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Effects of a Fifteen-week Off-season Period on Body Composition, Bone Health, and Physical Performance in Elite Female Futsal Players

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Abstract

The off-season is a critical yet underexplored period in elite female futsal, during which detraining may compromise body composition, bone health, and physical performance. This study examined the effects of a 15-week off-season in 28 elite players from the Spanish first division (26.05 ± 5.21 years). Assessments conducted at season end and after the off-season included DXA-derived body composition and bone variables, the 30 − 15 Intermittent Fitness Test, countermovement jump, Sit and Reach, and the Y-Balance Test–Lower Quarter. Lower-limb fat mass increased significantly in the right (+ 13.22%, p = 0.017) and left legs (+ 16.24%, p = 0.019), while left-leg lean mass decreased (− 3.78%, p = 0.013). Aerobic fitness declined significantly (− 5.88%, p = 0.008), whereas countermovement jump performance and flexibility remained unchanged. Dynamic balance decreased only in the left anterior direction (− 7.39%, p = 0.031). Bone mineral content and bone mineral density showed non-significant negative trends. Overall, the off-season induced meaningful deconditioning in lower-limb adiposity, aerobic fitness, and dynamic balance. These findings support individualized maintenance programmes combining aerobic, strength, neuromuscular, and nutritional strategies to preserve performance and musculoskeletal health in elite female futsal players.

1. Introduction

Futsal is a high-intensity indoor team sport characterised by intermittent efforts, frequent accelerations, decelerations, changes of direction, and explosive actions [1, 2]. The physical demands of elite futsal require players to maintain high levels of cardiorespiratory fitness, neuromuscular power, and musculoskeletal integrity throughout the competitive season [3, 4]. However, the annual training structure of professional futsal includes a mandatory off-season period, which can extend up to fifteen weeks in some professional leagues, during which players are typically released from structured training [5]. This phase of reduced or ceased training — referred to as detraining — is a critical window that may jeopardise the physiological adaptations accumulated during the competitive period [6, 7].

The effects of detraining on body composition in team-sport athletes are well established. Even short periods of training cessation (two to four weeks) have been associated with significant reductions in lean mass and concomitant increases in fat mass [8, 9], with lower-limb compartments appearing particularly susceptible to deconditioning given their reliance on daily mechanical loading [10]. Prolonged detraining periods exceeding eight weeks may amplify these changes substantially, producing body composition profiles that depart markedly from competitive-season values [7]. In female athletes, hormonal fluctuations during training cessation may further predispose adipose tissue accumulation due to the modulatory role of oestrogen on lipid metabolism [11]. Accurate body composition monitoring at the end of the off-season period is therefore essential for designing individualised pre-season strategies.

Bone health in athletes is profoundly influenced by mechanical loading history. Weight-bearing and impact sports such as futsal promote site-specific bone accrual in the lower limbs and axial skeleton

through repeated osteogenic stimuli [12, 13]. Cessation of these mechanical stimuli during the off-season may lead to unfavourable changes in bone mineral content (BMC) and bone mineral density (BMD) at load-bearing skeletal sites [14]. This is of particular clinical concern in female athletes in the context of Relative Energy Deficiency in Sport (RED-S) and the female athlete triad, where suboptimal bone metabolism can have long-term consequences on skeletal integrity and fracture risk [11, 15, 16].

Physical performance dimensions such as cardiorespiratory fitness, explosive strength, flexibility, and dynamic balance are also vulnerable to extended periods of detraining. Cardiorespiratory capacity, commonly evaluated via the 30 – 15 Intermittent Fitness Test (30 – 15 IFT; [17]), declines within the first two weeks of training cessation due to reductions in stroke volume, plasma volume, and mitochondrial density [6, 18]. The Counter Movement Jump (CMJ) test provides a reliable measure of lower-limb explosive power in football [19, 20], while the Sit & Reach test assesses lower back and hamstring flexibility [21]. Dynamic neuromuscular control, evaluated using the Y-Balance Test – Lower Quarter (YBT-LQ; [22]), is also considered a sensitive indicator of off-season deconditioning and is independently associated with lower-extremity injury risk [23].

Despite growing research on detraining in male football players [5, 9] studies targeting elite female futsal players are scarce. Sex-specific differences in body composition, hormonal status, and bone metabolism mean that findings from male populations cannot be directly extrapolated. Furthermore, multi-component assessments that simultaneously evaluate body composition, bone health, and multiple physical performance dimensions across a prolonged off-season are rare. Given the extensive fifteen-week inter-season break examined in this study, which substantially exceeds the four-to-eight weeks typically reported in the literature, the resulting deconditioning may be of heightened practical significance.

The primary objective of this study was to examine the effects of a fifteen-week off-season period on body composition, BMC, BMD, and a battery of physical performance tests (30 – 15 IFT, CMJ, Sit & Reach, and YBT-LQ) in elite female futsal players. It was hypothesised that lower-limb fat mass would increase significantly, bone mineral parameters would show meaningful negative trends, and cardiorespiratory fitness would decline following the off-season. These findings are intended to inform evidence-based off-season maintenance programmes for elite female futsal players.

2. Methods

2.1. Research Design

This was a prospective longitudinal experimental study with two separate measurement time points over a period of fifteen weeks. Data were collected between May 2025 (last match of the competitive season 2024–2025: 10 May 2025) and late August 2025, prior to the start of a four-week pre-season block leading into the 2025–2026 season. All assessments were conducted under standardised conditions at the same time of day (morning) to minimise circadian variation.

2.2. Participants

A total of 28 female elite futsal players (age: 26.05 ± 5.21 years; height: 165.8 ± 6.44 cm; body mass: 56.04 ± 4.19 kg) participated in the study. Two players were initially enrolled but excluded due to injury-related reasons, resulting in a final sample of 28 participants for all analyses. All players had more than five years of competitive experience and a minimum of three years competing in the 1ª División Fútbol Sala Iberdrola. During the competitive season, players trained an average of four sessions per week (incorporating strength, endurance, and speed components) and played one official match per weekend.

As an inclusion criterion, players had to be free from injuries at the time of both assessments. An injury was defined as any physical complaint sustained by a player resulting from training or match activity that led to an absence from the subsequent training session or match [24, 25].

Written informed consent was obtained from all participants prior to inclusion. Ethical approval was sought from the Bioethics Committee for Clinical Research of Hospital Universitario Getafe, an independent external hospital-based ethics committee. This external review procedure was selected to ensure that the study protocol underwent a rigorous and independent ethical assessment, including strict evaluation of participant safety, risk–benefit balance, informed consent procedures, data protection, and compliance with the requirements applicable to research involving human participants. The committee approved the study protocol on 25 March 2025 (Ref. A02/25). All procedures were conducted in accordance with the Declaration of Helsinki and relevant ethical guidelines and regulations.

2.3. Measurements

2.3.1. Body Composition and Bone Health

Bone mineral content (BMC, g), bone mineral density (BMD, g/cm²), fat mass (g; %), and lean mass (g) were assessed using dual-energy X-ray absorptiometry (DXA; Hologic Series Discovery QDR, APEX System Software Version 3.1.2; Bedford, MA, USA). Participants were scanned in the supine position, with the body and extremities fully extended within the scan lines of the examination couch. Each scan provided regional data (legs, trunk, pelvis, spinal segments) and whole-body subtotal values (Total Body Less Head, TBLH) for BMC, BMD, fat mass, and lean mass [12, 13].

2.3.2. Counter Movement Jump

Lower-limb explosive power was assessed using the Counter Movement Jump (CMJ) test. From an upright standing position with hands on hips, players performed a rapid knee flexion to approximately 90° followed by a maximal vertical jump. The best result from three attempts was used for analysis. This test evaluates explosive concentric-elastic strength and has been widely used in football populations [19, 26].

2.3.3. 30 − 15 Intermittent Fitness Test

Cardiorespiratory fitness was assessed using the 30 – 15 Intermittent Fitness Test (30 – 15 IFT), a validated field test for intermittent sport athletes [17]. Players performed 30-second shuttle runs alternated with 15-second passive recovery periods, beginning at 8 km/h and increasing by 0.5 km/h per stage until volitional exhaustion. The final velocity achieved (VIFT) was recorded as the test score.

2.3.4. Sit & Reach Test

Lower back and hamstring flexibility were assessed using the Sit & Reach test [21, 27]. Participants sat barefoot with legs fully extended, feet against a standardised box. With arms extended, players reached forward maximally without knee flexion and held the position for two seconds (Dugdale et al., 2018). Three trials with 10-second rest intervals were performed; the best score (cm) was retained (Bogalho et al., 2022).

2.3.5. Y-Balance Test – Lower Quarter

Dynamic lower-limb balance was evaluated using the Y-Balance Test – Lower Quarter (YBT-LQ), which assesses maximal reach in the anterior (ANT), posteromedial (PM), and posterolateral (PL) directions while standing unipedally [23]. Three practice trials per limb were completed to minimise learning effects, followed by three recorded attempts per direction [30]. Reach distances were normalised to limb length and expressed as percentages [31].

2.4. Statistical Analysis

Data are expressed as mean ± standard deviation (SD). Differences between pre- and post-off-season measurements were examined using the Wilcoxon signed-rank test for paired samples. The 95% confidence interval (95% CI) for the difference between time points was calculated for each variable. Effect size was quantified using Cohen's dz for paired comparisons and interpreted as: trivial (< 0.10), small (0.10–0.29), medium (0.30–0.49), and large (≥ 0.50). Statistical significance was set at $p < 0.05$. All analyses were performed using IBM SPSS Statistics for Windows (v24, SPSS Inc., Chicago, IL, USA). Kernel density estimation (KDE) plots were generated to visualise distributional changes in key performance variables across time points.

3. Results

3.1. Body Composition

Table 1 presents the body composition data at both measurement time points. Regarding fat mass in grams, statistically significant increases were observed in the right leg (+ 13.22%, $p = 0.017$, $dz = 1.11$) and the left leg (+ 16.24%, $p = 0.019$, $dz = 1.07$), both with large effect sizes. Non-significant but practically meaningful trends were found for total fat mass (+ 10.39%, $p = 0.087$, $dz = 0.70$). When expressed as fat mass percentage, the right leg showed a significant increase of + 10.93% ($p = 0.012$, $dz = 1.20$) and the left leg of + 13.35% ($p = 0.007$, $dz = 1.32$), both with large effect sizes. Total fat percentage showed a near-significant trend ($\Delta = +2.38\%$, $p = 0.059$, $dz = 0.80$).

For lean mass, the only statistically significant change was a reduction in the left leg (− 3.78%, p = 0.013, dz = − 1.17). Near-significant decrements with large effect sizes were observed in right leg (− 2.47%, p = 0.057, dz = − 0.80). Total lean mass declined by − 1.99% (p = 0.104, dz = − 0.66). No statistically significant changes were found in total body mass in any segment.

Table 1
Body composition variables before and after the off-season period.

Variable	Pre-off-season (N = 28)	Post-off-season (N = 28)	Δ Post − Pre	Δ from Pre (%)	CV Pre (%)	CV Post (%)	p value	Cohen dz
Fat mass (g)								
Right arm	868.83 ± 247.08	898.12 ± 309.73	29.29	3.37	28.44	34.49	0.671	0.16
Left arm	826.58 ± 260.91	838.28 ± 270.13	11.70	1.42	31.57	32.22	0.792	0.10
Right leg*	3133.78 ± 899.27	3547.91 ± 1061.83	414.13	13.22	28.70	29.93	0.017	1.11
Left leg*	3142.75 ± 861.26	3653.11 ± 1195.74	510.36	16.24	27.40	32.73	0.019	1.07
Trunk	6889.58 ± 2269.70	7517.10 ± 2076.91	627.52	9.11	32.94	27.63	0.234	0.46
Total	15607.67 ± 3900.94	17228.94 ± 4532.19	1621.27	10.39	24.99	26.31	0.087	0.70
Fat mass (%)								
Right arm	29.48 ± 5.13	30.86 ± 6.00	1.38	4.68	17.42	19.43	0.408	0.31
Left arm	29.67 ± 5.24	31.22 ± 4.31	1.55	5.22	17.64	13.80	0.214	0.48
Right leg*	28.81 ± 3.99	31.96 ± 5.02	3.15	10.93	13.83	15.71	0.012	1.20
Left leg*	28.98 ± 4.17	32.85 ± 5.95	3.87	13.35	14.38	18.12	0.007	1.32
Trunk	24.15 ± 6.02	26.20 ± 5.25	2.05	8.49	24.94	20.05	0.179	0.53
Total	26.01 ± 4.14	28.39 ± 4.49	2.38	9.15	15.93	15.82	0.059	0.80
Lean mass (g)								
Right arm	1898.65 ± 236.85	1827.61 ± 264.75	-71.04	-3.74	12.47	14.49	0.057	-0.80

Variable	Pre-off-season (N = 28)	Post-off-season (N = 28)	Δ Post − Pre	Δ from Pre (%)	CV Pre (%)	CV Post (%)	p value	Cohen dz
Left arm	1775.53 ± 167.23	1677.15 ± 255.92	-98.38	-5.54	9.42	15.26	0.051	-0.83
Right leg	7148.16 ± 1048.65	6971.44 ± 988.63	-176.72	-2.47	14.67	14.18	0.057	-0.80
Left leg*	7120.36 ± 974.98	6851.31 ± 1050.19	-269.05	-3.78	13.69	15.33	0.013	-1.17
Trunk	20479.08 ± 1600.00	20157.57 ± 1741.92	-321.51	-1.57	7.81	8.64	0.344	-0.36
Total	41291.30 ± 4024.18	40469.75 ± 4107.80	-821.55	-1.99	9.75	10.15	0.104	-0.66
Total mass (g)								
Right arm	2902.76 ± 446.28	2861.79 ± 499.54	-40.97	-1.41	15.37	17.46	0.540	-0.23
Left arm	2729.31 ± 418.99	2643.68 ± 509.84	-85.63	-3.14	15.35	19.29	0.262	-0.43
Right leg	10738.91 ± 1859.63	10955.45 ± 1847.72	216.54	2.02	17.32	16.87	0.068	0.76
Left leg	10722.30 ± 1708.94	10956.91 ± 1950.91	234.61	2.19	15.94	17.81	0.144	0.58
Trunk	28031.64 ± 3117.58	28333.84 ± 3089.24	302.20	1.08	11.12	10.90	0.434	0.29
Total	59282.90 ± 7283.97	59985.71 ± 7671.37	702.81	1.19	12.29	12.79	0.234	0.46

Values are presented as mean ± SD. Pre-off-season = final part of the competitive season; post-off-season = assessment after the off-season period. Differences and percentage changes are calculated as post-off-season minus pre-off-season. CV = coefficient of variation; dz = Cohen's dz for paired comparisons. *$p < 0.05$.

3.2. Bone Mineral Content and Bone Mineral Density

Table 2 presents the bone mineral data across the off-season period. No variable in either BMC or BMD reached statistical significance ($p < 0.05$). Nevertheless, consistent negative trends were observed across all measured skeletal sites, with several medium-to-large effect sizes indicating clinically relevant changes.

Regarding BMC, the largest absolute and relative change was observed in the right leg (− 20.88 g, − 4.57%, p = 0.061, dz = − 0.79), which approached statistical significance with a large effect size. The dorsal column showed a decrease of − 4.49% (p = 0.234, dz = − 0.40) and the lumbar column of − 1.90% (p = 0.694, dz = − 0.14). Left leg BMC declined by − 1.47% (p = 1.000, dz = − 0.28) and pelvis BMC by − 1.00% (p = 0.496, dz = − 0.25). Whole-body BMC Subtotal/TBLH decreased by − 1.60% (p = 0.231, dz = − 0.46).

For BMD, the pelvis showed the closest approach to statistical significance (− 3.85%, p = 0.071, dz = − 0.75), followed by the right leg (− 4.96%, p = 0.119, dz = − 0.63). The dorsal column BMD declined by − 3.23% (p = 0.251, dz = − 0.44), the lumbar column by − 3.33% (p = 0.169, dz = − 0.46), and the left leg by − 3.60% (p = 0.461, dz = − 0.40). Whole-body BMD Subtotal/TBLH decreased by − 2.19% (p = 0.299, dz = − 0.40). Collectively, the pattern of consistent negative trends across all measured skeletal sites — none reaching significance but most showing medium-to-large effect sizes — suggests a biologically meaningful but statistically underpowered response to fifteen weeks of mechanical unloading.

Table 2
Bone mineral content and bone mineral density before and after the off-season period.

Variable	Pre-off-season (N = 28)	Post-off-season (N = 28)	Δ Post − Pre	Δ from Pre (%)	CV Pre (%)	CV Post (%)	p value	Cohen dz
BMC (g)								
Right leg	457.00 ± 58.98	436.12 ± 52.43	-20.88	-4.57	12.91	12.02	0.061	-0.79
Left leg	459.12 ± 56.50	452.38 ± 51.38	-6.74	-1.47	12.31	11.36	1.000	-0.28
Dorsal column	119.54 ± 16.77	114.17 ± 12.55	-5.37	-4.49	14.03	10.99	0.234	-0.40
Lumbar column	71.20 ± 6.26	69.85 ± 9.91	-1.35	-1.90	8.79	14.20	0.694	-0.14
Pelvis	307.28 ± 41.70	304.21 ± 35.80	-3.08	-1.00	13.57	11.77	0.496	-0.25
BMC Subtotal / TBLH	1841.50 ± 220.57	1812.12 ± 200.78	-29.38	-1.60	11.98	11.08	0.231	-0.46
BMD ($g \cdot cm^{-2}$)								
Right leg	1.41 ± 0.12	1.34 ± 0.11	-0.07	-4.96	8.47	8.39	0.119	-0.63
Left leg	1.39 ± 0.13	1.34 ± 0.11	-0.05	-3.60	9.22	8.23	0.461	-0.40
Dorsal column	0.93 ± 0.08	0.90 ± 0.05	-0.03	-3.23	8.12	5.59	0.251	-0.44
Lumbar column	1.20 ± 0.10	1.16 ± 0.09	-0.04	-3.33	8.33	7.76	0.169	-0.46
Pelvis	1.30 ± 0.10	1.25 ± 0.10	-0.05	-3.85	7.72	7.68	0.071	-0.75
BMD Subtotal / TBLH	1.106 ± 0.079	1.082 ± 0.064	-0.024	-2.19	7.11	5.90	0.299	-0.40

Values are mean ± SD. Pre-off-season = final part of the competitive season; Post-off-season = assessment after the off-season period. Δ and percentage change were calculated as Post − Pre. CV = coefficient of variation; BMC = bone mineral content; BMD = bone mineral density. TBLH: Total Body Less Head

3.3. Physical Performance

Figure 1 displays the kernel density distributions for the 30 − 15 IFT score (panel A), CMJ best result (panel B), and Sit & Reach best score (panel C) before and after the off-season period. The 30 − 15 IFT score declined significantly from pre- to post-off-season (17.12 ± 1.25 km/h vs. 16.17 ± 1.15 km/h; Δ = −0.95 km/h; −5.88%; p = 0.008; dz = − 2.42), corresponding to a very large effect size. This is evidenced by the clear leftward shift of the post-off-season distribution and the significance bracket in panel A. The CMJ showed a non-significant reduction (26.01 ± 2.24 cm vs. 25.04 ± 3.25 cm; Δ = −0.97 cm; −3.73%; p = 0.331; dz = − 0.35; panel B). The Sit & Reach test showed no significant change between time points (25.94 ± 7.71 cm vs. 26.65 ± 8.20 cm; Δ = +0.71 cm; +2.74%; p = 0.332; dz = 0.34; panel C).

Kernel density distributions of 30–15 IFT score (A), CMJ best (B), and S&R best (C) before and after the off-season period. Blue lines/shaded areas represent pre-off-season values, and orange lines/shaded areas represent post-off-season values. Dashed vertical lines indicate mean values. Data are presented as mean ± standard deviation. * Indicates a significant difference between pre- and post-off-season values ($p < 0.05$).

Figure 2 presents the half-violin plots for the YBT-LQ across the anterior, right, and left directions for both the right and left limbs. The only statistically significant change was observed in the left limb anterior direction (Y-B L. anterior: 54.11 ± 6.57% vs. 50.11 ± 8.36%; Δ = −4.00%; −7.39%; p = 0.031; dz = − 0.87), representing a large effect size. The right limb anterior direction showed a near-significant negative trend (Y-B R. anterior: 53.44 ± 8.16% vs. 51.39 ± 7.70%; Δ = −3.84%; p = 0.115; dz = − 0.59). The remaining YBT-LQ directions showed no statistically significant differences: Y-B R. Right (p = 0.932; dz = − 0.03), Y-B R. Left (p = 0.542; dz = 0.21), Y-B L. Right (p = 0.773; dz = − 0.10), and Y-B L. Left (p = 0.198; dz = 0.47). Collectively, these results suggest a selective impairment of anterior neuromuscular control following the off-season, with the left limb being the most affected.

Half-violin plots show the distribution of Y-Balance Test performance for the right and left legs in the anterior, right/posterolateral, and left/posteromedial directions before and after the off-season period. Boxplots represent the median and interquartile range, and horizontal markers indicate mean values. Orange distributions represent pre-off-season values and blue distributions represent post-off-season values. * Indicates a significant difference between pre- and post-off-season values ($p < 0.05$).

4. Discussion

The principal findings of this study demonstrate that fifteen weeks of off-season training cessation in elite female futsal players produced significant and clinically meaningful deconditioning across multiple physiological domains. Lower-limb fat mass increased significantly with large effect sizes, left-leg lean mass decreased significantly, cardiorespiratory fitness declined, and dynamic lower-limb balance was impaired. Bone mineral parameters showed consistent negative trends without reaching statistical significance, a pattern that is nonetheless clinically relevant given the uniformity and magnitude of the effect sizes observed. The extended duration of the off-season investigated here (fifteen weeks)

substantially exceeds the four-to-eight weeks typical of professional football and futsal [5], making these findings particularly informative for leagues with prolonged inter-season breaks.

The significant accumulation of lower-limb fat mass (right leg: +13.22%, dz = 1.11; left leg: +16.24%, dz = 1.07) is consistent with existing detraining research in female team-sport athletes. Authors reported significant fat mass gains in professional football players across a relatively brief off-season [10], suggesting that the lower-limb fat compartment is among the most sensitive to training cessation. In the present study, the large effect sizes obtained for both legs underscore the magnitude of this response following fifteen weeks of inactivity. In female athletes, estrogen and progesterone fluctuations during periods of reduced training have been proposed as modulators of lipid partitioning, potentially amplifying adipose tissue accumulation in the lower extremities [11]. Furthermore, near-significant total fat mass accumulation and total fat percentage increases reinforce the systemic nature of this response. From a performance standpoint, excess lower-limb fat mass increases the metabolic cost of repeated high-intensity efforts and imposes a mechanical disadvantage during the accelerations and changes of direction that are fundamental to futsal performance [1, 2].

The significant decrease in left-leg lean mass, alongside near-significant losses in right leg lean mass, reflects a broad atrophic response to mechanical unloading. The asymmetric significance between limbs for lean mass changes may reflect inter-individual variability in off-season activity patterns or dominant limb usage. Authors demonstrated in a meta-analysis that training cessation produces measurable muscular deconditioning within two to four weeks [7], with lower-limb muscle mass particularly susceptible due to its dependence on high mechanical loading during sport-specific training. The preservation of trunk lean mass in the present study may reflect the contribution of activities of daily living to postural muscle maintenance, a pattern also noted [9].

Although no bone variable reached statistical significance ($p < 0.05$), the consistent pattern of negative trends across all measured skeletal sites merits careful interpretation. The right leg BMC approached significance and pelvis BMD reached a trend level, both with large effect sizes. Whole-body BMD Subtotal/TBLH declined by − 2.19% ($p = 0.299$) and BMC Subtotal/TBLH by − 1.60% ($p = 0.231$). These magnitudes are clinically relevant: authors demonstrated that cessation of mechanical loading produces measurable decrements in bone turnover markers within two weeks, and that site-specific BMD reductions emerge within four to eight weeks; a fifteen-week period of unloading would therefore be expected to produce appreciable skeletal mineral losses [14]. Authors found that female collegiate soccer players showed significant decreases in femoral neck aBMD and trabecular vBMD (− 3.0 ± 1.3 mg/cm³, $p = 0.02$) after an off-season period, a magnitude qualitatively comparable to the present findings [32]. That none of our bone variables reached $p < 0.05$ likely reflects a combination of limited statistical power ($n = 28$), substantial inter-individual variability in off-season physical activity levels, and the TBLH measurement approach which averages across both loaded and unloaded skeletal regions. The pelvis BMD and right-leg BMC trends are of particular clinical relevance given their roles in load transmission during high-intensity futsal movements [33]. In the broader context of RED-S and the

female athlete triad, even subclinical bone mineral losses sustained annually may cumulatively increase fracture risk over an athletic career [15, 16, 34].

The significant decline in 30 − 15 IFT score (− 5.88%) is entirely consistent with the established kinetics of cardiovascular detraining, and the very large effect size obtained underscores the extent of aerobic deconditioning following fifteen weeks of training cessation. Authors demonstrated that VO_2max and cardiac output begin to decline within one to two weeks of training cessation, reaching reductions of 10–15% after four to eight weeks [18]. Over fifteen weeks, substantially greater reversals of cardiovascular adaptations would be expected, including reductions in maximal stroke volume, plasma volume expansion, and skeletal muscle mitochondrial density. Previous studies reported significant aerobic fitness decrements over a five-week off-season in football players [35]; the fifteen-week duration in the present study provides a markedly greater detraining stimulus. The intermittent structure of the 30 − 15 IFT also makes it sensitive to neuromuscular fatigue resistance and repeated sprint ability — both of which are susceptible to extended detraining in futsal [3, 17].

The absence of significant changes in CMJ performance after fifteen weeks of detraining is notable. Authors reported that CMJ values can be maintained over moderate detraining periods, but prolonged cessation typically produces measurable decrements [20]. One plausible explanation is that players engaged in sufficient habitual physical activity to preserve neuromuscular function despite the absence of structured sessions. The small-to-medium effect size obtained (dz = − 0.35) suggests the practical magnitude of any explosive strength change was limited. The maintenance of Sit & Reach scores is consistent with evidence indicating that passive flexibility is relatively resilient to extended training cessation when baseline ambulatory activity is preserved [21].

Regarding the YBT-LQ, only the left limb anterior direction showed a statistically significant reduction (− 7.39%), representing a large effect size. The right limb anterior direction showed a near-significant trend of comparable magnitude, while all posterior directions remained stable across both limbs. This selective impairment of anterior reaches — the direction most closely linked to hip flexor and quadriceps neuromuscular control — is consistent with the significant lean mass losses observed in the lower limbs. Previous studies demonstrated that reduced anterior YBT-LQ scores independently predict lower-extremity injury risk in sport [22]. The asymmetric significance between limbs for anterior reach may reflect differences in dominant versus non-dominant limb usage during the off-season. The relative preservation of posterior reach directions may indicate that activities of daily living are sufficient to maintain hip extensor and calf neuromuscular function during an unstructured rest period [23, 31].

Several limitations of the present study should be acknowledged. First, dietary intake and energy availability were not monitored during the off-season, limiting causal attribution of the observed changes exclusively to training cessation [34]. Second, the sample size of 28, while appropriate for an elite cohort study, may have been insufficient to detect statistically significant bone mineral changes given the inter-individual variability in off-season activity levels. Third, the absence of objective monitoring of off-season physical activity (e.g., accelerometry) represents a methodological gap that future studies should

address. Fourth, the DXA TBLH approach provides aggregate bone measurements that may mask site-specific changes, and future studies employing regional DXA scans with dedicated femoral neck and hip analysis would provide greater sensitivity for detecting lower-limb bone changes in futsal players.

5. Conclusions

Fifteen weeks of off-season training cessation in elite female futsal players produced significant deconditioning in lower-limb fat mass, lean mass, cardiorespiratory fitness, and dynamic lower-limb balance. Bone mineral parameters showed clinically meaningful but statistically non-significant negative trends across all measured skeletal sites, suggesting that a larger sample or targeted regional DXA measurements may be required to confirm these changes statistically.

Sports scientists should implement systematic post-off-season screening of body composition and physical performance to identify players requiring targeted individualised interventions before resuming full-load training.

6. Data availability statement

The individual-level data supporting the findings of this study are not publicly available because the small and specific sample of elite female futsal players may permit participant re-identification, even after the removal of direct identifiers. Anonymised data may be requested from the corresponding author, M.L.M.-S. (marialuisa.martindesanpablo@universidadeuropea.es), for legitimate scientific research, replication, and verification purposes. Requests must include the applicant's name, institutional affiliation, and a description of the proposed use of the data and will normally be evaluated within 30 days. Access is subject to compatibility with the participants' informed consent, applicable ethical and institutional requirements, and completion of a data-use agreement. Approved users must maintain data confidentiality, must not attempt to re-identify or contact participants, must not share the data with third parties, and must use the data exclusively for the approved purpose.

Declarations

Conflicts of Interest

The authors declare no conflict of interest.

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Author Contribution

Conceptualization: M.L.M-S., J.S.S., C.S.L.; methodology: M.L.M-S., J.S.S., J.L.F., I.F-G.; formal analysis: M.L.M-S., J.S.S., I.F-G., C.S.L.; investigation: M.L.M-S., J.S.S., I.F-G., C.S.L.; resources: M.L.M-S., J.S.S., C.S.L, J.L.F., A.B.S.; data curation: M.L.M-S., J.S.S., C.S.L, J.L.F, A.B.S.; writing—original draft preparation: M.L.M-S., J.S.S.; writing—review and editing: M.L.M-S., J.S.S., C.S.L, J.L.F.; visualization: M.L.M-S., J.S.S., C.S.L, J.L.F., I.F-G.; supervision: M.L.M-S., J.S.S., C.S.L, J.L.F., I.F-G., A.B.S.; project administration: M.L.M-S., J.S.S., J.L.F.; funding acquisition: M.L.M-S., J.S.S. All authors have read and agreed to the published version of the manuscript.

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To the CF Futsal Rayo Majadahonda.

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Figures

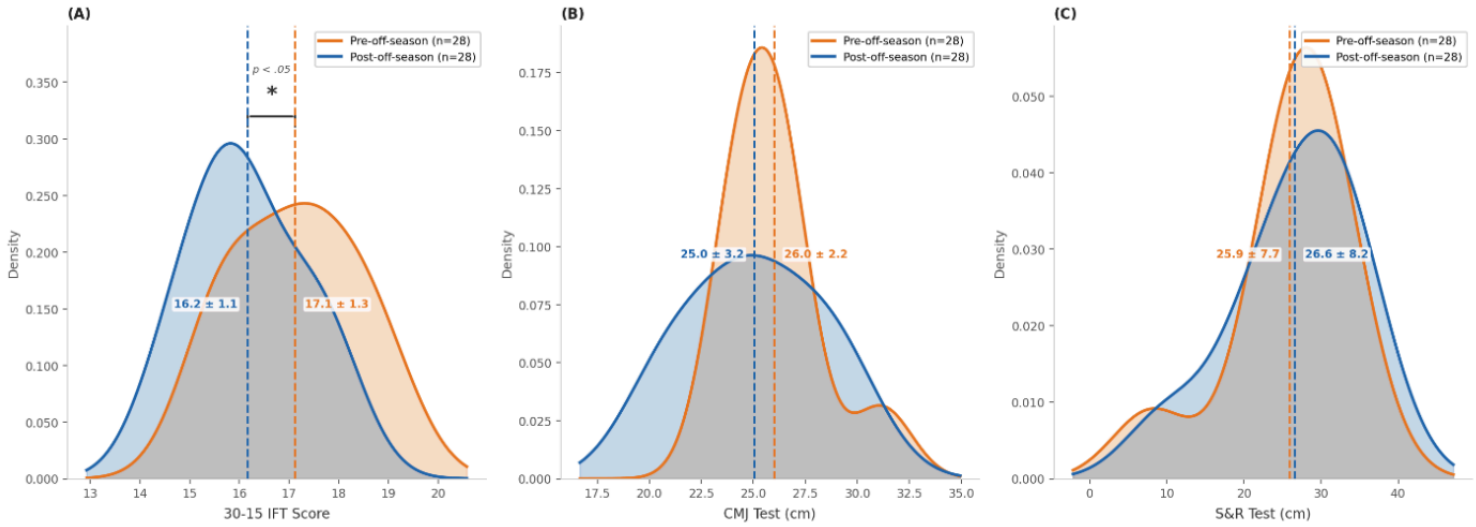


Figure 1

Kernel density distributions of 30-15 IFT score, CMJ best, and S&R best before and after the off-season period.

Kernel density distributions of 30–15 IFT score (A), CMJ best (B), and S&R best (C) before and after the off-season period. Blue lines/shaded areas represent pre-off-season values, and orange lines/shaded areas represent post-off-season values. Dashed vertical lines indicate mean values. Data are presented as mean ± standard deviation. * Indicates a significant difference between pre- and post-off-season values ($p < 0.05$).

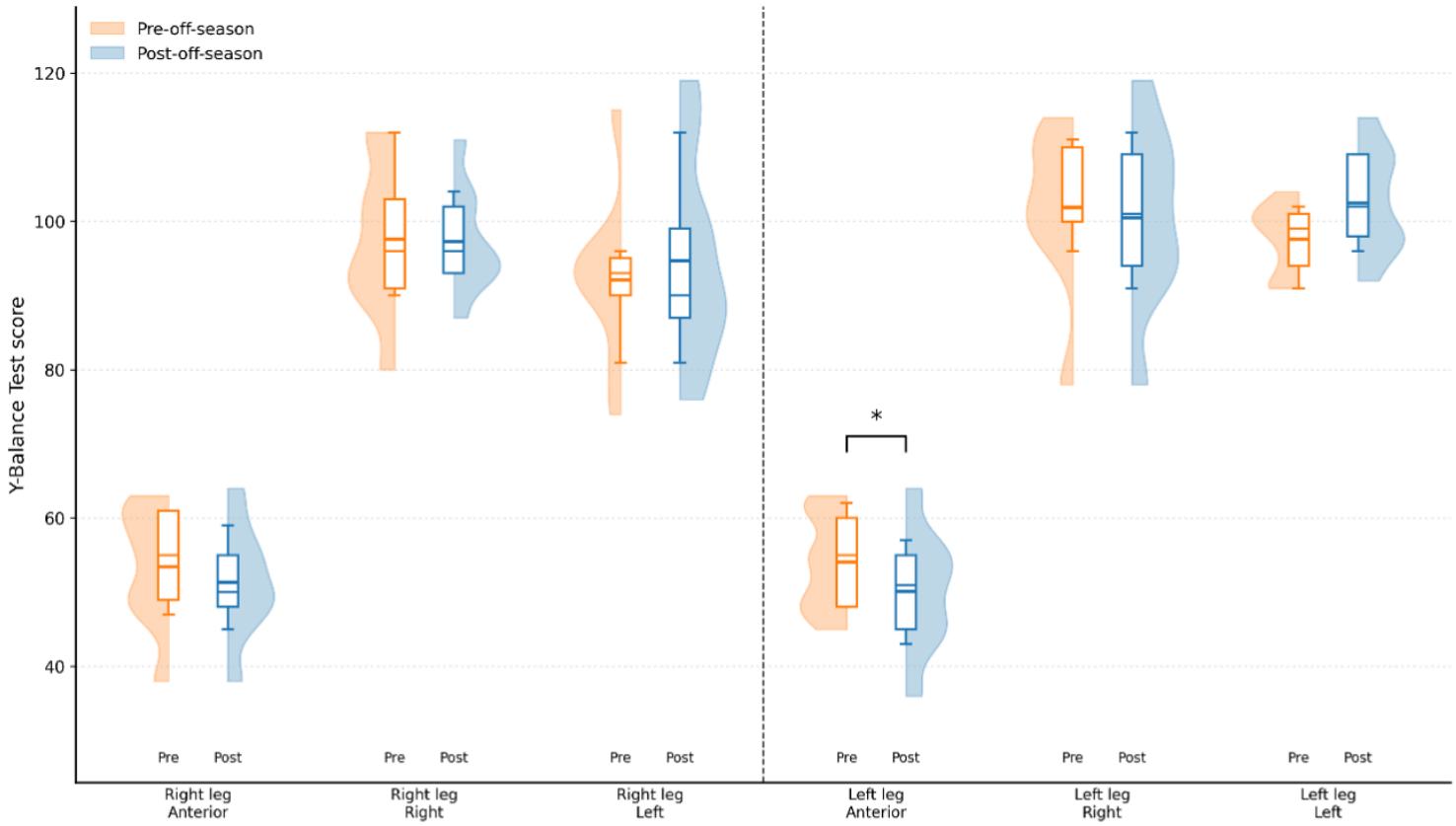


Figure 2

Half-violin plots of Y-Balance Test performance before and after the off-season period.

Half-violin plots show the distribution of Y-Balance Test performance for the right and left legs in the anterior, right/posterolateral, and left/posteromedial directions before and after the off-season period. Boxplots represent the median and interquartile range, and horizontal markers indicate mean values. Orange distributions represent pre-off-season values and blue distributions represent post-off-season values. * Indicates a significant difference between pre- and post-off-season values ($p < 0.05$).