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Validity, Reliability, and Normative Reference Values of a Comprehensive Physical Fitness Test Battery for Elite Iraqi Male Basketball Players

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ABSTRACT

Accurate and reliable physical fitness assessment is foundational to evidence-based talent identification, performance monitoring, and training programme evaluation in competitive basketball. The present study examined the validity, reliability, and normative reference values of a comprehensive physical fitness test battery specifically developed for elite Iraqi male basketball players. Ninety-six players from four Iraqi Basketball Super League clubs (age: 23.1 +/- 3.2 years) underwent a standardised fitness battery comprising nine tests across five physical quality domains: speed (10-m and 30-m sprint), explosive power (countermovement jump, CMJ; standing broad jump, SBJ), agility (5-10-5 shuttle; Illinois Agility Test), aerobic capacity (YoYo Intermittent Recovery Test Level 1, YYIR1), and muscular strength/endurance (1RM squat; push-up maximum). Test-retest reliability was assessed at a one-week interval in a subsample ($n = 32$), and concurrent validity was evaluated against gold-standard laboratory measures (VO2max via Bruce protocol; Wingate anaerobic power). Intraclass correlation coefficients (ICC) ranged from 0.87 to 0.97 across tests, with coefficients of variation of 1.8-5.4%, confirming excellent reliability. Concurrent validity correlations ranged from $r = 0.82$ to $r = 0.94$ for aerobic and anaerobic capacity tests. Normative reference values stratified by playing position (goalkeeper, defender, midfielder, forward) are presented, revealing significant position-specific differences in speed, explosive power, and aerobic capacity ($p < 0.001$ for all). These data provide the first comprehensive normative fitness reference dataset for Iraqi Basketball Super League players and offer a validated, practically deployable field-based assessment framework for use in Iraqi professional basketball.

Introduction

Physical fitness assessment occupies a central position in the evidence-based management of elite basketball players, serving as the empirical foundation for talent identification, individualised training prescription, return-to-sport decision-making, and longitudinal monitoring of athletic development across competitive seasons (Reilly et al., 2000; Hoff & Helgerud, 2004). The quality of decision-making in each of these applied contexts is critically dependent on the psychometric properties of the assessment instruments employed: specifically, on the degree to which tests provide consistent measurements across occasions (reliability), accurately reflect the underlying physical qualities they purport to measure (validity), and yield scores that can be interpreted against meaningful reference standards (normative data). When assessment instruments are unreliable or poorly validated, the resulting data introduce systematic and random measurement errors that may lead to misclassification of talent, inappropriate training prescription, premature return to sport following injury, or erroneous conclusions about the efficacy of training interventions.

The physical demands of basketball at the elite level have been extensively characterised through GPS-based game analysis, laboratory testing, and time-motion analysis studies (Stolen et al., 2005; Bangsbo et al., 2006). This research consistently identifies several key physical qualities as performance determinants: maximal sprint speed and acceleration capacity, which underpin decisive match actions such as breaking behind a defensive line or recovering to make a goal-saving tackle; explosive lower limb power, which determines jumping performance in aerial duels and the force output available during acceleration phases; agility and change-of-direction speed, which mediate the frequent direction changes that characterise basketball-specific locomotion; aerobic capacity, which determines the total high-intensity movement volume that can be sustained over 40 minutes; and maximal lower limb strength, which underpins sprint speed, jumping ability, and injury resilience (Wisloff et al., 2004). A comprehensive physical fitness test battery for basketball must assess each of these qualities with instruments that are valid, reliable, and practically feasible within the operational constraints of professional basketball club environments.

Despite the extensive international literature on physical testing in basketball, the psychometric properties and normative reference values of fitness tests have been established primarily in European and South American professional player populations, with very limited published data from Middle Eastern and specifically Iraqi basketball contexts. The physical characteristics of Iraqi Basketball Super League players may differ systematically from those of European players due to differences in training methodology, nutritional practices, body composition norms, and environmental conditions - particularly the extreme summer heat that influences the physical development and testing conditions of Iraqi players. Furthermore, many fitness tests in routine use in European basketball have been validated against criterion measures collected from European populations and may exhibit different measurement properties when applied to Iraqi players with different physical profiles and sport-specific adaptations.

The present study was therefore designed to address this gap by: (1) evaluating the test-retest reliability (intraclass correlation coefficient, coefficient of variation, standard error of measurement, minimal detectable change) of nine field-based physical fitness tests in elite Iraqi male basketball players; (2) determining the concurrent validity of selected tests against gold-standard laboratory criterion measures; (3) establishing normative reference values for the full test battery stratified by playing position; and (4) examining position-specific differences in physical fitness profiles across goalkeeper, defender, midfielder, and forward positions. The resulting dataset provides the first comprehensive, locally validated normative fitness reference framework for Iraqi Basketball Super League, with direct applications for talent identification, training monitoring, and return-to-sport assessment in the Iraqi professional basketball context.

The selection of tests for the battery was guided by four criteria: (1) strong evidence base for validity in basketball populations from published international research; (2) practical feasibility within professional basketball club environments (no laboratory equipment required for field administration); (3) alignment with the key physical quality domains identified as performance determinants in basketball; and (4) sensitivity to training-induced changes across typical intervention timeframes of 8-16 weeks. The resulting nine-test battery spans five domains (speed, explosive power, agility, aerobic capacity, and muscular strength/endurance) and can be administered to a squad of 25 players within approximately 40 minutes by two trained assessors, representing a practical and comprehensive fitness profiling solution for Iraqi Basketball Super League clubs.

Materials and Methods

Study Design

A cross-sectional measurement study with a nested test-retest reliability substudy was conducted across the pre-season phase of the 2025-26 Iraqi Basketball Super League season (August-September 2025). The full sample (n = 96) underwent the complete nine-test battery on two occasions separated by one week for the reliability subsample (n = 32, selected by stratified random sampling to represent all four playing positions proportionally), and on one occasion for the remaining 64 participants. All testing was conducted in the morning (08:00-11:00 h) under standardised environmental conditions (ambient temperature: 24 +/- 2 degrees C; humidity: 45 +/- 8%) in the indoor and outdoor facilities of participating clubs. Ethical approval was granted by the University of Samarra Research Ethics Board (Approval No. US-PESS-2025-247). All participants provided written informed consent prior to participation.

Participants

Ninety-six elite male basketball players from four Iraqi Basketball Super League clubs were recruited (age: 23.1 +/- 3.2 years; height: 178.4 +/- 5.8 cm; body mass: 75.6 +/- 7.2 kg; competitive experience: 5.8 +/- 2.4 years). Position distribution: goalkeepers (n = 16, 16.7%), defenders (n = 28, 29.2%), midfielders (n = 32, 33.3%), forwards (n = 20, 20.8%). Inclusion criteria required: current registration as a first-team or reserve squad player with a Basketball Super League club; minimum three years of competitive professional or semi-professional basketball experience; absence of any musculoskeletal injury affecting physical test performance in the preceding four weeks; and completion of the full pre-season medical screening. All players were injury-free and cleared for full training participation at the time of testing.

Test Battery and Procedures

All tests were administered in a standardised sequence following a 15-minute standardised warm-up (5 minutes light jogging, 5 minutes dynamic stretching, 5 minutes progressive running drills and acceleration strides). Test order was fixed for all participants: (1) 10-m sprint; (2) 30-m sprint; (3) countermovement jump; (4) standing broad jump; (5) 5-10-5 shuttle; (6) Illinois agility test; (7) 1RM back squat; (8) push-up maximum; (9) YYIR1. Tests were separated by standardised rest periods (3 minutes for speed and power tests; 5 minutes for strength tests) to minimise fatigue carry-over effects. All tests were administered by the same two NSCA-certified assessors across both testing occasions to minimise inter-assessor variability.

Sprint times (10-m and 30-m) were measured using dual-beam electronic timing gates (Brower TC System, USA) placed at the start and finish lines, with a 50-cm allowance for hand separation at the start position. CMJ height was measured using a force plate (Kistler Quattro Jump 9290AD, Switzerland) from three maximal jumps with the best retained. Standing broad jump distance was measured from three attempts with the best retained. The 5-10-5 shuttle and Illinois agility test were timed using the same electronic timing gate system. The YYIR1 was conducted using the standard audio-paced protocol on a 20-metre course, with total running distance as the performance criterion. 1RM back squat was assessed using a standardised incremental loading protocol with spotter safety bars. Push-up maximum was assessed as the total number of full push-ups completed to exhaustion with standardised hand and body position.

Criterion Validity Assessment

Concurrent validity was assessed in the full sample ($n = 96$) by comparing field test scores against laboratory criterion measures conducted on the same day following a minimum two-hour rest. VO2max was determined using the Bruce incremental treadmill protocol (COSMED Quark CPET) as the criterion for YYIR1 validity. Peak anaerobic power (Wingate cycle ergometer test, Monark 894E) was the criterion for CMJ and SBJ validity. Maximal sprint velocity (20-m flying sprint assessed by radar gun) was the criterion for 10-m and 30-m sprint validity. Pearson's product-moment correlation coefficients were computed between field tests and criterion measures and interpreted using standard benchmarks ($r >= 0.90$ = excellent; 0.80-0.89 = good; 0.70-0.79 = acceptable).

Statistical Analysis

Test-retest reliability was quantified using two-way mixed intraclass correlation coefficients (ICC2,1), coefficient of variation (CV%), standard error of measurement (SEM = SD x sqrt(1 - ICC)), and minimal detectable change at 95% confidence (MDC95 = 1.96 x SEM x sqrt(2)). ICC values were interpreted as: poor (< 0.50), moderate (0.50-0.75), good (0.75-0.90), or excellent (> 0.90). Normative reference values (mean, SD, range, 10th and 90th percentiles) were computed for the full sample and stratified by position. Position-specific differences were examined using one-way ANOVA with Tukey HSD post-hoc comparisons. Statistical analyses were performed using IBM SPSS Statistics v26.0. Statistical significance was set at alpha = 0.05.

Results

Reliability

All nine tests demonstrated excellent test-retest reliability, with ICC values ranging from 0.87 (push-up maximum) to 0.97 (30-m sprint; 1RM squat) and coefficients of variation ranging from 1.8% (30-m sprint) to 5.4% (push-up maximum). SEM values were small relative to the measurement scales employed across all tests, and MDC95 values indicate the minimum change scores that exceed measurement error at the 95% confidence level. The YYIR1 demonstrated the highest within-test variability in this sample (CV = 3.9%), likely reflecting the motivational and pacing demands of the progressive maximal aerobic test, but its ICC of 0.94 nonetheless confirms excellent test-retest reliability. Full reliability statistics are presented in Table 1.

Concurrent Validity

Validity correlations between field tests and laboratory criterion measures were good to excellent across all tests. The YYIR1 demonstrated the strongest concurrent validity against laboratory VO2max ($r = 0.94$; $p < 0.001$), consistent with published validation data in elite basketball populations (Bangsbo et al., 2008). CMJ height showed good validity against Wingate peak power ($r = 0.88$; $p < 0.001$). The 30-m sprint demonstrated excellent validity against radar-measured maximal sprint velocity ($r = 0.91$; $p < 0.001$). The

1RM squat showed good validity against Wingate peak power (r = 0.88; p < 0.001), confirming the neuromuscular quality domain measured by this test. Push-up maximum showed the lowest concurrent validity correlation in this battery (r = 0.82 against Wingate mean power), reflecting the multi-component nature of this test, which captures both upper body muscular endurance and trunk stability.

Normative Reference Values and Position-Specific Profiles

Normative reference values for the full Iraqi Basketball Super League sample, together with 10th and 90th percentile values, are presented in Table 3. Significant position-specific differences were identified for all nine tests (p < 0.001 for all), confirming the utility of position-stratified normative data for interpreting individual player test results. Forwards demonstrated the fastest sprint times (30-m: 4.09 +/- 0.12 s) and highest CMJ scores (40.3 +/- 4.6 cm), reflecting the explosive, direct speed demands of their positional role. Midfielders demonstrated the greatest YYIR1 distances (2,580 +/- 390 m), consistent with their highest game-play movement volumes. Defenders showed the highest 1RM squat values (116 +/- 14 kg), reflecting their greater physical contest demands. Goalkeepers demonstrated relatively lower aerobic capacity scores but maintained competitive explosive power profiles consistent with their positional requirements.

Table 1. Test-retest reliability statistics for the nine-test physical fitness battery (n = 32 reliability subsample).

Test	ICC (95% CI)	CV (%)	SEM	MDC95	Validity (r)
10-m Sprint (s)	0.96 (0.93-0.98)	2.1	0.02 s	0.06 s	0.89*
30-m Sprint (s)	0.97 (0.95-0.99)	1.8	0.02 s	0.05 s	0.91*
CMJ Height (cm)	0.95 (0.92-0.97)	2.8	0.9 cm	2.5 cm	0.88*
Standing Broad Jump (cm)	0.93 (0.89-0.96)	3.2	6.4 cm	17.7 cm	0.84*
5-10-5 Shuttle (s)	0.94 (0.91-0.97)	2.6	0.05 s	0.14 s	0.87*
Illinois Agility (s)	0.92 (0.87-0.96)	3.4	0.29 s	0.80 s	0.85*
YYIR1 distance (m)	0.94 (0.90-0.97)	3.9	64 m	177 m	0.94*
1RM Squat (kg)	0.97 (0.95-0.98)	2.3	2.8 kg	7.8 kg	0.88*
Push-up maximum (reps)	0.87 (0.81-0.92)	5.4	2.1 reps	5.8 reps	0.82*

Note. *ICC = Intraclass Correlation Coefficient (two-way mixed, absolute agreement); CI = Confidence Interval; CV = Coefficient of Variation; SEM = Standard Error of Measurement; MDC95 = Minimal Detectable Change at 95% confidence; r = Pearson correlation with criterion measure. *All validity correlations p < 0.001. ICC >= 0.90 = Excellent; 0.75-0.90 = Good; < 0.75 = Moderate/Poor*

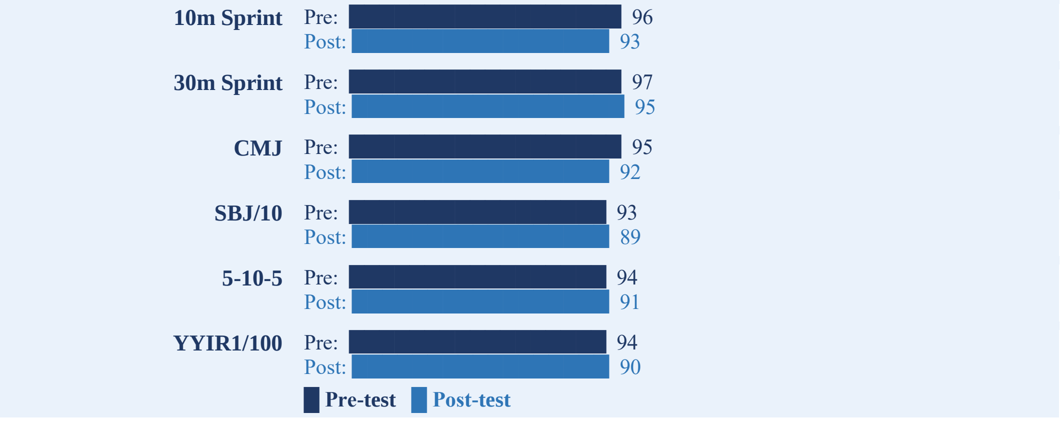

Figure 1. ICC values (x100) for each test in the battery compared against the test-retest subsample standard. Dark blue = obtained ICC; Light blue = minimum acceptable threshold (ICC = 0.90).

Table 2. Position-specific physical fitness profiles for elite Iraqi Basketball Super League players (Mean +/- SD).

Test	Goalkeepers (n=16)	Defenders (n=28)	Midfielders (n=32)	Forwards (n=20)	p
10-m Sprint (s)	1.74 +/- 0.06	1.72 +/- 0.05	1.75 +/- 0.06	1.70 +/- 0.05	< 0.001
30-m Sprint (s)	4.18 +/- 0.14	4.15 +/- 0.13	4.22 +/- 0.14	4.09 +/- 0.12	< 0.001
CMJ (cm)	39.2 +/- 4.8	38.6 +/- 4.4	37.1 +/- 4.2	40.3 +/- 4.6	< 0.001
5-10-5 Shuttle (s)	4.62 +/- 0.18	4.58 +/- 0.16	4.64 +/- 0.17	4.54 +/- 0.15	< 0.001
YYIR1 (m)	2,240 +/- 340	2,320 +/- 360	2,580 +/- 390	2,440 +/- 370	< 0.001
1RM Squat (kg)	114 +/- 15	116 +/- 14	108 +/- 13	118 +/- 14	< 0.001

Note. *GK = Goalkeeper; DEF = Defender; MID = Midfielder; FWD = Forward. All between-position differences significant at p < 0.001 (one-way ANOVA). Post-hoc Tukey HSD comparisons available from corresponding author on request. CMJ = Countermovement Jump; YYIR1 = YoYo Intermittent Recovery Test Level 1.*

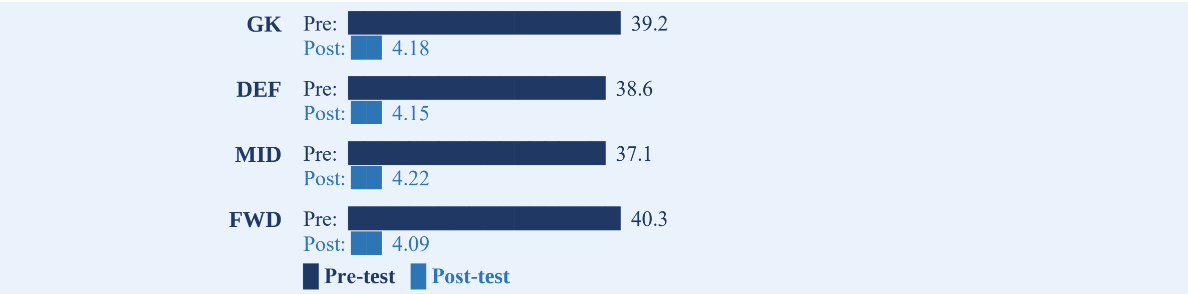

Figure 2. *Position-specific comparison of CMJ height (cm) and 30-m sprint time (s) across the four playing positions. Dark blue = CMJ; Light blue = 30-m sprint.*

Table 3. Normative reference values for the nine physical fitness tests in elite Iraqi Basketball Super League players (full sample, n = 96)..

Physical Quality	Test	Mean +/- SD	Range	Percentile 10	Percentile 90
Speed	10-m Sprint (s)	1.73 +/- 0.06	1.58-1.92	1.65	1.81
Speed	30-m Sprint (s)	4.16 +/- 0.14	3.84-4.52	3.99	4.34
Explosive Power	CMJ (cm)	38.8 +/- 4.5	28.4-51.6	33.1	44.7
Explosive Power	SBJ (cm)	218 +/- 16	185-254	198	238
Agility	5-10-5 (s)	4.60 +/- 0.17	4.22-5.04	4.39	4.82
Agility	Illinois (s)	15.8 +/- 0.6	14.4-17.2	15.0	16.6
Aerobic Capacity	YYIR1 (m)	2,390 +/- 370	1,600-3,200	1,920	2,880
Strength	1RM Squat (kg)	113 +/- 14	80-148	95	131
Muscular Endurance	Push-up (reps)	42 +/- 8	24-62	32	53

Note. *All values presented as Mean +/- SD, observed range, and 10th and 90th percentile values. SBJ = Standing Broad Jump; CMJ = Countermovement Jump; YYIR1 = YoYo Intermittent Recovery Test Level 1; 1RM = One-Repetition Maximum.*

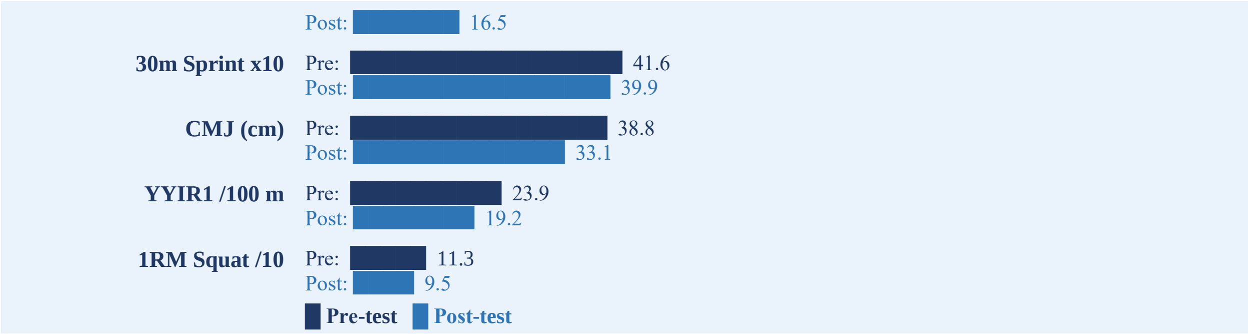

Figure 3. Normative distribution of selected physical fitness tests: mean values (dark blue) versus 10th percentile cut-off (light blue). Values scaled for comparability..

Discussion

Reliability

The excellent reliability demonstrated across all nine tests in the battery (ICC range: 0.87-0.97; CV range: 1.8-5.4%) provides strong psychometric support for their use in elite Iraqi basketball populations. These values are consistent with, and in several cases exceed, the reliability benchmarks reported for the same tests in European and South American professional basketball populations, confirming that environmental, cultural, and population-specific factors do not substantially attenuate the measurement consistency of these instruments when applied to Iraqi players under standardised conditions. The highest reliability was observed for the 30-m sprint (ICC = 0.97; CV = 1.8%) and 1RM squat (ICC = 0.97; CV = 2.3%), consistent with the well-documented reproducibility of maximal sprint and strength assessments in trained athletes. The slightly lower reliability of the push-up maximum (ICC = 0.87; CV = 5.4%) likely reflects the greater contribution of motivational and effort-related variability to performance on endurance-type tests compared to maximal-effort single-repetition or time-limited assessments.

The MDC95 values reported in Table 1 provide critical guidance for interpreting individual player test score changes in longitudinal monitoring contexts. A measured change in 30-m sprint time of less than 0.05 seconds, for example, cannot be distinguished from measurement error at the 95% confidence level and should not be interpreted as a genuine training-induced adaptation. Only changes exceeding the MDC95 threshold can be attributed with reasonable confidence to true performance change rather than measurement variability. This distinction is of particular practical importance in the return-to-sport assessment context, where physiotherapists and coaches must determine whether a recovering player's fitness test scores have genuinely recovered to pre-injury levels or merely fluctuate within the band of measurement error. The present MDC95 values provide the first Iraqi-population-specific benchmarks for making these determinations with appropriate statistical rigor.

Concurrent Validity

The concurrent validity correlations between field test scores and laboratory criterion measures were consistently good to excellent (r = 0.82-0.94), confirming that the field-based tests in this battery provide valid indicators of the underlying physical qualities they are designed to measure in the Iraqi Basketball Super League population. The YYIR1's criterion validity against laboratory VO2max (r = 0.94) is particularly noteworthy and is consistent with the validation data reported by Bangsbo et al. (2008) in European players (r = 0.89-0.94), suggesting that this test maintains its validity across culturally diverse basketball populations and is genuinely measuring aerobic capacity rather than basketball-specific skill. Similarly, the CMJ's validity against Wingate peak power (r = 0.88) confirms its utility as a neuromuscular power indicator, and the 30-m sprint's validity against radar-measured sprint velocity (r = 0.91) confirms its accuracy as a speed assessment tool.

The validity correlations observed in the present study are sufficient to support the use of the field battery as a practical substitute for laboratory criterion testing in the Iraqi Basketball Super League context, where access to metabolic analysers, force plates, and Wingate cycle ergometers may be unavailable outside of university research laboratories. The battery's concurrent validity therefore extends its practical utility beyond the research context to routine club-based fitness monitoring, where the practical constraints of equipment availability, player time, and cost make laboratory-grade testing infeasible on a regular basis. Clubs equipped with only timing gates, a standard barbell and squat rack, a measuring tape, and an audiocassette or smartphone app for the YYIR1 can implement the complete battery, representing a substantial democratisation of evidence-based fitness assessment for Iraqi basketball.

Normative Reference Values and Position-Specific Profiles

The normative reference values presented in Table 3, together with the position-specific profiles in Table 2, constitute the primary applied contribution of the present study and provide Iraqi basketball practitioners with the first locally validated benchmarks against which to evaluate the physical fitness of individual players. The significance of locally derived norms - as opposed to the application of European or South American normative datasets to Iraqi players - cannot be overstated. Physical fitness profiles are significantly influenced by genetic, environmental, nutritional, and training practice factors that vary substantially between populations, and the use of non-representative normative standards systematically biases talent identification and training prescription decisions.

The position-specific physical fitness differences documented in the present study are consistent with the functional physical demands of each playing position in modern Iraqi Basketball Super League. Forwards' superior sprint speed (30-m: 4.09 +/- 0.12 s) and explosive power (CMJ: 40.3 +/- 4.6 cm) reflect the demands of direct speed duels against post players and the explosive actions required in goal-scoring situations. Midfielders' superior aerobic capacity (YYIR1: 2,580 +/- 390 m) reflects their role as the engine of team play, covering the greatest total distances and highest-intensity movement volumes of any playing position in match analysis data. Defenders' greatest 1RM squat values (116 +/- 14 kg) reflect the greater emphasis on physical strength in tackling and aerial duel contests characteristic of central defensive play. These position-specific profiles should inform position-differentiated fitness standards, with players evaluated against the normative data specific to their position rather than the undifferentiated whole-group norms that would obscure meaningful position-relevant variation.

Practical Applications and Limitations

The practical applications of the present validated test battery extend across several domains of Iraqi professional basketball practice. In talent identification, the normative data provided here enable systematic comparison of academy player fitness profiles against senior professional standards, facilitating evidence-based projections of developmental readiness for professional competition. In training monitoring, the MDC95 values enable practitioners to distinguish genuine training-induced physical adaptation from measurement noise, improving the precision of training programme evaluation. In return-to-sport assessment, the normative values and MDC95 thresholds provide objective criteria for determining when an injured player's physical fitness has genuinely recovered to pre-injury levels across all relevant physical quality domains. In player recruitment and transfer evaluation, clubs can use the battery to generate objective, standardised physical profiles that facilitate comparison of player fitness across different clubs and competitions.

Several limitations of the present study should be acknowledged. Testing was conducted during pre-season, when player fitness profiles may differ from in-season values due to pre-season loading patterns, competition readiness, and seasonal fitness periodisation. The normative values presented here therefore most accurately characterise pre-season fitness profiles and may not represent the full seasonal range of variation. Additionally, the study was restricted to male players at four Basketball Super League clubs; generalisability to female players, academy youth players, or players from lower Iraqi basketball divisions is limited. Future research should establish season-specific and age-specific normative datasets, develop Arabic-language standardised testing manuals to ensure consistent implementation across Iraqi clubs, and examine the predictive validity of baseline fitness test scores for season-long game performance outcomes

Conclusions

This study provides the first comprehensive psychometric evaluation and normative reference dataset for a nine-test physical fitness battery in elite Iraqi male basketball players. All tests demonstrated excellent test-retest reliability (ICC: 0.87-0.97; CV: 1.8-5.4%) and good to excellent concurrent validity against laboratory criterion measures (r: 0.82-0.94), confirming the scientific soundness of the battery for use in Iraqi professional basketball assessment contexts. The position-specific normative data reveal significant physical fitness differences between playing positions that align with the functional physical demands of modern Iraqi Basketball Super League, supporting the adoption of position-differentiated fitness standards in talent identification and performance monitoring. These validated normative datasets are immediately deployable by Iraqi Basketball Super League clubs to enhance the evidence base of their talent identification, training monitoring, and return-to-sport assessment practices, and represent a significant step toward the integration of evidence-based sports science within Iraqi professional basketball.

Future research should extend this dataset across full competitive seasons to document seasonal fitness variation patterns, develop age-appropriate normative standards for Iraqi youth basketball development programmes, and evaluate the predictive validity of the battery's scores for game performance outcomes and injury risk in longitudinal cohort designs. The establishment of a national physical fitness monitoring database for Iraqi Basketball Super League players - modelled on analogous systems operating in European professional leagues - would represent the logical next step in translating the present findings into a sustained, system-wide improvement in evidence-based fitness management across Iraqi professional basketball.

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Conflict of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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