ANAEROBIC POWER OUTPUT ASSOCIATED WITH AGILITY-SPECIFIC TESTS WITH AND WITHOUT THE BALL IN FEMALE BASKETBALL PLAYERS

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Abstract:

The main purpose of the present study was to examine the associations between anaerobic power output and agility-related tests in basketball. Fifty-eight female basketball players (age: 24.3 ± 2.8 years, height: 185.1 ± 6.3 cm, weight: 83.4 ± 10.1 kg) of the Chinese 1st basketball division were recruited. Anaerobic power output was assessed by the Running-Based Anaerobic Sprint Test (RAST) and agility by the T-test and the T-505 test with and without the ball. Pearson's product moment correlation and regression analysis were used to examine the associations and predictive ability. Absolute power output (W) was inversely and strongly correlated with the T-test without the ball (r = -0.67) and with the ball (r = -0.64) and with the T-505 without the ball (r = -0.84) and with the ball (r = -0.73). Relative power output (W/kg/s) was inversely and strongly correlated with the T-test without the ball (r = -0.62) and with the ball (r = -0.50) and with the T-505 without the ball (r = -0.76) and with the ball (r = -0.70). Absolute power output was well-predicted by all agility tests, accounting for a minimum of 40% of the variance shared for the T-test with the ball. Similar observations were shown for the relative power output, where the T-test with the ball yielded the lowest amount of the variance shared (25%), while the T-505 test without the ball seemed to be the strongest factor for predicting the absolute (71%) and relative (57%) power outputs. The findings should serve as an avenue for planning training protocols to enhance agility-related outcomes to effectively increase anaerobic performance.

Keywords: *functional capacity, T-test, T-505, basketball, correlations, females*

Introduction

In sport, monitoring and tracking physiological capabilities for training and injury-related outcomes has become a priority for strength and conditioning coaches (Halson, 2014). Such approach may also be used for targeting athletes with lower performance output (Neupert, Gupta, Holder, & Jobson, 2022). Basketball, as a team sport, is characterized by short and explosive actions played throughout the game, that often last < 10 s (Gottlieb, Shalom, & Calleja-Gonzalez, 2021). These anaerobic actions use a large amount of energy stored in muscles and are easily activated. In addition to this 'alactic' process, the second source of energy is known as glycolytic system (or a 'lactatic' phase), which uses glycolysis to create, store and utilize energy for activities that last up to three minutes (Han, Gómez-Ruano, Calvo, & Calvo, 2023). Both energy systems provide athletes with the ability to perform these short-bout activities, like horizontal and vertical jumps, sprints, and ball drives, without relying on oxygen consumption (Mancha-Triguero, García-Rubio, Antúnez, & Ibáñez, 2020).

In general, basketball energy requirements are a mixture of aerobic and anaerobic systems (Metaxas, Koutlianos, Sendelides, & Mandroukas, 2009; Shalom, Gottlieb, Alcaraz, & Calleja-Gonzalez, 2023). During the game, players cover between 3.5 and 5 km (Figueira, Mateus, Esteves, Dadelienė, & Paulauskas , 2022) and perform repeated bouts of high-intensity activity interspersed with frequent stoppages, allowing them to recover. It has been well-documented that higher aerobic capacity leads to more efficient recovery between repeated high-intensity bouts (Castagna, et al., 2008). These kinds of movements of basketball players develop important motor abilities, including agility (Castagna, Chaouachi, Rampinini, Chamari, & Impellizzeri, 2009). Satisfied agility demands are viewed as a fundamental aspect of a successful athlete in basketball game, facilitating effective movements with the ball and without it (Erčulj, Blas, & Bračič, 2010).

The extent of these skills, specifically the motor capacity, is frequently assessed through different motor evaluations, and these assessments are appropriate and relevant since they are conducted in situations comparable to those of practice or competition (Erčulj, et al., 2010).

The anaerobic energy system is crucial for meeting the technical demands of basketball actions. This energy system enables athletes to produce explosive forces in brief intervals (power) without depending on oxygen intake to maximize sport-specific movements, especially in terms of agility (Alemdaroğlu, 2012). In high-pressure game scenarios involving horizontal or vertical movements such as fast breaks, aggressive drives to the basket, or rapid changes of direction, the anaerobic system allows players to access their energy reserves and generate peak force output (de Araujo, de Barros Manchado-Gobatto, Papoti, Camargo, & Gobatto , 2014).

However, up-to-date studies have predominantly utilized the isokinetic knee joint test and the vertical jump test to analyze lower limb strength and power associated with functional performance, which have yielded inconsistent results (Iossifidou, Baltzopoulos, & Giakas, 2005). These varied finds could arise from several factors, including the angular velocities of joints and participant positioning, which influence muscle length and contraction velocity, as well as participant traits and the techniques employed to calculate joint power in isokinetic dynamometry (Iossifidou, et al., 2005).

Certain research has tried to associate anaerobic performance with findings of isokinetic assessments. For example, Arslan (2005) discovered that anaerobic power was significantly associated with isometric and explosive leg strength. Similar observations were found in a study by Kin-İşler, Ariburun, Ozkan, Aytar, and Tandogan (2008), where isokinetic concentric knee extension strength had a significant correlation with both peak and mean power across all contraction velocities (60°, 150°, 240°). Nonetheless, a substantial correlation was found solely between 240° knee flexion strength and peak power during isokinetic concentric knee flexion. On the contrary, Alemdaroğlu (2012) found no significant correlations between agility measured by the T-drill test with anaerobic peak and mean power outputs, and fatigue index score in male first division basketball players.

Although some studies have explored the connections of anaerobic power output, most of them have concentrated on isokinetic knee strength, sprinting capability, and vertical jump performance in various athletes (Alemdaroğlu, 2012; Arslan, 2005; de Araujo, et al., 2014), there is a lack of studies focusing on basketball players. Since playing basketball involves various aspects of agility, including reaction speed, precision of movement, quick changes of direction, and rapid decision-making abilities (Li, Liu, Deng, & Wang, 2024), exploring the associations between anaerobic performance and agility should be a cornerstone for identifying athletic quality. Moreover, it is still unknown to what extent agility performance affects anaerobic outcomes, and whether the enhancement in one of these abilities can increase the other one (Alemdaroğlu, 2012).

The main purpose of this study was to examine the association between anaerobic performance assessed by the Running-Based Anaerobic Sprint Test (RAST) and the agility tests (T-test and T-505) with and without the ball among female basketball players from the Chinese 1st division league. Based on previous research findings, although inconclusive, we hypothesized that the agility tests would be negatively and moderately associated with anaerobic power output.

Materials and methods

Study participants

In this cross-sectional study, we recruited female basketball players from the 1st division league (referring to the professional and the highest level), with mean age of 24.3 ± 2.8 years, height: 185.1 ± 6.3 cm, weight: 83.4 ± 10.1 kg, during the pre-season period from September 10th to 22nd. The sample size calculation indicated that a low correlation reported in previous studies between anaerobic and agility performances ($r < 0.30$) (Alemdaroğlu, 2012), a statistical power of 0.90 (1-β), an α level set at 0.05, the appropriate sample size should be n = 47. The inclusion criteria comprised basketball players without injuries, which could hinder their full participation in the study, and the completion of all measurements. The exclusion criteria involved basketball players with pre-existing injuries or injury-related problems preventing them from continuing with the testing. All data related to the inclusion and exclusion criteria were collected through a questionnaire. The final sample consisted of 58 basketball players. Their common training protocol consisted of a 5-day, 2-hour per day training regimen, which included warm-up exercises, technical and tactical preparation components, and testing of different match-related formations. Before providing written consent, all participants were informed about the experimental protocol and potential risks. The procedures were carried out anonymously and in accordance with the Declaration of Helsinki, and the study was approved by the Ethical Committee of the Sports Academy of the Shenyang Institute of Science and Technology (Ethical code number 26112014/335247). All examinees had signed a statement expressing their willingness to proceed with the testing for the research, and measures were taken to ensure confidentiality and possibility for the participants to withdraw from the study at any time without facing any repercussions.

Study variables

Running-Based Anaerobic Sprint Test (RAST)

The RAST was initially created by Wolverhampton University (United Kingdom) as a modification of the original Wingate test to evaluate anaerobic power and capacity by measuring peak and mean power outputs (Zagatto, Beck, & Gobatto, 2009). The RAST comprises six 35-meter sprints maximally, each followed by a 10-second rest. By assessing body mass and sprint times, one can calculate the effort power in each sprint:

power = (body mass × distance˙2)/time˙3.

The outcomes of the RAST can provide an estimate of the neuromuscular and energy factors influencing maximal anaerobic performance, and it appears to be a suitable option for the evaluation protocol in sports where running is the primary mode of locomotion, including basketball (de Araujo, et al., 2014; Morrison, et al., 2022). For the purpose of this study, the absolute (W) and relative power outputs (W/kg/s) were calculated.

T-test

The agility T-test is the most frequently implemented change-of-direction speed test being used in basketball studies (Chaouachi, et al., 2009; Maggioni, et al., 2019; Pojskic, Sisic, Separovic, & Sekulic, 2018; Sekulic, et al., 2017; Sugiyama, Maeo, Kurihara, Kanehisa, & Isaka , 2021). It aims to assess the efficacy of various movements, particularly identified as being comprised in defensive actions (i.e., lateral shuffling and backpedaling) akin the fundamental basketball movements (Jakovljevic, Karalejic, Pajic, Macura, & Erculj , 2012; Stojanović, et al., 2019). By following the methodology used by Sekulić et al. (2017), a course was set up in a T formation, featuring one cone positioned 9.14 m from the starting line and two more cones located 4.57 m to either side of the initial cone. The participants were instructed to sprint 9.14 m from the start line to the first cone and tap its top with their right hand, then to shuffle 4.57 m to the left to the second cone and touch its top with their left hand, shuffle 9.14 m to the right to the third cone and touch its top with their right hand, and shuffle 4.57 m back to the left to the middle cone and tap its top with their left hand before ultimately backpedaling to the start line. The timing commenced on an auditory signal and ended with the participant crossing the timing gate on their way back. The best performance was kept as the final outcome for each athlete. The test was performed both with and without the ball.

T-505 test

The T-505 test involved sprinting to a marked point 5 m away from the starting position, touching the ground with one hand, immediately changing direction with a turn of 180º and running back to the starting point. To obtain objective data, two photocells (Witty photocell, Microgate, Bolzano, Italy) were positioned 10 m from the starting line and 5 m before the turning point (Živković, Marković, Cuk, Knežević, & Mirkov, 2025). Timing began when the photocell at the 10 m line was triggered and recorded the time for the 2 × 5 m section. Similarly to the T-test, the performance in the T-505 test was measured with and without the ball.

Testing protocol

Testing procedures were performed on two consecutive days to minimize the effects of environmental factors and to avoid fatigue. Before the testing, each examiner was instructed about the testing methodology and conducting anaerobic and agility tests. On the first day of measurement, we administrated the T- and T-505 tests to assess the level of agility between 9:00 a.m. and 11:00 a.m. The resting interval between the tests was 10 minutes. On the second day of measurement, the RAST was performed at the same hours.

Statistical analysis

Data distribution normality was checked using the Kolmogorov-Smirnov test with Q-Q plots and the homogeneity of variance using the Levene test. Basic descriptive statistics are presented as means and standard deviations (SD) with 95% confidence interval limits (95% CI). The associations between mean and peak anaerobic power outputs with the agility tests with and without the ball were calculated using the Pearson product moment correlation analysis with the following criteria: low = 0.10-0.30; moderate = 0.31-0.50; high = 0.51-0.70; very high = 0.71-0.90; nearly perfect = 0.9-0.99; and perfect = 1.0 correlation (Mukaka, 2012). To examine the predictive ability, a set of regression analyses with RAST outcomes as dependent variables and the agility tests as the independent variables was performed. Beta coefficients (β), coefficients of determination (R^2) and standard error of estimates (SEE) were used to present regression equations data. All statistical analyses were performed in SPSS v27.0 software (IBM, Armonk, NY, USA) with an alpha level set *a priori* at $p<.05$ to denote statistical significance.

Results

Basic descriptive statistics of the study participants are presented in Table 1. Figure 1 denotes the correlations between the absolute power output (W) and the agility tests measured without and with

Table 1. Basic descriptive statistics of the study participants (N = 58)

Study variables	Mean ± SD	Min – Max
Anthropometric data		
Age (years)	24.3 ± 2.8	22.8 – 26.2
Height (cm)	185.1 ± 6.3	178.6 – 195.1
Weight (kg)	83.4 ± 10.1	75.5 – 92.5
Body mass index (kg/m^2)	24.6 ± 2.8	23.9 – 25.6
Fat mass (%)	15.7 ± 3.2	8.4 – 18.3
Anaerobic power		
Power output (W)	689.7 ± 41.9	602.3 – 827.4
Relative power output (W/kg/s)	7.5 ± 0.6	6.5 – 9.0
Agility		
T-test without the ball (s)	9.1 ± 0.6	8.1 – 10.7
T-test with the ball (s)	9.4 ± 0.8	8.0 – 11.5
T-505 test without the ball (s)	2.5 ± 0.2	2.2 – 3.1
T-505 test with the ball (s)	3.4 ± 0.4	2.4 – 4.0

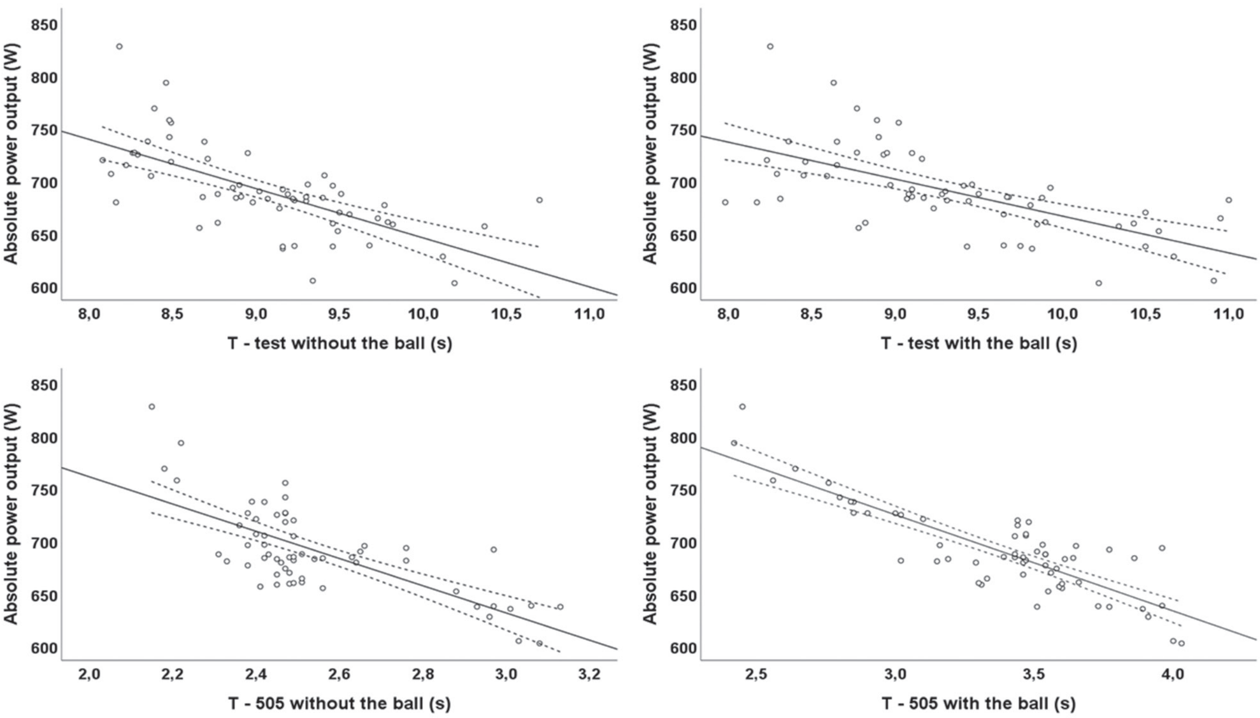

Figure 1. Correlations between absolute anaerobic power output (W) and agility tests with the ball and without it (N = 58).

the ball. Absolute power output was inversely and strongly correlated with the T-test without (*r* = -0.67, 95% CI -0.78 to -0.55, p<.001) and with the ball (*r* = -0.64, 95% CI -0.75 to -0.51, p<.001), and with the T-505 without (*r* = -0.84, 95% CI -0.91 to -0.73, p<.001) and with the ball (*r* = -0.73, 95% CI -0.82 to -0.59, p<.001).

Correlations between the relative power output (W/kg/s) and the agility tests measured without and with the ball are presented in Figure 2. Relative power output was inversely and strongly correlated with the T-test without (*r* = -0.62, 95% CI -0.76 to -0.48, p<.001) and with the ball (*r* = -0.50, 95% CI -0.65 to -0.35, p<.001), and with the T-505 without (*r* = -0.76, 95% CI -0.85 to -0.61, p<.001) and with the ball (*r* = -0.70, 95% CI -0.81 to -0.52, p<.001).

Linear regression equations estimating both absolute (W) and relative power (W/kg/s) outputs based on the agility tests without and with the ball are shown in Table 2. Absolute power output was well-predicted by all agility tests, accounting for a minimum of 40% of the variance shared for the T-test with the ball. Similar observations were shown for the relative power output, where the

Table 2. Estimated linear regression equations between the absolute (W) and relative power outputs (W/kg/s) and the agility tests (N = 58)

Study variables	Absolute power output (W)			
	Equation	R^2	SEE	p
T-test without the ball (s) (1)	1112.9 – 46.7 * (1)	0.45	31.5	< 0.001
T-test with the ball (s) (2)	1016.9 – 35.1 * (2)	0.40	32.7	< 0.001
T-505 test without the ball (s) (3)	998.9 – 91.5 * (3)	0.71	22.7	< 0.001
T-505 test with the ball (s) (4)	1019.6 – 129.5 * (4)	0.53	29.1	< 0.001
	Relative power output (W/kg/s)			
T-test without the ball (s) (5)	12.8 – 0.6 * (5)	0.39	0.44	< 0.001
T-test with the ball (s) (6)	10.9 – 0.4 * (6)	0.25	0.49	< 0.001
T-505 test without the ball (s) (7)	11.2 – 1.1 * (7)	0.57	0.37	< 0.001
T-505 test with the ball (s) (8)	11.8 – 1.7 * (8)	0.49	0.40	< 0.001

Note. p<.001

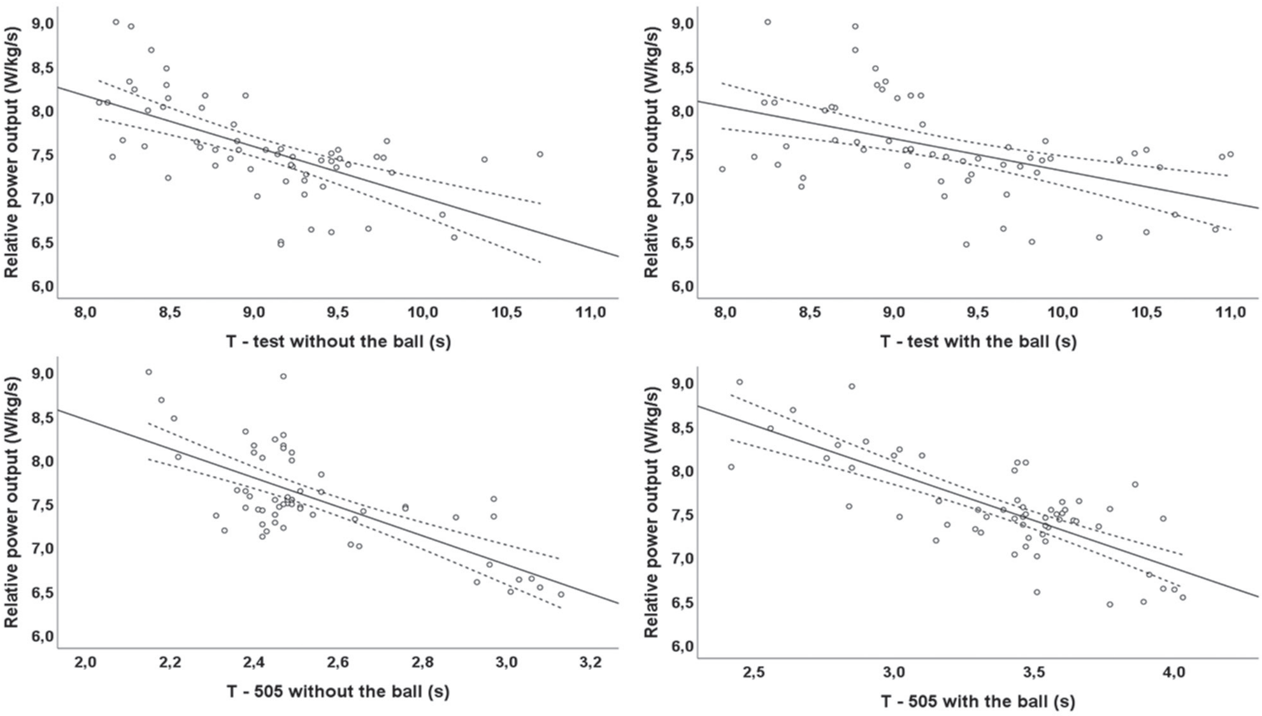

Figure 2. Correlations between relative anaerobic power output (W/kg/s) and agility tests with the ball and without it (N = 58)

T-test with the ball yielded the lowest amount of the variance shared (25%), while the T-505 test without the ball seemed to be the strongest factor for predicting the absolute (71%) and relative (57%) power outputs.

Discussion and conclusion

The main purpose of this study was to establish the associations between anaerobic power output and agility-related tests in female basketball players. Findings suggest that better agility performance (indicating that players are faster in performing a certain agility task) with and without the ball is associated with higher absolute and relative anaerobic power outputs.

This is one of the first studies examining the associations between anaerobic and agility outputs in female basketball players. Assessment techniques such as the RAST and agility tests are utilized to evaluate enhancements in anaerobic and repeated sprint performance. These evaluations enable coaches to monitor development and make educated choices regarding workload, and pinpointing areas requiring enhancement. De Pedro-Múñez, Álvarez-Yates, Serrano-Gómez, and García-García (2025) supported frequent assessment of performance evaluations to prevent plateaus and sustain training efficacy. Information obtained from these tests informs periodization and recovery tactics. Additionally, these assessments facilitate talent identification and establishing benchmarks among teams. Ongoing evaluation establishes a feedback system that enables athletes to monitor their progress. Consistent testing fosters a sense of responsibility and excellence in performance. Thus, assessment instruments are essential for sustaining optimal anaerobic performance levels across the year.

Anaerobic strength and the capacity to perform agility test at maximum level are essential for success in basketball (Sun, et al., 2025). Improving these physical characteristics results in enhanced explosiveness, quicker recovery, and improved decision-making when fatigued. Incorporating assessments such as the RAST guarantees that progress can be quantified as well as the continuous evolution of preparation. Through the steady use of evidence-driven techniques, basketball players can exploit their complete anaerobic capability. As the sport progresses, training programs need to adjust to accommodate its rising physical requirements. A comprehensive approach to anaerobic training not only enhances athletic performance but also supports long-term athletes' development, their overall well-being, and career longevity (Wang, et al., 2024).

We found moderate-to-strong associations between anaerobic power output and agility performance, which is not entirely in line with the existing literature. In specific, a study by Alemdaroğlu (2012) showed no significant correlation between the Wingate anaerobic test and agility assessed by the T-drill agility test in professional male basketball players. A study by Mikołajec et al. (2023) found no significant correlations between anaerobic speed reserve and change of direction movements, highlighting the importance of examining a complete anthropometric profile of the players. Comparable findings were reported in a study by Kin-İşler et al. (2008), where isokinetic concentric knee extension strength demonstrated a significant relationship with both peak and average power at all contraction velocities.

The interplay between agility performance and anaerobic power output is crucial in basketball, as these movements are usually of high-intensity and short duration (< 10 s), which trigger alactatic components of a system to provide energy at rapid pace in a short period of time (Brochhagen & Hoppe, 2025). Thus, increases in functional capacity (mainly anaerobic components), achieved through high-intensity interval training and repeated sprint training, may have positive contributions to improving agility in basketball players. Similarly, we confirmed the hypothesis that faster basketball players had higher peak and mean anaerobic power outputs, in contrary to slower players. From a physiological perspective, anaerobic performance is often associated with cardiovascular endurance, which improves the delivery of blood and nutrients to the muscles, improving neuro-muscular connection and enabling players to perform agility-related movements at maximum level (Kurt & Acar, 2025).

This study has several limitations that need to be considered. Firstly, we did not gather individual or team loading exposure to analyze the intensity and duration of work under training and match conditions. Additionally, other aspects of physical fitness, including body composition, flexibility, and speed/agility/coordination, were not assessed. Thirdly, we did not analyze the relationships between anaerobic power output and agility performance based on playing positions. Fourth, a retrospective injury report was not collected, as having one or more injuries prior to testing might have influenced the associations between anaerobic power and agility performance. Fifth, a cross-sectional design could not be used to examine causal associations between the independent and the outcome variables; thus, longitudinal follow-up studies on the same topic are warranted. Finally, the associations between anaerobic power and agility performance were not adjusted for the time spent playing in a regular basketball game, as players with more playing time might be more prone to injury risk and elevated fatigue, compared to players with less playing time.

In conclusion, the findings of this study showed that better performance in agility tests was associated with higher mean and peak anaerobic power outputs in female basketball players. This would suggest that by improving agility performance, female basketball players may be able to increase their anaerobic power, and *vice versa*. Thus, strength and conditioning coaches should use this information in planning and programing training cycles to monitor and track those individuals with lower agility and functional performance outcomes.

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