

Weekly external load periodization and positional match-play demands during a professional football pre-season: A GPS-based study

 **Danail Ivanov**  . Department of Football and Tennis. National Sports Academy "Vasil Levski". Sofia, Bulgaria.

ABSTRACT

GPS microtechnology is now routine in professional football for tracking external training and match load, yet reports that integrate training periodization, positional match demands and body-composition monitoring within one pre-season squad remain rare outside major European leagues. This study described weekly external training load across a seven-week professional pre-season, compared positional running demands across pre-season friendly matches—with particular attention to whether competitive high-intensity profiles persist under rotational conditions—and monitored body mass and body fat percentage. Data came from the GPS system (Catapult Sports) of a Bulgarian First League club: 40 training sessions, 9 friendly matches (134 player-match observations, 28 players, five positions) and seven body-composition assessments (34 players). Weekly training and high-speed running distance varied descriptively but not significantly between weeks (Kruskal-Wallis, $p = .083$). During matches, relative distance, high-speed running, sprint distance, maximal velocity, sprint efforts and acceleration/deceleration efforts differed by position ($p \leq .030$), with central defenders showing the lowest high-intensity output and full-backs/wide players the greatest sprint demands—profiles that closely matched those reported for competitive matches. Body mass and body fat percentage stayed stable ($p = .961$). These club-specific findings support the use of pre-season friendlies as an ecologically valid reference for position-specific conditioning from the earliest weeks of preparation and suggest that a single pre-season block may not shift body composition in already lean professional players. **Keywords:** performance analysis; soccer; time-motion analysis; athlete monitoring; body composition; team sports; microcycle; pre-season friendlies.

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 **Corresponding author.** National Sports Academy "Vasil Levski", Department of Football and Tennis, Sofia 1700, Bulgaria.

E-mail: danail.ivanov@nsa.bg

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INTRODUCTION

External load monitoring with GPS microtechnology is now a fixture of daily practice in professional football. Coaches and sport scientists rely on it to quantify what players actually do on the pitch: distance covered, high-speed running, sprinting, and the accelerations and decelerations that video analysis alone could never capture with the same precision (Rice et al., 2022). The pre-season period carries particular weight in this respect. It is the window in which the physical platform for the entire competitive season is built, and problems with load management here tend to resurface later, in the form of fatigue or injury, once matches start counting (Nobari et al., 2022).

Match running demands are not distributed evenly across the pitch. Across a wide range of studies, in youth and senior squads, in different leagues and confederations, a consistent picture emerges: wide players and full-backs rack up the most high-speed running and sprinting, central defenders the least, while central midfielders tend to cover the greatest total ground, usually at a lower relative intensity (Vieira et al., 2019; Aquino et al., 2020; Aquino et al., 2017). The consistency of this pattern across settings (Modrić et al., 2019, 2021; Goranović et al., 2022; Goto & Saward, 2020; Rey et al., 2023; Parr et al., 2022) suggests it reflects something structural about the positions themselves rather than a quirk of any single dataset. What remains far less clear is whether this same profile holds up in pre-season friendlies—games usually treated as a vehicle for squad rotation and fitness-building rather than genuine competition, with playing time spread thin across a large group of players (Muñoz et al., 2022). Almost all the evidence on positional running profiles comes from official matches in the best-resourced leagues; friendlies, and clubs outside that bracket, remain comparatively under-studied.

Within a competitive season, the week-to-week structure of training load relative to the next fixture—the microcycle, typically described from MD-5 to MD+1—is well documented, with volume and intensity deliberately undulated to balance development against recovery (Hasan et al., 2021; Nobari et al., 2021; Evans et al., 2021). Pre-season is a different animal: there is no fixture to anchor the cycle at the outset, and coaches instead have to build volume from a blank slate. How that build-up actually unfolds, described week by week across an entire preparatory block, is something the literature has surprisingly little to say about, particularly outside the handful of leagues that dominate the sports-science literature.

Pre-season is also conventionally treated as a chance to shed the body fat players tend to carry over from the off-season and to reset toward competition-ready condition (McEwan et al., 2020). The evidence for how much actually changes, and how quickly, is mixed. Some cohorts show real reductions in fat mass over a pre-season block (Milanese et al., 2015; Suárez-Arrones et al., 2019); others find next to nothing, largely because full-time professionals now train individually through the off-season and arrive at pre-season already close to their in-season body composition, leaving little room left to change (Čaušević et al., 2024; Madić et al., 2018).

No study, to our knowledge, has examined weekly training-load periodization, positional match demands and body-composition tracking together within a single pre-season cohort from the Bulgarian First League—a competitive context that, like much of Eastern Europe, rarely features in this literature. Beyond simply adding region-specific data, the present study focuses on a practically important and still under-examined question: do position-specific high-intensity running profiles remain stable in pre-season friendlies despite extensive squad rotation and a non-competitive match context? Answering that question has direct relevance for conditioning staff who must decide whether friendlies can serve as a valid reference for position-specific load prescription during preparation. This study therefore set out to: (1) describe the weekly external training load

across a seven-week professional pre-season in a Bulgarian First League club; (2) compare positional running demands across a series of pre-season friendlies, with particular attention to whether the familiar competitive profiles persist under rotational conditions; and (3) track changes in body mass and body fat percentage over the same period.

MATERIAL AND METHODS

Participants

The data analysed here come from the club's own day-to-day athlete-monitoring routine, collected by the performance staff as part of normal practice, independently of this study, and anonymized before analysis. The training dataset spans 40 team sessions over a seven-week pre-season (12 June to 4 August 2026). The match dataset draws on 9 pre-season friendlies against nine different Bulgarian opponents, each meeting a pre-specified data-quality check (a clear first-half/second-half split; see Procedures) and yields 134 player-match observations from 28 outfield players across five positional groups: central defenders ($n = 4$), full-backs ($n = 4$), central midfielders ($n = 7$, including players nominally listed as attacking midfielders), wide players ($n = 8$) and forwards ($n = 5$). Body composition was tracked in 34 squad members across up to seven assessment dates. Descriptors such as age or stature were not part of the club's routine records and are not reported here.

Measures

Training and match load were captured with 10-Hz GPS units (Catapult Sports, Melbourne, Australia), worn in a vest between the shoulder blades and processed through the manufacturer's cloud platform. Each training session's team summary included total distance (m), high-speed running distance (the report's highest flagged velocity zone, "*HS Dist*"), the count of combined acceleration/deceleration efforts above the manufacturer's default threshold, and relative distance ($\text{m} \cdot \text{min}^{-1}$). For matches, the individual variables extracted were distance (m), relative distance ($\text{m} \cdot \text{min}^{-1}$), Velocity Band 5 distance (high-speed running, 19.8–25.0 $\text{km} \cdot \text{h}^{-1}$), Velocity Band 6 distance (sprinting, >25.0 $\text{km} \cdot \text{h}^{-1}$), maximal velocity ($\text{km} \cdot \text{h}^{-1}$), sprint efforts, and combined acceleration/deceleration efforts. These velocity thresholds follow the classification originally set out by Di Salvo et al. (2009), which is what the club's Catapult system was configured to reproduce. Body mass and body fat percentage were measured by club staff with bio-impedance scales as part of routine weight monitoring.

Procedures

Where the club's own reporting labelled a session with a match-day-relative tag (MD-5 through MD+1), that tag was retained; earlier in the pre-season, before the friendly schedule was set, many sessions carried no such label. Playing time was not printed directly anywhere in the source reports, so it had to be worked out for each player as distance divided by relative distance; high-speed running, sprint distance, sprint efforts and acceleration/deceleration counts were then expressed relative to that estimated playing time (per minute, or per 90 minutes for counts), which put half-time substitutes and players who went the distance on the same footing. Of ten friendlies originally identified, one, against Spartak Varna, was dropped from the positional analysis before any statistics were run: its source report logged a single 145-minute "*auto-created*" period with no half split, which made playing time, and therefore every relative variable derived from it, unreliable. The remaining nine matches held up under the same check and were kept in full. A handful of duplicate body-composition entries, where the same value for the same player and date appeared in more than one club file, were removed; minor spelling inconsistencies for player names across files were standardized to one form per player.

This is a retrospective analysis of pre-existing, anonymized data collected through the club's routine monitoring program, not a prospective experiment or clinical trial. Under the applicable national framework for retrospective analyses of routinely collected anonymized performance data, formal review by an institutional ethics committee was not required. Every player's signed employment contract with the club includes explicit agreement that GPS and related performance data gathered in training and matches may be used by the club's sports-science department for research purposes, under the data-protection framework the club operates under. Data were anonymized prior to analysis and no individually identifiable information is reported.

Analysis

Values are reported as mean $\pm$ SD unless stated otherwise. Given the unbalanced structure of the data, normality was not assumed, so the Kruskal-Wallis H test was used for the two main between-group comparisons—weekly training distance across the pre-season and positional differences in match variables—with epsilon-squared (ϵ^2) reported as effect size (roughly: small .01–.06, medium .06–.14, large $\geq$.14). Significant omnibus results were followed up with Dunn's post hoc test, Bonferroni-corrected for multiple comparisons. Change in body fat percentage between the first and last team assessment was tested with the Wilcoxon signed-rank test, restricted to players with data at both time points. Significance was set at $p < .05$, and all analysis was run in Python 3 (pandas, SciPy, scikit-posthocs). Because multiple match observations originated from the same players, the independence assumption of the Kruskal-Wallis test is not fully met; p-values should therefore be interpreted with appropriate caution (see Limitations).

RESULTS

Weekly training load

Forty sessions were analysed across the seven-and-a-half-week pre-season, with 1 to 7 sessions logged per calendar week. Average session distance ranged, purely descriptively, from 2,616 m (week 9, a single session) up to 7,303 m (week 1); high-speed running per session ranged from 82 m to 411 m (Figure 1). None of this variation reached statistical significance across weeks (Kruskal-Wallis, $H = 13.95$, $p = .083$). The substantial week-to-week variability visible in Figure 1 underscores the heterogeneous nature of pre-season content (fitness testing, tactical work, small-sided games, travel). A clearer descriptive pattern appeared once match-day tags became available in the final three weeks: distance climbed steadily from MD-5 ($2,412 \pm 1,263$ m) to MD-2 ($4,754 \pm 333$ m), dipped at MD-1 ($3,890 \pm 120$ m), and peaked at MD+1 ($5,737 \pm 235$ m), higher than any other tagged session (Table 1). With only 2–3 sessions behind each tag, this pattern is reported strictly as a preliminary descriptive observation and was not tested inferentially.

Table 1. Team-level external training load by match-day-relative microcycle tag.

Match-day tag	n sessions	Distance, mean (m)	Distance, SD (m)	Acc+Dec efforts, mean (n)
MD-5	2	2412	1262.9	50
MD-4	2	3566	650.5	85.5
MD-3	3	4253.7	903	102.7
MD-2	2	4753.5	333	107.5
MD-1	2	3890	120.2	81.5
MD+1	2	5737	234.8	128.5

Note. MD = match day (relative tag; e.g., MD-2 = two days before the next match, MD+1 = one day after the previous match). Descriptive data only ($n = 2$ –3 sessions per tag); not tested inferentially. Source: Catapult Sports GPS reports, FC Botev Plovdiv pre-season training sessions.

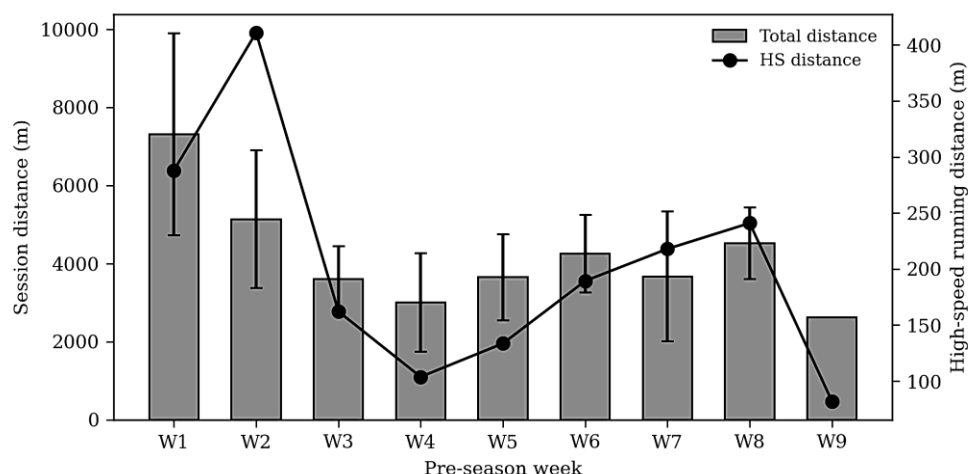


Figure 1. Team-mean session distance (bars, left axis) and high-speed running distance (line, right axis) by pre-season week (W1–W9; error bars = SD).

Positional match-play demands

Across the 134 player-match observations from 28 players in 9 friendlies, relative distance, high-speed running, sprint distance, maximal velocity, sprint efforts and acceleration/deceleration efforts all varied significantly by position (Table 2). Central defenders stood out at the low end: less relative distance than central midfielders (Dunn's test, $p = .012$), the lowest high-speed running of any position ($p \leq .008$ against every other group), and the fewest acceleration/deceleration efforts ($p \leq .014$ against every other group). Sprinting told a different story: full-backs and wide players covered the most sprint distance and produced the most sprint efforts, both significantly ahead of central defenders and central midfielders ($p \leq .033$). Central midfielders, meanwhile, posted the lowest maximal velocity of any position ($p \leq .006$ versus full-backs, wide players and forwards), while forwards touched the highest top speeds in the sample (Figure 2). Effect sizes were small for relative distance ($\epsilon^2 = .052$) but medium-to-large for high-speed running, sprinting and mechanical load ($\epsilon^2 = .14-.20$).

Table 2. Positional match-play external load (mean $\pm$ SD, expressed relative to playing time) and Kruskal-Wallis comparison between positions.

Variable	Central defenders (n = 25)	Full-backs (n = 21)	Central midfielders (n = 39)	Wide players (n = 31)	Forwards (n = 18)	H	p	ϵ^2
Distance (m/min)	87.36 $\pm$ 16.89	98.67 $\pm$ 11.01	97.97 $\pm$ 24.97	97.03 $\pm$ 15.66	93.67 $\pm$ 24.65	10.71	.0300	.052
HSR distance, VB5 (m/min)	3.21 $\pm$ 1.26	4.88 $\pm$ 1.49	4.59 $\pm$ 1.74	4.43 $\pm$ 1.22	4.70 $\pm$ 1.73	21.69	.0002	.137
Sprint distance, VB6 (m/min)	0.80 $\pm$ 0.62	1.71 $\pm$ 0.81	0.94 $\pm$ 0.59	1.60 $\pm$ 0.99	1.58 $\pm$ 0.87	29.73	.0000	.199
Max velocity (km/h)	28.51 $\pm$ 2.28	29.81 $\pm$ 1.21	28.09 $\pm$ 1.47	29.67 $\pm$ 2.02	30.83 $\pm$ 2.08	28.72	.0000	.192
Sprint efforts (n/90min)	4.32 $\pm$ 3.72	7.96 $\pm$ 3.19	4.57 $\pm$ 3.03	7.11 $\pm$ 4.11	7.37 $\pm$ 3.68	24.04	.0001	.155
Accel+Decel efforts (n/90min)	140.44 $\pm$ 34.40	204.09 $\pm$ 25.49	204.30 $\pm$ 64.75	186.96 $\pm$ 44.87	197.71 $\pm$ 67.33	28.85	.0000	.193

Note. CD = central defenders; FB = full-backs; CM = central midfielders; W = wide players; FW = forwards. HSR = high-speed running; VB5/VB6 = Catapult velocity bands 5 and 6 (19.8–25.0 and >25.0 km/h, respectively). A total of 134 player-match observations from 28 players across 9 pre-season friendly matches were analysed (one match was excluded a priori; see Procedures). H = Kruskal-Wallis test statistic; p = significance level; ϵ^2 = epsilon-squared effect size. Source: Catapult Sports GPS reports, FC Botev Plovdiv pre-season friendly matches.

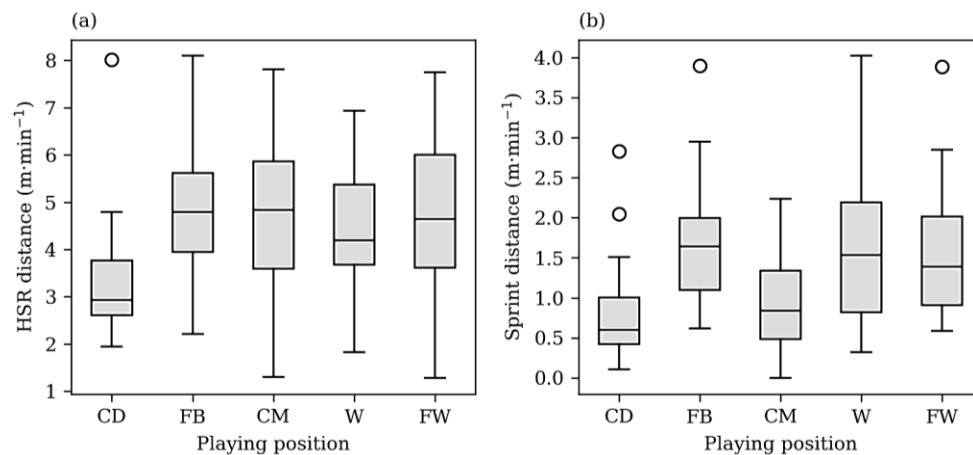


Figure 2. Positional distribution of (a) high-speed running (Band 5) distance and (b) sprint (Band 6) distance, expressed relative to playing time.

Body composition

Team body mass sat between 77.3 and 78.9 kg across the seven assessment dates (11 June–15 July); body fat percentage, recorded on three of those dates, ranged from 6.41% to 6.65% (Table 3, Figure 3). Among the 23 players assessed at both the first (18 June, $6.33 \pm 1.90\%$) and last (15 July, $6.36 \pm 2.02\%$) time point, there was no significant change (Wilcoxon signed-rank test, $W = 125.0$, $p = .961$). The visual stability of both body mass and body-fat percentage in Figure 3, set against relatively large standard deviations, is consistent with the absence of a detectable short-term shift.

Table 3. Team body mass and body fat percentage across the pre-season.

Date	n (weight)	Body mass. mean (kg)	Body mass. SD (kg)	n (fat)	Body fat. mean (%)	Body fat. SD (%)
2026-06-11	23	78.9	5.3	0	-	-
2026-06-12	23	77.5	7.5	0	-	-
2026-06-18	25	77.9	7.3	25	6.41	1.9
2026-06-24	27	77.3	7.1	0	-	-
2026-07-02	30	78.2	6.8	30	6.53	2.07
2026-07-08	29	78	7.3	0	-	-
2026-07-15	28	78	7.1	28	6.65	2.02

Note. Body fat percentage was assessed on three of the seven dates. Source: club bio-impedance body-composition records, FC Botev Plovdiv pre-season.

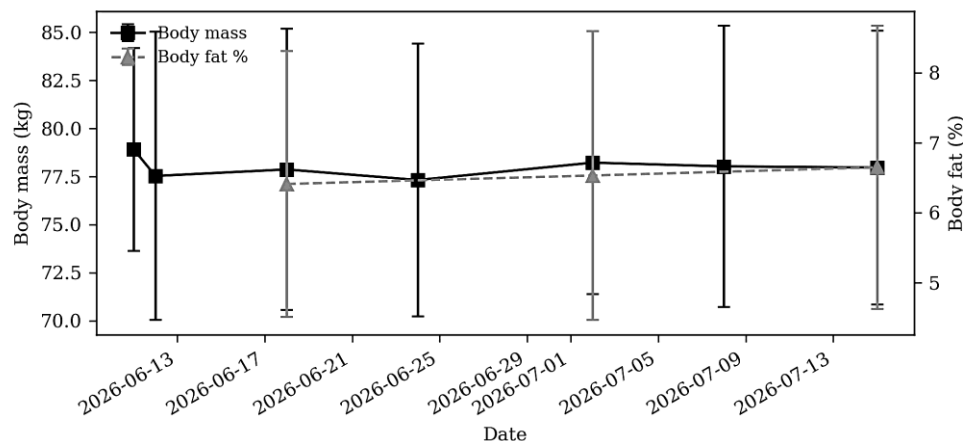


Figure 3. Team-mean body mass (squares, solid line, left axis) and body fat percentage (triangles, dashed line, right axis) across the pre-season (error bars = SD).

DISCUSSION

Three linked observations emerged from tracking a single Bulgarian First League squad through a seven-week pre-season. First, training distance and high-speed running fluctuated substantially from week to week without reaching statistical significance, reflecting the heterogeneous content of pre-season. Second—and centrally—the positional profile of match running in pre-season friendlies aligned closely with the pattern long established for competitive matches, despite heavy squad rotation and the developmental purpose of these games. Third, body mass and body fat percentage remained stable, consistent with a squad that was already lean on arrival. Together these findings suggest that, even in a rotational, non-competitive context, pre-season friendlies continue to impose position-specific high-intensity demands that can usefully guide conditioning design, while short-term body-composition change is unlikely to be a realistic expectation in already lean professional players.

That training distance did not differ significantly between weeks, despite a fairly wide numerical range of 2,616 to 7,303 m, is unsurprising once the number of session-specific factors at play during pre-season is considered: fitness testing days, tactical sessions, small-sided games, travel for friendlies. All of that adds noise both within and between weeks, and a purely descriptive weekly comparison has limited power to detect structure against that backdrop. The descriptive build-up from MD-5 to MD-2 followed by a dip at MD-1 is consistent with the classic in-season taper, where volume is deliberately pulled back before a match (Nobari et al., 2021; Hasan et al., 2021). The elevated MD+1 distance is more notable: during the competitive season that slot is usually reserved for light recovery work, yet here it carried the highest distance of any tagged session. One plausible reading is that, in pre-season, MD+1 is sometimes used for additional aerobic or technical-tactical work once acute post-match recovery demands are lower than in a congested competitive calendar. With only two sessions behind that tag, however, this remains a hypothesis-generating observation rather than a confirmed periodization pattern.

The most practically relevant finding is the preservation of position-specific high-intensity profiles in friendlies. Central defenders remained lowest across high-speed running, sprinting and mechanical load; full-backs and wide players highest for sprint-related output; central midfielders combined relatively high total distance with the lowest top speed; forwards were fastest overall. This pattern tracks almost exactly what has been reported repeatedly in competitive matches across leagues, age groups and confederations (Vieira et al., 2019; Aquino et al., 2017, 2020; Modrić et al., 2019, 2021; Goranović et al., 2022; Rey et al., 2023). That consistency, observed here under conditions of heavy rotation and shortened individual minutes, indicates that pre-season friendlies still expose players to a position-specific high-intensity stimulus that closely resembles competitive demands. Friendlies may therefore serve as an ecologically valid bridge between training and competition—useful both as a monitoring checkpoint and as a reference for setting position-specific exposure targets during preparation. It is also worth noting where the effect was weakest: overall relative distance showed only a small effect size ($\epsilon^2 = .052$), against medium-to-large effects for high-speed running, sprinting and mechanical load ($\epsilon^2 = .14 - .20$). That split fits a pattern already established in the literature: position discriminates the high-intensity, mechanical side of match running far more than it discriminates overall volume (Modrić et al., 2019).

Body mass and body fat percentage showed no statistically detectable change (6.33% versus 6.36% between the first and last paired fat assessment). Some pre-season cohorts do show real fat loss over a comparable block (Milanese et al., 2015; Suárez-Arrones et al., 2019); others, working with full-time professionals, find little to nothing and attribute this to players already arriving in lean condition after individualized off-season training and nutrition support (Čaušević et al., 2024; Raizel et al., 2017). The body-

fat values recorded here (approximately 6.3–6.7%) sit on the low end for outfield professionals, which favours the second explanation: there may simply not have been much fat left to lose. At the same time, the measurement method matters. Bio-impedance is more sensitive to daily hydration status than criterion methods such as DXA (Milanese et al., 2015), and only three assessment points were available for fat percentage. Under these conditions the study cannot confidently separate genuine physiological stability from measurement noise; the safest conclusion is simply that no detectable change occurred within the limits of the monitoring protocol used.

From a practical standpoint, the three strands of the dataset point in the same direction. Weekly training load was highly variable, underscoring the need for flexible rather than rigidly periodized planning in pre-season. Positional match demands in friendlies reproduced the competitive high-intensity hierarchy, supporting the use of these games as reference points for position-specific conditioning targets from the earliest weeks of preparation. Body-composition stability suggests that, in an already lean squad, readiness is better indexed by external-load exposure and recovery markers than by short-term changes in fat mass. For clubs operating with similar resources, these observations translate into concrete recommendations: (i) begin differentiated high-speed and mechanical-load work for full-backs and wide players, and aerobic/tempo emphasis for central midfielders, from the first weeks of pre-season rather than waiting for competitive matches; (ii) treat friendlies as structured monitoring opportunities rather than purely developmental fixtures; and (iii) set realistic expectations for body-composition change within a single short pre-season block.

The study was conducted in a mid-tier professional environment typical of many clubs outside the wealthiest European leagues. GPS monitoring was implemented as part of routine operations rather than a research project, using a single system configuration and existing staff workflows. The fact that clear positional differentiation still emerged under these conditions suggests that the practical value of external-load monitoring does not depend exclusively on extensive sports-science infrastructure. Lessons regarding the stability of positional profiles in friendlies and the limited short-term responsiveness of body composition are therefore potentially transferable to other clubs working with comparable resources.

Limitations

Several limitations should be acknowledged. Playing time was never printed directly in the source reports and had to be back-calculated from distance and relative distance; that allowed identification and exclusion of one internally inconsistent match, but it remains an indirect estimate. The exact GPS unit model was not specified in the extracted reports, though the velocity-zone configuration followed standard high-speed-running and sprint thresholds (Di Salvo et al., 2009) and the same 10-Hz device and settings were used consistently. Player descriptors such as age and stature were not part of the club's routine records.

The positional analysis treated 134 player-match observations as independent, whereas multiple observations originated from the same 28 players; this violates the independence assumption of the Kruskal-Wallis test and may inflate statistical significance. Mixed-effects models with player identity as a random effect would be preferable in future multi-season datasets; in the present analysis p-values should be interpreted cautiously.

The data come from a single club and a single pre-season, so all findings are club-specific observations rather than general characteristics of professional preparation. Body composition was measured with bio-impedance rather than a criterion method, over a seven-week window and with only three fat assessments, limiting the ability to detect small true changes or to separate them from hydration-related measurement noise.

CONCLUSIONS

Over a seven-week professional pre-season in a Bulgarian First League club, training distance and high-speed running varied considerably from week to week without reaching statistical significance. Pre-season friendlies reproduced the position-specific high-intensity profile long established for competitive football—central defenders lowest, full-backs and wide players highest for high-speed running, sprinting and mechanical load—despite extensive squad rotation. Body mass and body fat percentage remained stable, consistent with an already lean squad.

These club-specific observations support the use of pre-season friendlies as an ecologically valid reference for position-specific conditioning targets from the earliest stages of preparation, and they suggest that short-term body-composition change should not be counted on as a primary outcome of a single pre-season block in players who arrive already lean.

Conditioning staff working in similarly resourced environments may reasonably begin differentiated sprint and mechanical-load exposure for wide players and full-backs, and aerobic emphasis for central midfielders, during the first weeks of pre-season, using friendlies as ongoing monitoring checkpoints rather than purely developmental fixtures.

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CONFLICT OF INTEREST

The author declares that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this manuscript. The author is employed by FC Botev Plovdiv as Assistant Coach and, in that role, has direct operational access to the club's routine athlete-monitoring data used in this study; this affiliation is disclosed here for transparency and does not constitute a financial conflict of interest. No author holds a financial interest in the GPS technology provider named in the manuscript (Catapult Sports) beyond its routine use as club equipment.

AI USE DISCLOSURE

In accordance with current publishing ethics and transparency recommendations, an AI-based assistant (Claude, Anthropic) was used as a supportive tool during the preparation of this manuscript to: (a) extract tabulated values from the club's PDF GPS and body-composition reports into structured datasets; (b) carry out descriptive and inferential statistical computations under the author's direction; (c) retrieve candidate literature for the Introduction and Discussion via a bibliographic search tool; and (d) assist with drafting and editing the manuscript text, including revisions made by the author to bring the wording closer to his own voice. Every dataset, statistical result, cited source and sentence produced with this assistance was reviewed, independently verified against the original source documents, and edited by the author, who takes full and exclusive responsibility for the scientific content, analysis, interpretation and conclusions of this manuscript. The AI tool was not used to generate original scientific findings, hypotheses, or interpretations independent of the author's own judgement, and is not listed as an author. The author retains full responsibility for the content of the manuscript and confirms its originality, integrity, and accuracy.

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