudinal study was designed to track the neuromuscular performance (i.e., sprint time, CMJ kinetic variables, and SLJ distance) of elite male futsal players. The subjects competed on Liga Nacional de Fútbol Sala (LNFS; first Division of Spain) and UEFA Futsal Champions League over the 2019–2020 season, which spanned from August to March due to the COVID-19 restrictions imposed in Spain. The testing procedures were performed regularly during the season, at 4 time points (i.e., September [Sep], October [Oct], December [Dec], and January [Jan]) (Figure 1). In each session, all players completed the same standardized general warm-up protocol consisting of running-based activities, dynamic stretching, and core and lower-body activation exercises, followed by a test-specific warm-up (i.e., submaximal attempts in all tested exercises). The regular and congested weekly in-season training and game schedule is presented in Table 1. The evaluations were completed in the team's facilities during regular weeks (i.e., 1 game per week), 3 days after a match, in the following order: vertical jump, SLJ, and sprint test. Each trial was separated by a 1-minute rest interval, and 3 minutes were allowed between successive tests.

Subjects

Twelve players (age: 26.7 ± 3.1 years old, body mass: 76.7 ± 6.3 kg, height: 1.79 ± 0.06 m, body fat: $9.9 \pm 1.2\%$) from an elite

futsal team volunteered to take part in the study. Athletes who did not complete more than 1 assessment due to injury (i.e., as determined by the team's medical team that was responsible for the evaluation and recording of injuries according to the consensus statement of injuries in soccer (8), previously used in futsal (18)) were not included in the analysis. Two players did not meet these inclusion criteria; hence, 10 players were finally included in the study. By signing a professional contract with the club, all players provided individual consent for data collection and study participation. All procedures were approved by the Ethics Committee of the Catholic University of Murcia (UCAM) and were conducted according to the Declaration of Helsinki.

Procedures

Sprint Test. Two pairs of photocells (WITTY System, Microgate, Bolzano, Italy) were positioned at the starting line and at 10 m. Players started from a staggered position, 0.3 m behind the starting line and performed a maximal all-out linear sprint twice, with a 1-minute rest (intraclass correlation coefficient [ICC] = 0.71, coefficient of variation [CV]: = 4.5%). The fastest time was considered for analysis. All athletes performed the test on a wooden surface using regular futsal shoes.

Horizontal Jump Test. Athletes performed a SLJ, positioning their feet shoulder-width apart behind the starting line and the arms at the side of the body. A countermovement with arm swing was allowed before jumping. They were instructed to jump as far as possible in the horizontal direction, and the longest distance was recorded for analysis. Players performed a maximal effort three times with a 1-minute rest (ICC: = 0.92, CV: = 3.8%). Athletes were required to land with both feet simultaneously, and in case they fell forward or backward or touched the ground with one hand, the trial was considered invalid and repeated. The distance between the starting point and the heel of the rear foot measured by a tape to the nearest 1 cm was considered.

Vertical Jump Test. Athletes performed a CMJ on a portable force platform (Kistler 9286BA Kistler Group, Winterthur, Switzerland). Data were exported and analyzed using proprietary software (Python v.3.8.3). Athletes were required to perform a downward movement followed by a complete, rapid extension of the lower limbs. The depth of the countermovement was self-selected to avoid changes in jumping coordination. The hands were placed on the hips throughout the whole movement, and athletes were directed to jump as high as possible and land close to the take-off point. They executed three maximal trials with a 1-minute rest between each (ICC: = 0.97, CV: = 5.9%). Jump height and multiple kinetic variables (i.e., eccentric and concentric peak power and velocity, duration, center of mass [COM]

Table 1
Typically normal and congested weekly schedule during the competitive period.*

Normal Week (1 Game)							
Day	1	2	3	4	5	6	7
AM	Recovery	Power-strength training	Power-strength training	Tec-Tact training	Tec-Tact training	Tec-Tact training	Game
PM		Tec-Tact training	Tec-Tact training				
Congested week (>2 Games)							
Day	1	2	3	4	5	6	7
AM	Power-strength training	Tec-Tact training	Game	Recovery	Tec-Tact training	Tec-Tact training	Game
PM	Tec-Tact training						

*Tac = tactical training; Tec = technical training.

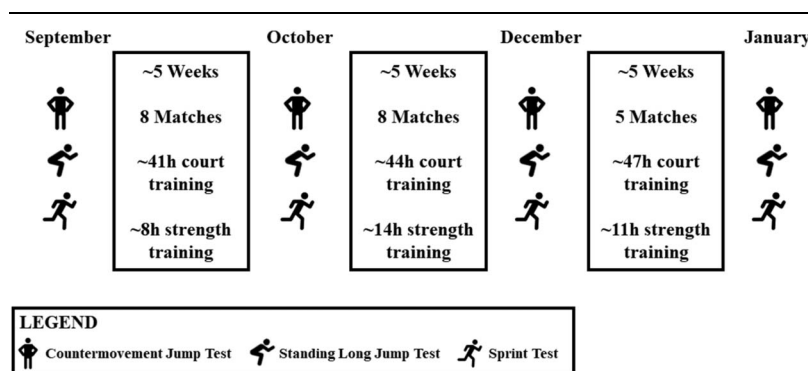


Figure 1. Representation of the study design.

displacement, landing peak force, and rate of force development [RFD] to peak force) from the best jump trial (according to the highest jump height) were retained for analysis.

Statistical Analyses

Data are presented as mean $\pm$ standard deviations (SD). Statistical analysis was performed using a statistical package (Jamovi, 2020; version 1.8). One-way repeated measures ANOVA was used, and post hoc pairwise comparisons conducted. Cohen's ES with 95% confidence intervals (95% CIs) were computed to determine the magnitude of every paired comparison and classified as: trivial (<0.2), small (>0.2 – 0.6), moderate (>0.6 – 1.2), large (>1.2 – 2.0), and very large (>2.0 – 4.0) (3). Significance level was set at $p \leq 0.05$.

Results

Figure 2 displays the group and individual data for sprint performance during the competitive period. A nonsignificant but moderate time effect was observed ($p = 0.155$; ES = 1.03). Specifically, the following results were found when comparing consecutive measurements: Sep–Oct ($p = 0.240$; mean difference [Dif_{mean}] = 3.9%; ES = 0.81; 95% CI: [0.07–1.52]), Oct–Dec ($p = 1.00$; Dif_{mean} = –1.1%; ES = –0.18; 95% CI: [–0.83–0.47]), Dec–Jan ($p = 0.933$; Dif_{mean} = 2.2%; ES = 0.20; 95% CI: [–0.50–0.90]), and Sep–Jan ($p = 0.081$; Dif_{mean} = 4.7%; ES = 1.05; 95% CI: [0.20–1.85]).

Figure 3 presents the group and individual data for vertical and SLJ performance, and Table 2 depicts the data for selected CMJ kinetic variables. Regarding SLJ distance, a nonsignificant but moderate time effect was detected ($p = 0.164$; ES = 1.03). In detail, the following results were obtained: Sep–Oct ($p = 0.518$; Dif_{mean} = –2.2%; ES = –0.36; 95% CI: [–0.99 to 0.28]), Oct–Dec ($p = 0.856$; Dif_{mean} = 0.6%; ES = 0.14; 95% CI: [–0.51 to 0.79]), Dec–Jan ($p = 0.463$; Dif_{mean} = –2.3%; ES = –0.54; 95% CI: [–1.27 to 0.21]), and Sep–Jan ($p = 0.376$; Dif_{mean} = –3.9%; ES = –0.54; 95% CI: [–1.23 to 0.17]).

Considering vertical jump, a significant difference was found only in concentric peak power ($p = 0.040$; ES = 1.24), when comparing Sep to Oct ($p = 0.013$; Dif_{mean} = –3.1%; ES = –1.26; 95% CI: [–2.09 to –0.40]). Moreover, a nonsignificant and moderate time effect was found for jump height ($p = 0.175$; ES = 1.00). Specifically, pairwise comparisons displayed the following results: Sep–Oct ($p = 0.300$; Dif_{mean} = –3.6%; ES = –0.72; 95% CI: [–1.40 to –0.00]), Oct–Dec ($p = 0.595$; Dif_{mean} =

2.6%; ES = 0.53; 95% CI: [–0.17 to 1.22]), Dec–Jan ($p = 0.503$; Dif_{mean} = –3.5%; ES = –0.51; 95% CI: [–1.24 to 0.23]), and Sep–Jan ($p = 0.479$; Dif_{mean} = –5.1%; ES = –0.48; 95% CI: [–1.17 to 0.21]). In the rest of the analyzed variables during the CMJ concentric (“upward”) phase, no significant changes were observed (peak velocity: $p = 0.142$; ES = 1.06; duration: $p = 0.938$; ES = 0.20). In the eccentric (“downward”) phase, nonsignificant trivial to moderate decreases were observed in peak power ($p = 0.529$; ES = 0.78), peak velocity ($p = 0.238$; ES = 0.90), duration ($p = 0.316$; ES = 0.84), and COM displacement ($p = 0.554$; ES = 0.62). In the landing phase, there were nonsignificant and small to moderate changes in peak force ($p = 0.188$; ES = 1.00) and RFD to peak force ($p = 0.681$; ES = 0.50).

Discussion

The purpose of this study was to examine potential fluctuations in neuromuscular performance (i.e., sprint time, vertical jump height and selected kinetic variables, and SLJ distance) across the season in elite futsal players. Our main findings were (a) physical abilities (i.e., sprint time, SLJ distance, and vertical jump height) displayed nonsignificant but gradual declines throughout the competitive period, (b) concentric peak power was the only CMJ kinetic variable that decreased significantly, and (c) all other CMJ metrics considering the three phases (i.e., eccentric, concentric, and landing) showed nonsignificant small to moderate changes.

It seems that elite futsal players were not able to improve their sprinting ability throughout the competitive period (they sustained a gradual nonsignificant decline), aligning with previous

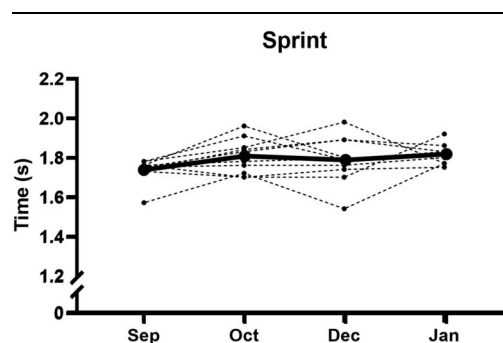
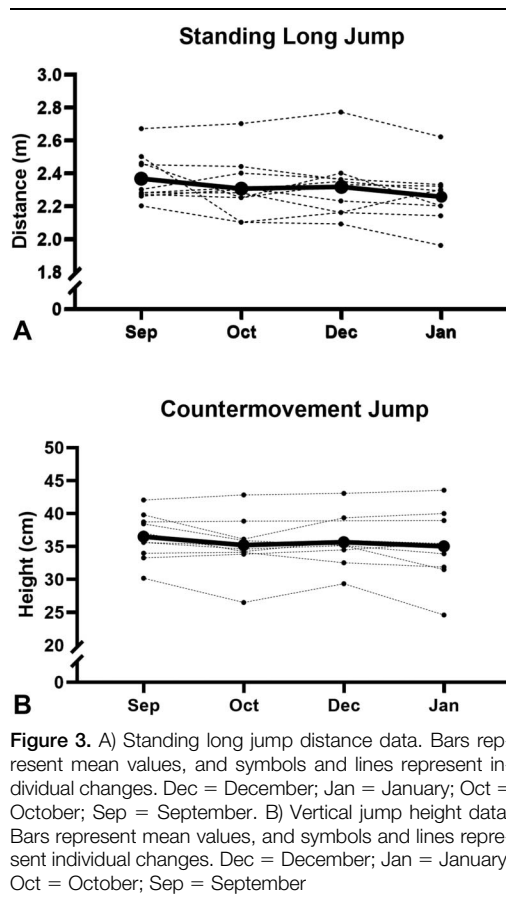


Figure 2. Sprint time data during the season. Bars represent mean values, and symbols and lines represent individual changes. Dec = December; Jan = January; Oct = October; Sep = September.



findings in team-sports athletes (13,19,22). For instance, Oliveira et al. (22) observed that repeated sprint ability was maintained during in-season in elite Brazilian futsal players. In another study, Haugen et al. (13) found that sprint performance was superior at the off-season compared with in-season and pre-season. This phenomenon could be related to the concurrent training effect between power and endurance adaptations across the season and the insufficient recovery during congested periods (13,20). From an applied standpoint, it is important to note that in this study, despite not achieving statistical significance, sprint times were ~5% ($ES = 1.05$) higher (i.e., indicating lower performance) in Jan when compared to Sep, suggestive of a gradual decrease in maximal sprinting ability across the season. Periodic assessment of this quality during the competitive period could identify potential neuromuscular performance impairments, allowing individualized power-speed-oriented training prescription according to a player's competition and training cumulative load and response thereof.

Moderate but nonsignificant decrements in jumping ability were observed throughout the season. Mean CMJ height and SLJ distance values were, on average, 5.1% ($ES = -0.48$) and 3.9% ($ES = -0.54$) lower, respectively, in Jan when compared to Sep aligning with findings in other studies in team sports (7,16,17,32). For example, Kipp et al. (16) observed that although team-average jump height did not change over the course of the season, in individual players, greater competition volume was associated with decreased CMJ height in female collegiate volleyball players. In professional ice hockey, a significant decrease in CMJ height across the season was found (9). By contrast, an investigation in NBA players revealed that, in players with greater playing

minutes, repetitive vertical jump power and lower-body power increased during the competitive period (11). These divergent results could be explained by the characteristics or loading demands of the sports investigated (e.g., basketball vs ice hockey) and timing of the retest (i.e., pre-season, early season, mid-season, and late season, 36 hours after the last game vs before the start of the regular season and at the end of the regular season). In this study, jump height had slight, steady but nonsignificant decreases over the season. Nevertheless, from a practical perspective, it is important to acknowledge that each athlete responds individually to the applied stress, and by identifying abnormal responses, tailored-made training strategies may then be implemented to avoid or mitigate detrimental effects.

A comprehensive kinetic analysis of the CMJ identified a significant and large ($ES = 1.24$) decline in concentric peak power and small to moderate but nonsignificant effects in eccentric and landing phase-specific metrics (i.e., peak power and velocity, RFD, duration, etc), with the largest differences observed between Sep and Jan (Table 2). Significant changes in CMJ kinetic variables have been noted in studies in other team-sports athletes (9,16). In professional ice-hockey athletes, Gannon et al. (9) found that concentric peak velocity and COM displacement decreased in the late season when compared to the early season. Moreover, the concentric power decrements may reflect potential residual fatigue or the muscular skeletal system that negatively affect power production capabilities as the season progresses (6). Therefore, sports practitioners, coaches, and scientists should be aware that a thorough kinetic analysis of the CMJ might provide valuable information regarding the neuromuscular status of the athletes that may not be obtained when analyzing jump height alone (10,26). Finally, frequent evaluations during the competitive period may allow to describe better the effects of training or competition stress on jump-landing cycle fluctuations. We also noted that although CMJ height steadily decreased, eccentric (i.e., peak power and velocity, duration, and COM displacement) and landing (i.e., peak force and RFD to peak force) metrics showed positive trends during specific time points of the season.

There are limitations to this study that must be acknowledged. First, the season was abbreviated because of the COVID-19 pandemic (i.e., interrupted in March 2020 and recommenced directly with play-off games in June 2020). Therefore, the duration of the competition season was 6 months instead of the typical ~8-month season. Second, a small sample size was analyzed. Nevertheless, it is important to note that futsal teams are composed of only 12–14 players, from which 10 were tested during the season, representing >80% of the team's players. Third, subject's total playing time, which could mediate the fluctuations of the neuromuscular performance throughout the season, was not recorded. Finally, a more comprehensive testing battery (e.g., including change of direction tasks, unilateral and bilateral drop jumps, or maximal strength assessments) and more frequent evaluations (e.g., weekly tests) could allow to describe better the effects of training or competition stress on neuromuscular performance during the competitive period. Nevertheless, the aim of the study was to evaluate the chronic adaptations on neuromuscular performance during in-season, with tests conducted at a moment of the week (i.e., three days after competition) at which point the residual fatigue effects associated with match-play are limited (25).

In summary, considering the neuromuscular performance tests and variables assessed, only concentric peak power in CMJ decreased significantly across the season. However, gradual and nonsignificant decrements were observed in other assessments

Downloaded from http://journals.lww.com/nsca-jscr by BhdMf5ePHKav1zEoum1tQfN4a+kJLhEZgbsIH04XM10hCym on 03/27/2023

Table 2

Description of horizontal and countermovement jump kinematic and kinetic variables during the season.*†

Variables	Units	Sept	Oct	Dec	Jan	p	Split periods						Total period	
							Sept–Oct		Oct–Dec		Dec–Jan		Sept–Jan	
							%	ES	%	ES	%	ES	%	ES
SLJ	cm	2.37 ± 0.14	2.31 ± 0.17	2.32 ± 0.20	2.26 ± 0.17	0.164	−2.2	−0.36	0.6	0.14	−2.3	−0.54	−3.9	−0.54
CMJ _{Height}	cm	36.5 ± 3.48	35.2 ± 4.12	35.6 ± 3.87	35.0 ± 5.54	0.175	−3.6	−0.72	2.6	0.53	−3.5	−0.51	−5.1	−0.48
RSI _{modified}	m/s	0.51 ± 0.09	0.47 ± 0.10	0.48 ± 0.08	0.50 ± 0.12	0.126	−7.9	−0.71	7.4	0.46	0.0	0.03	−4.6	−0.28
Eccentric (“downward”) phase														
Peak power	W/kg	−18.1 ± 4.63	−18.1 ± 6.24	−17.2 ± 4.79	−20.1 ± 5.88	0.529	−1.3	0.04	5.2	−0.10	11.7	−0.65	5.2	−0.48
Peak velocity	m/s	−1.28 ± 0.15	−1.21 ± 0.25	−1.30 ± 0.20	−1.34 ± 0.17	0.238	−5.5	0.34	13.0	−0.62	2.3	−0.09	3.0	−0.32
Dec duration	ms	165 ± 35.0	176 ± 43.0	171 ± 36.0	163 ± 30.0	0.316	6.5	0.38	−3.7	−0.31	2.1	0.16	4.3	0.23
COM displacement	cm	31.3 ± 4.11	30.1 ± 3.57	32.6 ± 4.06	30.5 ± 3.18	0.554	−3.4	−0.39	7.6	0.62	−2.6	−0.36	−0.8	−0.00
Concentric (“upward”) phase														
Peak power	W/kg	54.7 ± 5.24	53.0 ± 5.55	51.9 ± 4.61	52.9 ± 6.67	0.040‡	−3.1	−1.26	−0.4	−0.34	−1.0	0.16	−4.8	−0.93
Peak velocity	m/s	2.80 ± 0.12	2.76 ± 0.14	2.78 ± 0.12	2.76 ± 0.18	0.142	−1.6	−0.81	1.3	0.74	−1.3	−0.49	−1.7	−0.46
Duration	ms	259 ± 27.0	259 ± 28.0	266 ± 27.0	259 ± 26.0	0.938	0.1	−0.00	1.9	0.10	0.5	0.11	2.2	0.16
Landing phase														
Peak force	N/kg	105 ± 28.7	104 ± 41.3	92.4 ± 19.5	89.1 ± 17.4	0.188	−1.0	−0.02	−6.3	−0.43	0.5	−0.05	−18.1	−0.70
RFD to peak force§	N/s/kg	3,721 ± 3,003	3,398 ± 2,294	3,685 ± 2,884	2,784 ± 1948	0.681	−3.4	−0.25	3.3	0.08	9.0	−0.09	−15.8	−0.50

*CI = confidence interval; COM = center of mass; Decel = deceleration; RFD = rate force development; RSI = reactive strength index; SLJ = standing long jump.
†Values presented as mean ± SD.
‡p < 0.05; significant differences analyzed by one-way repeated measures ANOVA.
§RFD to peak force: average RFD calculated from landing [time 1] to landing peak force [time 2]. Impulse, force, RFD, and power variables are expressed relative to body mass.

(e.g., sprint time [4.7%; ES = 1.05], SLJ distance [3.9%; ES = -0.54]) and vertical jump outcomes (e.g., CMJ height [5.1%; ES = -0.48]). Other jump-landing phase cycle metrics (i.e., eccentric peak power and velocity, duration, COM displacement, landing peak force, and RFD to peak force) showed positive small to moderate fluctuations throughout the season. The accumulated training and game demands may preclude futsal players from increasing gross sprinting and jumping performance (such as height or power) during the competitive period.

Practical Applications

Monitoring elite futsal players' performance is crucial not only for individual athlete care but also for the team's success. From an applied perspective, monitoring practices should consider the individual athlete's response to the match and training stress they are exposed to, to identify the need for adjustments to competition or training load and recovery and, ultimately, to minimize potential performance decrements. Based on the current data, practitioners are encouraged to perform a broad speed-power assessment including a more thorough kinetic analysis of the CMJ as it might provide valuable information regarding the neuromuscular status of the athletes that may not be identified when monitoring jump height alone. Specifically, concentric peak power should be considered a variable of interest as, in the current study, it was the only CMJ metric that decreased significantly across the season.

References

- Andersson HM, Raastad T, Nilsson J, et al. Neuromuscular fatigue and recovery in elite female soccer: Effects of active recovery. *Med Sci Sports Exerc* 40: 372–380, 2008.
- Azevedo RR, Carpes FP. Cognitive and neuromuscular influences on perceived effort during a competitive season in futsal. *Apunts Sports Med* 56: 100368, 2021.
- Batterham AM, Hopkins WG. Making meaningful inferences about magnitudes. *Int J Sports Physiol Perform* 1: 50–57, 2006.
- Budgett R. Overtraining syndrome. *Bri J Sports Med* 24: 231–236, 1990.
- Claudino JG, Cronin J, Mezêncio B, et al. The countermovement jump to monitor neuromuscular status: A meta-analysis. *J Sci Med Sport* 20: 397–402, 2017.
- Cohen DD, Restrepo A, Richter C, et al. Detraining of specific neuromuscular qualities in elite footballers during COVID-19 quarantine. *Sci Med Football* 5: 26–31, 2021.
- Feroli D, Bosio A, Zois J, La Torre A, Rampinini E. Seasonal changes in physical capacities of basketball players according to competitive levels and individual responses. *PLoS One* 15: e0230558, 2020.
- Fuller CW, Ekstrand J, Junge A, et al. Consensus statement on injury definitions and data collection procedures in studies of football (soccer) injuries. *Scand J Med Sci Sports* 16: 83–92, 2006.
- Gannon EA, Higham DG, Gardner BW, et al. Changes in neuromuscular status across a season of professional men's ice hockey. *J Strength Cond Res* 35: 1338–1344, 2021.
- Gathercole R, Sporer B, Stellingwerff T, Sleivert G. Alternative countermovement-jump analysis to quantify acute neuromuscular fatigue. *Int J Sports Physiol Perform* 10: 84–92, 2015.
- Gonzalez AM, Hoffman JR, Rogowski JP, et al. Performance changes in NBA basketball players vary in starters vs. nonstarters over a competitive season. *J Strength Cond Res* 27: 611–615, 2013.
- Grazioli R, Loturco I, Lopez P, et al. Effects of moderate-to-heavy sled training using different magnitudes of velocity loss in professional soccer players. *J Strength Cond Res*, 2020. Online ahead of print.
- Haugen TA. Soccer seasonal variations in sprint mechanical properties and vertical jump performance. *Kinesiology* 50: 102–108, 2018.
- Illa J, Fernandez D, Reche X, Carmona G, Tarragó JR. Quantification of an elite futsal team's microcycle external load by using the repetition of high and very high demanding scenarios. *Front Psychol* 11: 577624, 2020.
- Kijowski KN, Capps CR, Goodman CL, et al. Short-term resistance and plyometric training improves eccentric phase kinetics in jumping. *J Strength Cond Res* 29: 2186–2196, 2015.
- Kipp K, Kiely M, Geiser C. Competition volume and changes in countermovement jump biomechanics and motor signatures in female collegiate volleyball players. *J Strength Cond Res* 35: 970–975, 2021.
- Legg J, Pyne DB, Semple S, Ball N. Variability of jump kinetics related to training load in elite female basketball. *Sports* 5: 85, 2017.
- López-Segovia M, Vivo Fernández I, Herrero Carrasco R, Pareja Blanco F. Preseason injury characteristics in Spanish professional futsal players: The LNFS project. *J Strength Cond Res* 36: 232–237, 2022.
- Los Arcos A, Martínez-Santos R, Yanci J, Mendez-Villanueva A. Monitoring perceived respiratory and muscular exertions and physical fitness in young professional soccer players during a 32-week period. *Kinesiology* 49: 153–160, 2017.
- Loturco I, Pereira LA, Kobal R, et al. Half-squat or jump squat training under optimum power load conditions to counteract power and speed decrements in Brazilian elite soccer players during the preseason. *J Sports Sci* 33: 1283–1292, 2015.
- McLean BD, Coutts AJ, Kelly V, McGuigan MR, Cormack SJ. Neuromuscular, endocrine, and perceptual fatigue responses during different length between-match microcycles in professional rugby league players. *Int J Sports Physiol Perform* 5: 367–383, 2010.
- Oliveira R, Leicht A, Bishop D, Barbero-Alvarez JC, Nakamura F. Seasonal changes in physical performance and heart rate variability in high level futsal players. *Int J Sports Med* 34: 424–430, 2013.
- Rabelo FN, Pasquarelli BN, Gonçalves B, et al. Monitoring the intended and perceived training load of a professional futsal team over 45 weeks: A case study. *J Strength Cond Res* 30: 134–140, 2016.
- Ribeiro JN, Gonçalves B, Coutinho D, et al. Activity profile and physical performance of match play in elite futsal players. *Front Psychol* 11: 1709, 2020.
- Silva J, Rumpf M, Hertzog M, et al. Acute and residual soccer match-related fatigue: A systematic review and meta-analysis. *Sports Med* 48: 539–583, 2018.
- Spyrou K, Alcaraz PE, Marín-Cascales E, et al. Effects of the COVID-19 lockdown on neuromuscular performance and body composition in elite futsal players. *J Strength Cond Res* 35: 2309–2315, 2021.
- Spyrou K, Freitas TT, Marín-Cascales E, Alcaraz PE. Physical and physiological match-play demands and player characteristics in futsal: A systematic review. *Front Psychol* 11: 2870, 2020.
- Spyrou K, Freitas TT, Marín-Cascales E, Herrero-Carrasco R, Alcaraz PE. External match load and the influence of contextual factors in elite futsal. *Biol Sport* 39: 349–354, 2021.
- Stochi de Oliveira R, Borin JP. Monitoring and behavior of biomotor skills in futsal athletes during a season. *Front Psychol* 12: 1881, 2021.
- van Klij P, Langhout R, van Beijsterveldt A, et al. Do hip and groin muscle strength and symptoms change throughout a football season in professional male football players? A prospective cohort study with repeated measures. *J Sci Med Sport* 24: 1123–1129, 2021.
- Vøllestad NK. Measurement of human muscle fatigue. *J Neurosci Methods* 74: 219–227, 1997.
- Wade JA, Fuller JT, Devlin PJ, Doyle TL. Senior and junior rugby league players improve lower-body strength and power differently during a rugby league season. *J Strength Cond Res* 36: 1367–1372, 2022.