Gacon 45–15 Performance Across Clubs, Coaching Environments, and Competitive Levels: A Retrospective Multilevel Study

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Soccer | Intermittent fitness testing | Between- and within-squad variability | Individualized training prescription

Headline

Gacon 45–15 performance differed between Italian football team-seasons, yet substantial variability remained within squads. Playing position explained little additional variability, and individual performances overlapped across competitive levels. These findings challenge the use of league category, squad averages or playing position as stand-alone criteria for interpreting individual fitness. Integrating these contextual references with individual test results may better inform performance-based training groups and running-intensity prescriptions.

Aim of the Paper

The Gacon 45–15 test is an intermittent field assessment historically described as popular in Italian soccer, with validity and reliability investigated in young football players (1). Although field testing can provide useful information for physical assessment and training prescription, its application requires consideration of the measurement properties, intended purpose, and interpretation of the selected outcome (2).

In professional soccer, practitioners frequently interpret fitness results using normative or squad benchmarks (68%) and playing-position comparisons (52%) (3). However, the extent to which these group-level references adequately represent individual performance remains uncertain. Examining Gacon 45–15 variability between and within team-seasons, across competitive levels, and among playing positions may therefore clarify the limitations of collective benchmarks and inform more individualized, context-sensitive training decisions.

Methods

This retrospective, multicohort observational study analysed 208 Gacon 45–15 test observations collected from senior men's first-team squads of eight Italian football clubs across 12 team-seasons, spanning Serie B, Serie C and Serie D. Performance was expressed as the running speed ($km \cdot h^{-1}$) corresponding to the last successfully completed stage of the test, using 0.5 $km \cdot h^{-1}$ increments. Clubs and team-seasons were assigned pseudonymous identifiers to preserve confidentiality in the reported results.

Gacon 45–15 assessments were obtained from historical records across different clubs, seasons, and coaching environments. Testing was conducted within a shared methodological framework by a recurring group of fitness coaches, providing continuity in test administration despite differences in the broader sporting contexts. Records were reviewed for duplicate entries, identity discrepancies, and consistency between completed stages and recorded speeds. One assessment occasion was selected per team-season, with one record per player. Player identifiers could not be linked reliably across team-seasons; the 208 observations therefore do not necessarily represent 208 distinct individuals. Following predefined quality-control procedures, 208 observations (206 outfield and two goalkeeper observations) were retained in the primary variance-components analysis. The two goalkeeper observations were excluded from playing-position comparisons (n = 206). A broader quality-control-valid sample of 266 observations was retained for sensitivity analyses.

Between-team-season variability was estimated using a linear mixed-effects model fitted by restricted maximum likelihood, with team-season specified as a random intercept. A variance partition coefficient (VPC) quantified the proportion of total modelled variance attributable to team-season grouping. Playing position was subsequently included as a fixed effect to estimate adjusted positional contrasts and its additional contribution to explaining within-team-season variability. Exploratory 95% confidence intervals were obtained using 999 club-level bootstrap resamples. Robustness was examined through leave-one-club-out analyses and alternative-sample sensitivity checks.

Ethical Considerations

This retrospective study analysed pseudonymized Gacon 45–15 data collected during routine football-club assessments. Players had been informed of their use for performance monitoring. No new testing or participant contact occurred, and no study-specific consent was sought. No documented ethics committee approval or formal waiver was available. The study was conducted in accordance with the privacy and confidentiality principles of the Declaration of Helsinki.

Results

Mean Gacon 45–15 performance across 208 observations and 12 team-seasons was 18.51 ± 1.06 $km \cdot h^{-1}$. The mixed-effects model estimated between-team-season variance of 0.322 and residual variance of 0.852 $(km \cdot h^{-1})^2$, yielding a VPC of 27.4% (exploratory bootstrap 95% CI: 9.8–39.5%) (Figure 1). With 72.6% of variability remaining within the residual component, team-season membership provided an incomplete representation of individual performances. This heterogeneity suggests that squad-average Gacon speeds should be complemented by individual results when considering test-relative running-intensity prescriptions.

Among 206 outfield observations, midfielders achieved

higher Gacon 45–15 speeds than defenders (adjusted difference: +0.345 km·h^{-1}; exploratory 95% CI: +0.033 to +0.616) and forwards (+0.448 km·h^{-1}; +0.195 to +0.666) (Supplementary Figure S1). The forward–defender contrast was uncertain (−0.102 km·h^{-1}; −0.501 to +0.365). However, playing position reduced within-team-season residual variance by only 3.4% (Table 1). Thus, although positional profiles differed on average, playing position provided limited additional information for characterizing individual Gacon performance within squads (Supplementary Figure S2).

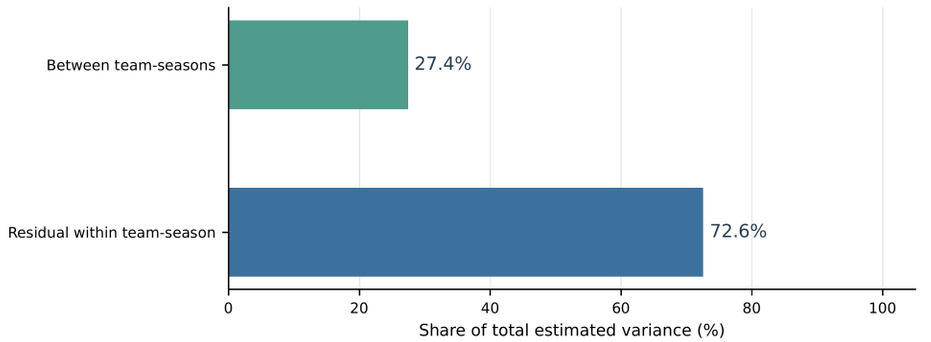


Fig. 1. Mixed-model variance partition of Gacon 45–15 performance. The team-season component accounted for 27.4% of modelled variance and the residual component for 72.6%; these estimates do not measure test–retest reliability or causal team effects.

Table 1. Multilevel variance components and adjusted playing-position contrasts. VPC = variance partition coefficient; MID = midfielder; DEF = defender; FWD = forward. Variance components use 208 observations, and positional comparisons use 206 outfield observations. Intervals are exploratory club-bootstrap 95% confidence intervals.

Parameter / contrast	Estimate	Exploratory 95% CI
Team-season variance (km·h^{-1})^2	0.322	—
Residual variance (km·h^{-1})^2	0.852	—
Team-season VPC	27.4%	9.8–39.5%
MID − DEF (km·h^{-1})	+0.345	+0.033 to +0.616
MID − FWD (km·h^{-1})	+0.448	+0.195 to +0.666
FWD − DEF (km·h^{-1})	−0.102	−0.501 to +0.365
Residual variance reduction after position	3.4%	—

Mean Gacon 45–15 performance was 19.18 ± 0.88 km·h^{-1} in Serie B, 18.61 ± 1.07 km·h^{-1} in Serie C, and 18.36 ± 1.05 km·h^{-1} in Serie D (Supplementary Table S1). Nevertheless, individual performances overlapped across competitive categories, while team-season means varied considerably within Serie C (18.06–19.63 km·h^{-1}) and Serie D (17.92–19.40 km·h^{-1}) (Figure 2). These descriptive findings suggest that competitive category alone provides an incomplete reference for interpreting individual Gacon performance, supporting the consideration of squad-specific distributions and individual test results. Serie B findings were limited to one team-season.

The team-season VPC remained between 22.9% and 31.6% across leave-one-club-out analyses and was similar in the broader quality-control-valid sample (n = 266; 27.7%) and after excluding one extreme residual (n = 207; 29.3%) (Supplementary Table S2). These findings suggest that the observed combination of between-squad differences and substantial residual within-squad variability was not dependent on a single club or influential observation, reinforcing the relevance of interpreting individual Gacon performances alongside squad-level references.

Discussion

The partitioning of Gacon 45–15 performance variability suggests that football fitness assessment should be understood as a multilevel process in which squad context and individual performance provide complementary information. Differences between team-seasons were relevant, yet substantial residual variability persisted within these environments. From an applied perspective, this distinction challenges the assumption that a squad-average test result adequately characterizes every player. Context-informed individualization may therefore offer a more appropriate framework for interpreting assessment data and informing subsequent running-training decisions, although its effectiveness requires direct experimental evaluation.

Our findings suggest that relying exclusively on playing-position or competitive-level benchmarks may lead to misleading interpretations of individual Gacon 45–15 performance. Despite average positional differences, considerable variability remained within squads, and players from different competitive categories exhibited overlapping results. Consequently, athletes sharing the same position or competitive level should not automatically be assumed to have comparable test-derived running capacities. A more context-informed approach would integrate individual Gacon scores with squad-specific performance distributions, using positional and competitive-level references as supplementary information rather than primary determinants of individualized running-intensity prescriptions.

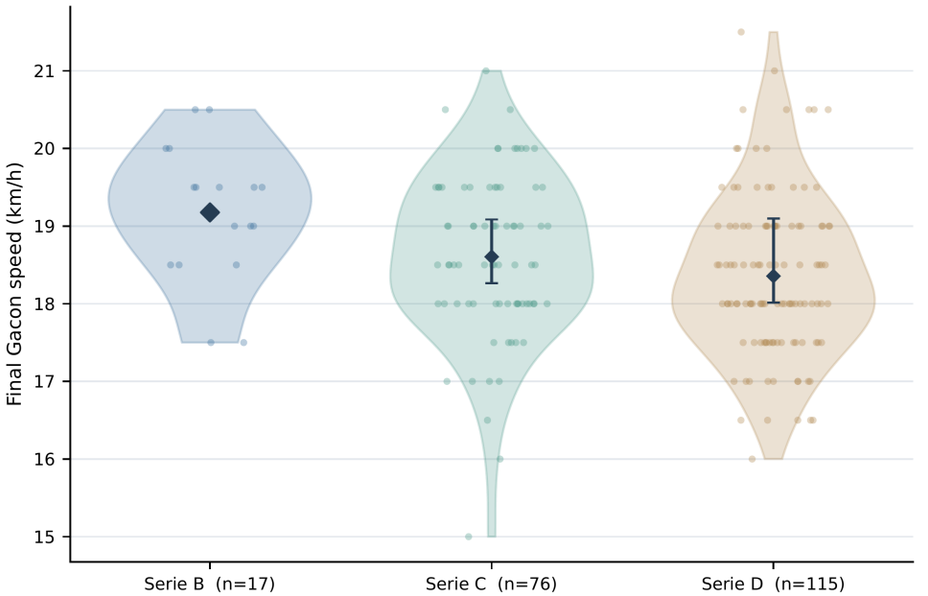


Fig. 2. Individual Gacon 45–15 speed overlap across competitive levels. Points represent observed test performances, violin shapes depict category-specific distributions, and diamonds indicate category means. Vertical bars show exploratory 95% confidence intervals from club-level resampling for Serie C and Serie D; no between-club interval was estimable for Serie B (one team-season).

A distinctive strength of this study is its coverage of eight clubs across 12 team-seasons and three competitive categories, including repeated observations from some clubs across different seasons and competitive levels. This diversity encompasses different sporting, coaching and performance-staff environments, extending the interpretation beyond a single-squad snapshot. The observed heterogeneity suggests that even within the same club, historical performance references may not adequately represent a subsequent squad. Accordingly, individualization should be driven by each player's measured Gacon performance within the current team-season context, rather than by club identity, playing position or competitive category alone. This approach may inform performance-based training groups and relative running-intensity prescriptions, although its effectiveness requires experimental evaluation.

An additional consideration is that fitness-test selection should reflect the intended assessment purpose and the characteristics of the running-training methods implemented throughout the season. In soccer, linear and change-of-direction intermittent exercises impose different locomotor and physiological demands, which should be considered when selecting tests and interpreting their outcomes (4). Accordingly, the Gacon 45–15 may provide a relevant reference for predominantly linear intermittent-running prescriptions, whereas shuttle-based assessments may be more appropriate when training involves repeated changes of direction (5). Test selection should therefore be guided by the intended training application, while accounting for validity, reliability and the non-interchangeability of test-derived speeds.

Practical Applications

- The analysis of 208 Gacon 45–15 observations across eight clubs and 12 team-seasons highlights the limitations of interpreting individual fitness through squad averages, playing-position norms or competitive-level benchmarks alone.
- With only 27.4% of performance variance attributable to team-season grouping and substantial residual variability, practitioners should prioritize each athlete's measured performance within the current squad context.
- This approach aligns with the value placed on complementary individual and team-level fitness information in elite soccer (6).
- Individual Gacon results may inform flexible performance-based running groups and relative intensity prescriptions, provided the selected test is appropriate for the intended training application.
- Because collective training can impose different individual physiological demands (7), and training-load–fitness associations vary among professional players (8), prescriptions should be complemented by individual response monitoring and reassessment.

Strengths and Limitations

- A principal strength of this study is the inclusion of multiple clubs, seasons and competitive categories, including repeated contributions from some clubs under differing sporting and staff environments. This design allowed Gacon performance variability to be examined across multiple real-world football contexts rather than within a single squad. However, the observational structure does not permit the independent estimation of coaching, fitness-staff or competitive-level effects, and repeated club observations should not be interpreted as longitudinal changes within the same players.
- The retrospective eight-club sample limits generalizability, particularly because Serie B was represented by only one team-season. The residual component combines unexplained variation and potential measurement error; it cannot be interpreted exclusively as stable physiological

differences between players. Although testing followed an investigator-reported shared framework, sample-specific test–retest reliability and inter-operator equivalence were not quantified. Neither within-player longitudinal changes nor the training effects of Gacon-based grouping and prescriptions were evaluated.

Conclusion

Across eight clubs and 12 team-seasons, Gacon 45–15 performance differed between squads and substantially within them, with overlap across playing positions and competitive levels. These findings support interpreting individual test performance within the current squad and intended training context, treating positional and category benchmarks as supplementary rather than stand-alone prescription criteria. This context-driven approach may inform the selection of appropriate fitness tests, the organization of performance-based training groups and individualized running-intensity prescriptions, complemented by monitoring individual training responses.

AI Use Statement

Language and editing; Writing and drafting: ChatGPT (OpenAI) assisted with language refinement and manuscript organization. Data and analysis: ChatGPT assisted with developing and quality-checking R scripts implemented in RStudio. The authors retain full responsibility for the original data, statistical analyses, results, interpretations, figures, tables, references, and publication.

Data Availability Statement

Data available on request. An anonymized dataset underlying the reported analyses may be made available to interested researchers upon reasonable request to the corresponding author, Pasquale D'Antonio (pasqualedantonio91@gmail.com). The source records are held by the participating clubs. Any release of de-identified or pseudonymized analytical data is subject to applicable data-protection safeguards and authorization from the relevant data controllers; no directly identifiable athlete or club records will be disclosed.

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Conflicts of Interest

The authors declare no conflicts of interest.

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