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Relationships Between Reactive Neuromuscular Performance and Physical Capacities in Elite Female Basketball Athletes

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ABSTRACT

Background: Neuromuscular performance, particularly reactive strength and stretch-shortening cycle (SSC) efficiency, is considered important for explosive actions in basketball. However, limited research has simultaneously examined relationships between concentric explosive strength, repeated jump reactive capacity, dynamic balance, body composition, and sport-specific physical performance in elite female basketball players.

Methods: Thirteen elite female basketball players (age: 24.6 ± 0.7 years; height: 171.9 ± 9.8 cm; body mass: 67.4 ± 10.1 kg) completed assessments of body composition (bioelectrical impedance analysis), dynamic balance (Y-Balance Test), sprint (10 m and 20 m), agility (T-Test and Illinois Test), and neuromuscular performance (Squat Jump, 30-second MultiJump test including anaerobic capacity and Reactive Strength Index). Pearson and Spearman correlation analyses were performed.

Results: Squat Jump variables showed weak, non-significant correlations with sprint and agility performance. In contrast, 30-second MultiJump anaerobic capacity ($r = -0.646$, $p = 0.031$) and Reactive Strength Index ($r = -0.659$, $p = 0.027$) were significantly correlated with 10-m sprint time. Dynamic balance was significantly associated with anaerobic capacity and RSI for the left leg ($r = 0.663-0.664$, $p < 0.05$), but body composition showed negligible relationships with neuromuscular variables.

Conclusions: In elite female basketball players, repeated reactive neuromuscular capacities (anaerobic jump capacity and Reactive Strength Index) are more strongly associated with short-distance sprint performance than isolated concentric explosive strength, dynamic balance, or body composition. Training and monitoring should prioritise reactive strength and SSC efficiency.

Keywords: reactive strength index, repeated jump ability, sprint, agility, female basketball, neuromuscular performance.

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INTRODUCTION

Basketball is a highly demanding intermittent team sport requiring players to perform explosive actions such as sprinting, jumping, fast accelerations, decelerations, and changes of direction across multiple directions performed under incomplete recovery (Rodríguez-Fernández et al., 2023). Successful performance in basketball depends on an athlete's capacity to do high-intensity neuromuscular actions repeatedly while maintaining both technical accuracy and tactical efficiency throughout the game. In elite female basketball players, the physical characteristics like lower-limb explosive strength, reactive ability, sprint acceleration, and agility are highly important as they directly influence critical game actions such as rebounding, fast breaks, defensive transitions, and offensive maneuvering (Ramirez-Campillo et al., 2024; Cherni et al., 2021). Recent systematic reviews have shown that enhancements in neuromuscular performance significantly improve sport-specific physical fitness and competitive effectiveness. (Cao and al.; 2024)

Neuromuscular performance is one of the most important physical factors that affects how well a basketball player performs. Lower-limb explosive power affects how high an athlete's vertical jump and acceleration. Reactive strength, on the other hand, is a measure of how effectively an athlete can switch from eccentric to concentric muscle actions by using the stretch-shortening cycle (SSC) efficiently. In basketball, the SSC is very important because jumping, landing, sprinting, rapidly changing directions are all important parts of the game (Markovic & Mikulic, 2010). Conventional tests like the Squat Jump (SJ) mainly measure concentric force production; In contrast, repeated jump protocols give a better representation of reactive strength, anaerobic power, and SSC efficiency. Recent evidence indicates that reactive neuromuscular characteristics can demonstrate strong correlations with sport-specific sprint and agility performance compared to isolated concentric power measures (Ramirez-Campillo et al., 2025; Cherni et al., 2021).

Plyometric and neuromuscular training interventions have consistently resulted in positive effects on sprint speed, jump height, and agility performance among female basketball players, indicating the functional significance of neuromuscular attributes within this population (Cherni et al., 2021; Ramirez-Campillo et al., 2024). Nonetheless, despite an increasing acknowledgment of these adaptations, a limited number of studies have specifically examined the relationship between detailed neuromuscular variables, such as flight time, contact time, anaerobic jump capacity, and reactive strength index (RSI), and physical performance outcomes in elite female basketball players. This gap is particularly pertinent as female athletes might show distinct neuromuscular and biomechanical characteristics that affect performance determinants, injury susceptibility, and training adaptability (Spiteri and al., 2018).

In addition to neuromuscular performance, dynamic balance is considered an important functional skill in basketball because it is associated with postural control, landing stability, unilateral force production, and injury prevention. The Y-Balance Test (YBT) is usually used to measure dynamic balance, inter-limb asymmetries, and the quality of movement in athletes. Although balance performance may enhance movement efficiency and reduce lower injury risk, recent findings indicate that its direct correlation with explosive performance may be subordinate to neuromuscular factors such as reactive strength and stretch-shortening cycle (SSC) efficiency (Chaabene et al., 2021). Therefore, understanding the relative impact of dynamic balance on basketball performance remains to be investigated. (Zahn and al., 2025)

Body composition variables such as fat mass and muscle mass are also frequently monitored in basketball athletes due to their potential influence on power-to-weight ratio, movement economy, and overall physical capacity. Nevertheless, in relatively homogeneous elite populations, anthropometric characteristics alone may not adequately explain variations in neuromuscular or athletic performance, as functional qualities frequently play a more significant role than morphological characteristics once baseline competitive standards are attained (Nikolaidis et al., 2024).

Therefore, a comprehensive approach integrating body composition, neuromuscular performance, dynamic balance, sprinting, and agility may provide a more complete understanding of the physical determinants of elite female basketball performance. Although previous research has often examined these variables independently, few studies have simultaneously investigated the relationships between concentric explosive strength, reactive neuromuscular performance, anaerobic repeated jump capacity, dynamic balance, and sport-specific physical performance in elite female basketball players.

The aim of the present study was to examine the relationships between neuromuscular performance variables (Squat Jump, repeated jump anaerobic capacity, and Reactive Strength Index), dynamic balance, body composition, and physical performance measures (sprint and agility) in elite female basketball players. The hypothesis proposed that reactive neuromuscular variables, specifically repeated jump anaerobic capacity and Reactive Strength Index (RSI), would demonstrate stronger correlations with sprint and agility performance than with body composition or dynamic balance parameters. Dynamic balance was expected as well to present complementary but relatively weaker associations with physical performance outcomes.

2. Methods

2.1 Participants

Thirteen female basketball players voluntarily participated in the study. They competed in the Excellence Division (age: 24.6 ± 0.7 years; body mass: 78.5 ± 3.5 kg; height: 182.8 ± 2.6 cm). All athletes trained regularly (five sessions per week) and competed once a weekend, with a competitive experience exceeding five years. They were all in good general health, with no pathology or recent injury that could have influenced test results. All players were informed of the study's objectives and procedures and provided written informed consent. They subsequently completed the various tests described in the experimental protocol.

2.2. Body composition assessment by bioelectrical impedance analysis

Body mass and body composition were assessed using bioelectrical impedance analysis (Tanita TBF-215GS). This technique has been validated against dual-energy X-ray absorptiometry (DXA) as a reference method and demonstrates good reproducibility (Le Gallais & Millet, 2007). The impedance difference, which reflects the degree of resistance of body compartments to an electrical current, allows for the identification of tissues and the quantification of muscle, fat, and water components. The variables measured by bioelectrical impedance analysis included total body mass (kg), total muscle mass (kg), fat mass expressed as a percentage of body weight, and total body water percentage.

2.3. Dynamic balance assessment

The Y-Balance Test (Lower Quarter) was performed according to the standardized protocol described by Plisky et al. (2006). Following a warm-up and familiarization phase, each participant performed three reaching trials in three distinct directions – anterior, posteromedial, and posterolateral – with each stance leg. Reach distances were measured in centimeters from the center of the platform to the farthest point reached by the distal aspect of the foot, without any support or loss of balance. Only valid trials (maintenance of unilateral stance, controlled return to the starting position without falling) were retained, and the best performance per direction was used for analysis. To normalize the results, each reach distance was divided by the participant's lower limb length (measured from the anterior superior iliac spine to the medial malleolus) and multiplied by 100 to obtain a percentage. The composite score was calculated as the mean of the three normalized directions for each leg.

Inter-limb asymmetry was quantified according to the distinction proposed by Bishop et al. (2019): absolute asymmetry corresponds to the raw difference (in cm) between the two limbs, whereas relative asymmetry expresses this difference as a percentage relative to the better performance. An asymmetry threshold $> 10\%$ was used to identify marked functional imbalance (Bishop et al., 2019). Additionally, the proportion of participants

presenting an asymmetry $> 4\%$ – a commonly accepted injury risk threshold (Plisky et al., 2006) – was also reported for comparative purposes.

2.4. Physical performance: assessment of speed and agility

Speed was assessed using photocells placed at the start and finish of the sprint distance. The photocells were positioned at thigh height to obtain the most accurate measurement (Buchheit, 2003). Upon the first passage, the timer automatically started and stopped when the athlete crossed the finish photocells. The start was performed with support on the front leg placed as close as possible to the start line. Speed was evaluated over distances of 10 and 20 meters.

Agility was measured using the T-Test and the Illinois Test. Photocells were placed at the start line. They were triggered by the athlete's passage, who performed a sprint according to the T-Test pattern and returned to cross the start line between the photocells, thereby stopping the timer. The same procedure was used for the Illinois Test, with one pair of photocells triggered at the start and another pair stopping the timer at the finish (according to the Illinois Test pattern). Two trials were performed for each player, and the best performance was retained.

2.5. Vertical Jump Assessment Using Optojump

Jumps were assessed using the Microgate Optojump Next system (Microgate Engineering, Bolzano, Italy). The system enables the determination of several jump components, including flight time, ground contact time, jump height, anaerobic capacity, and jump frequency across different jump series. Players were instructed to perform the jumps as quickly and as high as possible while attempting to maintain minimal ground contact time (Sands et al., 2004). Measurements were conducted in a standing position with free arm movement, without requiring a standardized initial posture.

2.6. Experimental protocol

The testing session took place over two days at the same time of day. On the first day, participants underwent bioelectrical impedance analysis to determine body mass, fat mass percentage, muscle mass, and total body water percentage. Subsequently, they performed the 10 meter and 20 meter sprint test and the Illinois Test. On the second day, athletes began with the dynamic balance assessment using the Y-Balance Test, followed by the T-Test agility test, and finished with vertical Jump assessment after recovery.

2.7. Statistical analysis

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Results are expressed as mean values $\pm$ standard deviation. Correlations between the results of the different tests were assessed using Pearson's correlation coefficient. When the assumptions of normality and homogeneity of variance were not met (verified by the Shapiro–Wilk test), Spearman's rank correlation coefficient was used. Data were analyzed using Jandel Scientific software (SigmaStat and SigmaPlot), with the significance threshold set at $*p* < 0.05$.

3. Results

Table 1. Anthropometric characteristics and body composition of the female basketball players

Variables	Anthropometrics				Body Composition		
	Weight (kg)	Height (cm)	BMI (kg/m ²)	Lower Limb Length (cm)	Fat Mass (%)	Muscle Mass (kg)	Body Water (%)
Mean $\pm$ SD	67.4 $\pm$ 10.1	171.9 $\pm$ 9.8	22.8 $\pm$ 2.9	93.4 $\pm$ 4.9	32.8 $\pm$ 7.6	41.8 $\pm$ 8.5	52.4 $\pm$ 4.3
Minimum	48.8	160	16.88	88.0	23.0	18.1	47.4
Maximum	81.9	195	25.3	102.3	49.2	49.9	60.2

Mean values $\pm$ SD

The participants' anthropometric characteristics indicate a mean body mass of 67.4 $\pm$ 10.1 kg and a mean height of 171.9 $\pm$ 9.8 cm. This corresponds to a mean body mass index (BMI) of 22.8 $\pm$ 2.9 kg/m². Analysis of body composition revealed mean fat mass, muscle mass and total body water values of 32.8 $\pm$ 7.6%, 41.8 $\pm$ 8.5 kg and 52.4 $\pm$ 4.3% respectively. It is worth noting that fat mass values showed substantial inter-individual variability, ranging from 23.0% to 49.2%.

Table 2. Neuromuscular performance characteristics : Squat Jump and Repeated Jump Test

Variables	Mean $\pm$ SD	Min	Max
Squat Jump height (cm)	31.85 $\pm$ 3.01	27.80	37.40
Squat Jump flight time (ms)	00.51 $\pm$ 0.02	00.48	00.55
30s MultiJump height (cm)	26.56 $\pm$ 3.67	20.08	31.77
30s MultiJump flight time (ms)	00.46 $\pm$ 0.03	00.41	00.51
30s MultiJump contact time (ms)	00.20 $\pm$ 0.03	00.17	00.28
30s MultiJump Anaerobic capacity	38.99 $\pm$ 6.31	30.96	49.99
30s Reactive Strength Index (RSI)	01.42 $\pm$ 0.29	01.05	01.93

Mean values $\pm$ SD

Neuromuscular performance assessments revealed moderate variability among participants across explosive and reactive strength variables. Squat Jump performance

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demonstrated a mean jump height of 31.85 ± 3.01 cm, with a corresponding mean flight time of 0.51 ± 0.02 s, reflecting the athletes' concentric lower-limb explosive power.

During the 30-second MultiJump test, mean jump height decreased to 26.56 ± 3.67 cm, while mean flight time was 0.46 ± 0.03 s, indicating the additional physiological demands of repeated jumping efforts. Mean contact time was 0.20 ± 0.03 s, suggesting generally efficient reactive strength capabilities among participants.

Anaerobic performance during repeated jumping was reflected by a mean anaerobic capacity score of 38.99 ± 6.31 , while the Reactive Strength Index (RSI) averaged 1.42 ± 0.29 , indicating moderate inter-individual differences in stretch-shortening cycle efficiency. Overall, these findings suggest that although the athletes displayed relatively homogeneous concentric explosive strength, greater variability was present in repeated reactive and anaerobic performance capacities.

Table 3. Y-Balance Test results

Variables	Right Leg	Left Leg	Asymmetry (Mean)	Asymmetry (Absolute)	% of subjects >10%
Scores by direction (cm)					
Anterior Direction	69.07 ± 9.8	68.24 ± 10.59	$+1.5 \pm 7.2$	4.2	18.2
Posterolateral Direction	100.60 ± 11.33	100.68 ± 9.75	-0.11 ± 7.2	5.3	18.2
Posteromedial Direction	96.88 ± 11.26	96.96 ± 12.87	$+0.59 \pm 9.43$	7.9	45.5
Composite Score (%)	95.10 ± 8.46	94.79 ± 8.35	$+0.44 \pm 4.86$	4.20	

Mean values $\pm$ SD

Dynamic balance performance was generally symmetrical between the right and left lower limbs across all movement directions. In the anterior direction, mean reach distances were 69.07 ± 9.8 cm for the right leg and 68.25 ± 10.59 cm for the left leg. Posterolateral and posteromedial performances were similarly balanced between limbs, with composite scores of $95.10 \pm 8.46\%$ and $94.79 \pm 8.35\%$ for the right and left legs, respectively.

Despite these symmetrical group averages, inter-limb asymmetry analysis revealed notable individual variability. Absolute asymmetry values remained relatively low in the anterior (4.2%) and posterolateral (5.3%) directions, but were substantially greater in the posteromedial direction (7.9%), where 45.5% of participants exceeded the 10% asymmetry threshold. These findings suggest that although overall dynamic balance was preserved at the group level, a considerable proportion of athletes presented potentially meaningful unilateral deficits, particularly in the posteromedial direction.

Table 4. Physical performance measures : sprint and agility

Test	Mean $\pm$ SD	Minimum	Maximum
Sprint 10 m (s)	2.30 ± 0.22	1.80	2.57

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Sprint 20 m (s)	3.85 ± 0.31	3.23	4.43
T-Test (s)	11.56 ± 0.54	10.89	12.73
Test Illinois (s)	18.98 ± 0.87	18.09	20.38

Mean values ± SD

Sprint and agility assessments indicated relatively homogeneous physical performance characteristics among participants. Mean sprint times were 2.30 ± 0.22 s over 10 meters and 3.85 ± 0.31 s over 20 meters, reflecting satisfactory acceleration and linear speed capacities for elite female basketball players.

Agility performance was represented by mean times of 11.56 ± 0.54 s in the T-Test and 18.98 ± 0.87 s in the Illinois Test. Variability remained moderate across all performance variables, suggesting relatively consistent physical capacities within the sample while still allowing for measurable inter-individual differences.

Table 5. Correlations between neuromuscular performance and sprint/agility

Variables	Sprint 10m	Sprint 20m	T-Test	Illinois
SJ height	R=0.034 P=0.920	R=-0.0267 P=0.938	R=-0.241 P=0.475	R=-0.123 P=0.719
SJ flight time	R=0.0390 P=0.909	R=-0.0230 P=0.946	R=-0.234 P=0.489	R=-0.118 P=0.730
30sMJ height	R=-0.495 P=0.121	R=-0.434 P=0.182	R=-0.315 P=0.346	R=-0.371 P=0.261
30sMJ flight time	R=-0.481 P=0.135	R=-0.440 P=0.176	R=-0.352 P=0.289	R=-0.376 P=0.254
30sMJ contact time	R=-0.069 P=0.840	R=-0.096 P=0.778	R=-0.265 P=0.432	R=-0.068 P=0.843
30sMJ Anaerobic capacity	R=-0.646 P=0.031*	R=-0.560 P=0.073	R=-0.400 P=0.223	R=-0.484 P=0.132
30s Reactive Strength Index (RSI)	R=-0.659 P=0.0274*	R=-0.573 P=0.0653	R=-0.406 P=0.215	R=-0.495 P=0.122

*: significant correlations at $p < 0.05$

Correlation analysis demonstrated that most Squat Jump variables were not significantly associated with sprint or agility performance. Squat Jump height and flight time showed weak and non-significant relationships with all sprint and agility measures, suggesting that concentric explosive strength alone may not be a primary determinant of these physical capacities in this sample.

In contrast, repeated jump performance variables demonstrated stronger associations. Notably, 30-second MultiJump anaerobic capacity showed a significant negative correlation with 10-meter sprint time ($r = -0.646$, $p = 0.031$), while Reactive Strength Index also correlated significantly with 10-meter sprint performance ($r = -0.659$, $p =$

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0.027). These findings indicate that athletes with greater anaerobic and reactive capacities tended to demonstrate superior short-distance acceleration.

Although correlations with 20-meter sprint and agility tests did not reach statistical significance, moderate negative relationships were observed, particularly for anaerobic capacity and RSI, suggesting a trend whereby enhanced stretch-shortening cycle efficiency may positively influence broader athletic performance. Overall, repeated reactive neuromuscular performance appears more relevant to sprint capacity than isolated concentric jump performance.

Table 6. Correlations between dynamic balance and neuromuscular performance

Variables	Score YBT R (%)	Score YBT L (%)	Asymmetry
SJ height	R=-0.274 P=0.415	R=0.058 P=0.866	R=-0.583 P=0.0597
SJ flight time	R=-0.277 P=0.409	R=0.051 P=0.882	R=-0.578 P=0.0627
30sMJ height	R=0.263 P=0.435	R=0.580 P=0.062	R=-0.549 P=0.0805
30sMJ flight time	R=0.257 P=0.445	R=0.573 P=0.065	R=-0.545 P=0.0827
30sMJ contact time	R=-0.113 P=0.740	R=0.189 P=0.578	R=-0.509 P=0.110
30sMJ Anaerobic capacity	R=0.385 P=0.242	R=0.663 P=0.026*	R=-0.456 P=0.159
30s Reactive Strength Index (RSI)	R=0.403 P=0.219	R=0.664 P=0.0260*	R=-0.424 P=0.194

* significant correlations at $p < 0.05$

Dynamic balance composite scores demonstrated limited associations with most neuromuscular variables. However, significant positive correlations were identified between left-leg Y-Balance composite score and both MultiJump anaerobic capacity ($r = 0.663$, $p = 0.026$) and Reactive Strength Index ($r = 0.664$, $p = 0.026$).

These findings suggest that superior reactive strength and anaerobic performance may contribute to enhanced unilateral dynamic balance capacity, particularly for the left lower limb. Although most other correlations remained non-significant, moderate positive trends were observed between repeated jump performance variables and Y-Balance scores, indicating a potential functional relationship between neuromuscular efficiency and postural control.

Overall, dynamic balance appears to be more closely associated with repeated reactive performance capacities than with pure concentric explosive strength.

Table 7. Correlations between body composition and neuromuscular performance

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Variables	% Masse grasse	Masse musculaire
SJ height	R=0.013 P=0.970	R=0.206 P=0.543
SJ flight time	R=0.017 P=0.961	R=0.199 P=0.558
30sMJ height	R=-0.085 P=0.804	R=-0.460 P=0.154
30sMJ flight time	R=-0.0867 P=0.688	R=-0.486 P=0.800
30sMJ contact time	R=0.159 P=0.640	R=0.315 P=0.345
30sMJ Anaerobic capacity	R=-0.0680 P=0.842	R=-0.423 P=0.195
30s Reactive Strength Index (RSI)	R=-0.0693 P=0.839	R=-0.414 P=0.205

Body composition variables demonstrated generally weak and non-significant relationships with neuromuscular performance measures. Fat mass percentage showed minimal association with Squat Jump, MultiJump, anaerobic capacity, or Reactive Strength Index variables, suggesting limited direct influence on explosive and reactive performance capacities within this elite sample.

Similarly, muscle mass did not demonstrate statistically significant correlations with neuromuscular variables, although moderate negative trends were observed with repeated jump height and flight time. These findings indicate that, among relatively homogeneous elite female basketball players, neuromuscular performance may depend more on functional neuromuscular qualities than on body composition characteristics alone.

Overall, body composition does not appear to be a primary determinant of neuromuscular performance in this population.

4. DISCUSSION

4.1 Main findings

The present study aimed to investigate the relationships between neuromuscular performance, dynamic balance, body composition, and physical performance in elite female basketball players. The main results show that repeated reactive neuromuscular capacities, especially anaerobic capacity and the Reactive Strength Index (RSI) from the 30-second MultiJump test, were significantly more associated to sprint performance than isolated concentric explosive strength measured by the Squat Jump. In particular, higher anaerobic capacity and higher RSI were significantly related with improved 10-meter sprint performance. This suggests that reactive strength and stretch-shortening cycle (SSC) efficiency are important for short-distance acceleration.

Conversely, Squat Jump height and flight time showed weak and non-significant correlations with sprint and agility variables, suggesting that concentric explosive strength alone may inadequately reflect athletic performance in this population. Dynamic balance showed limited but relevant correlations with specific neuromuscular variables, especially repeated reactive performance, whereas body composition showed negligible impact on neuromuscular outcomes. These findings indicate that in elite female basketball players, performance capacities may be more significantly influenced by functional neuromuscular efficiency rather than isolated anthropometric or solely concentric strength attributes.

4.2 Neuromuscular performance and sprint capacity

One of the most important findings of this study is the significant association between repeated jump anaerobic capacity, RSI, and 10-meter sprint performance. Athletes demonstrating greater repeated jump anaerobic capacity and superior reactive strength exhibited faster short-distance sprint times, highlighting the importance of SSC efficiency and neuromuscular reactivity in basketball-specific acceleration.

These findings are consistent with current literature emphasizing that acceleration performance in team sports depends not only on maximal force production but also on the rapid application of force during very short ground contact times (McMahon et al., 2024; Turner et al., 2023). Reactive strength, often quantified through RSI, reflects the athlete's ability to rapidly transition from eccentric to concentric muscle actions, a quality particularly relevant for explosive sprint initiation, repeated jumps, and rapid changes of direction common in basketball (Bishop et al., 2019).

The absence of significant relationships between Squat Jump variables and sprint performance may be explained by the biomechanical specificity of the tests. The Squat Jump primarily measures concentric force production in the absence of a pre-stretch phase, whereas sprint acceleration relies heavily on SSC mechanisms, elastic energy reutilization, tendon stiffness, and neuromuscular coordination (Markovic & Mikulic, 2010). Therefore, while Squat Jump may reflect general lower-limb power, it may not adequately capture the reactive and elastic qualities required for basketball-specific sprint performance.

These observations align with recent findings in female team-sport athletes, where repeated jump and plyometric assessments have shown stronger relationships with sprint and agility than traditional vertical jump tests alone (Ramirez-Campillo et al., 2023; 2024). In practical terms, this suggests that coaches should prioritize training interventions targeting reactive strength, repeated power output, and SSC efficiency, such as plyometric training, repeated hurdle jumps, and reactive sprint drills, rather than focusing exclusively on concentric strength development.

Interestingly, while correlations with 20-meter sprint performance were moderate, they did not reach statistical significance. This may indicate that reactive neuromuscular qualities are particularly influential during initial acceleration phases (0–10 m), whereas longer sprint distances may increasingly depend on stride mechanics, maximal velocity capacity, and technical factors (Loturco et al., 2023).

Overall, the present findings reinforce the growing consensus that reactive neuromuscular performance is a key determinant of short-distance speed performance in basketball players, particularly in female elite populations where this area remains underexplored. These results support the integration of repeated jump assessments and RSI monitoring into regular performance evaluation protocols.

4.3 Reactive strength, agility, and change-of-direction performance

Although the associations between repeated jump variables and agility tests (T-Test and Illinois Test) did not reach statistical significance, moderate negative relationships were observed, particularly for anaerobic capacity and RSI. These trends suggest that athletes with greater reactive strength and repeated explosive capabilities may possess superior change-of-direction (COD) efficiency, even if statistical confirmation was limited by sample size.

Basketball is characterized by frequent multidirectional movements requiring rapid deceleration, eccentric control, and force reapplication. Effective COD performance depends heavily on SSC efficiency, neuromuscular coordination, and the ability to minimize ground contact time while generating horizontal and lateral force (Nimphius et al., 2018). Therefore, the moderate associations observed in this study are biomechanically plausible and align with the functional requirements of the sport.

Recent studies have demonstrated that reactive strength qualities are often more strongly related to agility and COD tasks than maximal strength or isolated concentric power alone (Young et al., 2023; Asadi et al., 2016). Specifically, reduced contact time during plyometric tasks is associated with enhanced braking efficiency and reacceleration capacity, both of which are essential during agility maneuvers. The lack of stronger statistical associations in the present study may reflect the relatively small sample size, inter-individual technical variability, or the multifactorial nature of agility, which also includes perceptual and decision-making components.

Furthermore, agility assessments such as the T-Test and Illinois Test involve multiple physical determinants beyond neuromuscular performance, including coordination, movement technique, and anthropometric factors. Consequently, while reactive strength appears relevant, it may represent only one component of a broader performance framework.

From an applied perspective, these findings suggest that reactive strength development should remain an important component of basketball conditioning programs, particularly through multidirectional plyometrics, lateral reactive drills, and deceleration-focused exercises. Such interventions may enhance both sprint acceleration and agility performance simultaneously.

4.4 Dynamic balance and neuromuscular function

Dynamic balance demonstrated generally symmetrical group performance, although notable asymmetries were present in some athletes, particularly in the posteromedial direction. This pattern is relevant, as asymmetries exceeding 10% have been associated with elevated injury risk and functional instability in athletic populations (Plisky et al., 2015).

The observed significant associations between left-leg composite Y-Balance scores and both anaerobic capacity and RSI suggest that reactive neuromuscular efficiency may positively influence unilateral balance performance. Athletes capable of producing rapid force while maintaining neuromuscular control may exhibit superior postural regulation during dynamic tasks.

These findings are supported by recent evidence indicating that neuromuscular qualities such as lower-limb stiffness, proprioception, and reactive force production contribute to postural stability and movement efficiency (Gribble et al., 2012). However, the relatively limited number of significant associations suggests that dynamic balance is likely a complementary rather than primary determinant of explosive performance.

This supports the growing perspective that while Y-Balance testing remains valuable for injury screening, asymmetry detection, and functional profiling, it may have limited standalone predictive value for sprint or agility performance in elite athletes (Schürer et al., 2021). Therefore, balance assessments should be integrated as part of a broader multidimensional performance evaluation rather than used in isolation.

Practically, maintaining adequate dynamic balance remains important for injury prevention, landing mechanics, and unilateral control, but performance-oriented training should prioritize reactive neuromuscular qualities more directly linked to sport-specific outputs.

4.5 Body composition and neuromuscular performance

Body composition variables demonstrated weak and largely non-significant relationships with neuromuscular performance outcomes. Fat mass percentage and muscle mass showed limited associations with jump performance, reactive strength, or anaerobic capacity, suggesting that within a relatively homogeneous elite female basketball sample, anthropometric factors may have reduced explanatory power.

These findings are consistent with literature indicating that among trained athletes, functional neuromuscular characteristics may be more influential than morphological variables once basic anthropometric requirements are met (Nikolaidis et al., 2024). While excessive fat mass may negatively impact movement economy and relative power output, moderate variations within elite cohorts may not substantially affect performance.

Similarly, absolute muscle mass does not necessarily reflect neuromuscular quality, motor unit recruitment efficiency, tendon properties, or SSC effectiveness, all of which play critical roles in explosive athletic performance (Cormie et al., 2011).

This distinction reinforces the importance of moving beyond traditional body composition metrics when evaluating basketball performance. While anthropometric assessments remain relevant for profiling and monitoring, they should not be overemphasized when predicting functional performance capacities in elite female players.

4.6 Practical applications

The present findings offer several practical implications for coaches, sport scientists, and performance specialists working with elite female basketball players.

Key recommendations include:

- Prioritize repeated jump assessments and RSI monitoring as performance-relevant neuromuscular indicators
- Integrate plyometric and reactive strength training to improve acceleration and SSC efficiency
- Emphasize reduction of ground contact time during explosive drills
- Use Y-Balance testing primarily for functional screening and asymmetry monitoring rather than direct performance prediction
- Maintain body composition monitoring as a supportive, but secondary, performance tool

Overall, training programs should focus on enhancing reactive strength, repeated explosive performance, and anaerobic neuromuscular endurance to optimize basketball-specific physical capacities.

4.7 Limitations

Several limitations should be acknowledged. First, the relatively small sample size ($n = 13$) may have reduced statistical power and limited the detection of certain associations. Second, the cross-sectional design precludes causal inference. Third, the study focused

exclusively on elite female basketball players, which may limit generalizability to other populations or competitive levels.

Additionally, agility tests used in this study primarily assessed pre-planned COD performance rather than reactive agility involving perceptual components, which may have influenced the observed relationships.

Future studies should incorporate larger cohorts, longitudinal designs, and more comprehensive neuromuscular profiling—including force plate analysis, electromyography, and sport-specific reactive tasks.

4.8 Future directions

Future research should explore:

- Longitudinal adaptations to reactive strength training
- Neuromuscular predictors of injury risk
- Inter-limb asymmetry relationships with reactive performance
- Advanced predictive models combining anthropometry, neuromuscular variables, and biomechanics
- Female-specific neuromuscular adaptations across competitive levels

Such work would further clarify the complex determinants of basketball performance and support evidence-based training optimization.

5. CONCLUSION

In conclusion, the present study demonstrates that repeated reactive neuromuscular capacities, particularly anaerobic capacity and Reactive Strength Index, are more strongly associated with sprint and athletic performance than isolated concentric explosive strength, dynamic balance, or body composition in elite female basketball players.

These findings highlight the central importance of stretch-shortening cycle efficiency, reactive strength, and repeated explosive performance in basketball-specific physical performance. While dynamic balance and body composition remain relevant for functional profiling and injury prevention, neuromuscular qualities appear to represent the primary physical determinants of short-distance acceleration and broader athletic capacity.

Therefore, performance assessment and conditioning programs for elite female basketball players should prioritize reactive neuromuscular development to maximize competitive performance.

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