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Lower-Body Power, Body Composition, and Agility Performance Among Youth Badminton Athletes

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Abstract

Agility is an important component in badminton. Agility is the ability to move with speed and accuracy to reach the shuttlecock in various corners of the court. This study aims to analyze the correlation between lower-limb power and body composition on agility performance in badminton athletes. Participants were 27 female badminton athletes aged 15.44 ± 0.97 years. Body composition (height, body fat percentage - BF%, body mass, BMI, skeletal whole body muscle - SM%), countermovement jump - CMJ, and t-test agility was measured. The data was analyzed using descriptive statistics, Spearman correlation test and hierarchical multiple regression. Spearman correlation test showed that there was no significant relationship with agility (r = -0.40, p = 0.884). Hierarchical regression analysis showed that age, body composition, and CMJ only explained 17.4% of the variance in agility, with a statistically insignificant contribution (ΔR² = 0.019, p = 0.483). Among the independent variables, BF% had a strong positive relationship with body mass (r = 0.763, p < 0.01), indicating that the higher BF%, the higher the body mass. Meanwhile, SM% had a significant negative correlation with BF% (r = -0.498, p < 0.01) and body mass (r = -0.506; p < 0.01), indicating that the higher SM%, the lower the BF% and body mass. Although the variables tested did not contribute significantly to agility, various previous studies have shown that training programs such as plyometrics, core strength training, and Velocity-Based Resistance Training (VBRT) are effective in increasing lower-limb power, which also affects agility.

Keywords: *agility, body fat, skeletal muscle, lower-limb power, CMJ, youth, badminton*

INTRODUCTION

Badminton is a sport that demands short, high-intensity actions. It is characterized by rapid movements involving acceleration, deceleration, jumps,

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lunges, rapid changes of direction used in stop and go maneuvers (Stepper et al., 2025; Phomsoupha & Laffaye, 2015; Chen et al., 2019).

The demands of the game require athletes to possess various specific physical components. These include: speed, agility, strength, flexibility, muscular endurance, coordination (Phomsoupha & Laffaye, 2015).

Among the various physical components, agility plays a crucial role in movement speed, positional shift accuracy, and movement efficiency in responding to the opponent's shuttlecock (Arnando et al., 2024; Kuo et al., 2022). Athletes with good agility are able to change direction quickly and precisely without losing balance, enabling them to effectively cover all corners of the court and dominate the match (Shedge et al., 2024; Arnando et al., 2024).

Previous literature has consistently shown that lower-limb power supports explosive movements, including sprints and rapid changes of direction, which are common in badminton (Andersen et al., 2018; Sonoda et al., 2018; Spiteri et al., 2014). Therefore, lower-limb power is a vital physical component often measured using the vertical jump (França et al., 2024). Overall, a positive correlation between lower-limb power and agility has been found.

In contrast, research by França et al. (2024) found that body fat percentage had a significant negative effect on sprint time and agility, while fat-free mass and lower-limb power had a positive correlation with both. Other studies reported a detrimental correlation between body fat and lower-limb explosive power in agility tests and field-based performance tests (França et al., 2022; Esco et al., 2018). This finding is consistent with previous research, which indicates that a higher proportion of body fat can inhibit power production due to increased body mass without an accompanying increase in force production (Paterson et al., 2016). Conversely, high fat-free mass is positively associated with increased strength and explosive performance (Silva, 2019).

Although several studies have shown a correlation between lower-limb power and body composition and agility, most of these findings have been obtained from non-badminton sports. However, in the context of badminton, particularly for female athletes, studies integrating these three variables are still limited. Furthermore, there are few studies that specifically examine the contribution of each variable to agility using a multivariate statistical approach. These limitation indicate that there is still insufficient evidence to understand how lower-limb strength and body composition collectively influence agility performance in female badminton athletes. Then, the highly explosive and multidirectional demands of badminton require more spesific understanding of the physical factors that contribute to agility, making this research crucial for developing more targeted training recommendations for athletes.

Therefore, this study explores the correlation between lower-limb power, body composition (body fat % and skeletal body muscle %) and agility in female badminton athletes.

METHODS

Study Design

A Quantitative cross-sectional design was used during the badminton athletes regular training period. Data collection took place at the badminton club on three consecutive mornings to ensure consistent environmental conditions. All assessments including body composition measurements and physical performance tests were carried out on an indoor badminton court. The entire measurements process was supervised by experienced coaching staff to ensure accuracy and procedural reliability.

Participants

The study subjects were 27 female badminton athletes, aged 14-17, attending the same badminton education and training center. All athletes participated in an intensive training program six times a week, with an average duration of four hours and 30 minutes, covering technical, tactical, and physical training. The athletes had been training at the same club for an average of one to two years, indicating a relatively consistent level of training experience within the group. All athletes were in good physical condition, based on subjective reports and had no history of musculoskeletal injuries in the past three months. They had no history of diabetes, hypertension, or cardiovascular disease. Prior to participation, all athletes signed an informed consent form indicating their willingness to serve as research participants and acknowledging the study information provided to them. Consent was also obtained from their parents, coaching staff, and club management.

Anthropometric Measurements and Body Composition

Height was measured using a digital stature meter. Body composition is assessed using Omron Karada Scan HBF-375 device (Omron Healthcare Co., Ltd., Kyoto, Japan). The parameters analyzed included Body mass, Body Mass Index (BMI), Body Fat Percentage (BF%), Skeletal Whole Body Muscle Percentage (SM%). All measurements were performed in the morning.

Lower-limb Power

Lower-limb power was measured using the Countermovement Jump (CMJ) technique with arm swings (Heishman et al., 2018). Measurements were performed using the Takei Digital Vertical Jump (Jump-MD, Takei Kikay Kogyo, Japan).

Participants were asked to perform the CMJ at maximum effort three times, with sufficient rest time between attempts. The highest score was documented and used for analysis.

The jump height (cm) displayed by the tool is then used to calculate the Peak Power (W) estimate using the method discovered by(S P Sayers 1, 1999).

Peak Power (W) = (60.7 x jump height [cm]) + (45.3 x body mass [kg]) -2055

Agility

Agility is measured using the *t*-test method by (Semenick, 1990). Participants started with a 9.14 m forward sprint, followed by a 4.57 m right shuffle, a 9.14 m left shuffle, a 4.57 m right shuffle, and a 9.14 m backward run returning to the starting position. Time was performed using a stopwatch. Two trials were conducted, with a 3-minute rest interval, and only the fastets time was used for analysis.

Statistics

Descriptive statistics are displayed in detail as mean values.± standard deviation, median, minimum, and maximum. The Shapiro-Wilk test was applied to assess data normality. The outcomes of the normality test are displayed in the descriptive statistics table.

The correlation between lower-limb power and body composition on agility were analyzed using Pearson's correlation coefficient for normally distributed data, Spearman's rank correlation coefficient for non-normal data (Samanipour et al., 2025). The strength of the correlation refers to the criteria: 0.1 < r < 0.3 (small), 0.3 < r < 0.5 (medium), and > 0.5 (large) (Pallant, 2020). To see the extent to which lower-limb power explains the variation in the influence of athlete agility performance, a hierarchical multiple regression analysis test was used, by controlling for age variables (phase I), body composition (BF% and SM%) for (phase II), and adding all variables with the CMJ variable (W) for (phase III) (França et al., 2024).

All data analyses were performed using Microsoft Excel software version 2016 (Microsoft Corp., Redmond, WA, USA) and IBM SPSS Statistics version 25.0 (IBM Corp., Armonk, NY, USA) with a significance level set at p < 0.05.

RESULTS

Table 1 presents descriptive statistics of chronological age, height, body composition, lower-limb power and agility performance of female badminton athletes.

Table 1. Descriptive Statistics of Age, Height, Body Composition, Lower-Limb Power, and Agility Performance of Female Badminton Athletes (n = 27)

Variables	Mean ± SD	Median	Min	Max	Distribution
Age (years)	15.44 ± 0.97	15	14	17	NA
Height (cm)	154.46 ± 4.77	155.60	139.00	160.60	NA
Body mass (kg)	48.97 ± 6.15	49.60	34.50	60.90	NA
BMI (kg/m^2)	20.48 ± 2.03	20.60	16.44	23.82	NA
BF (%)	22.53 ± 2.75	22.30	16.60	29.90	Normal
SM (%)	30.31 ± 1.41	30.40	27.20	32.50	Normal
CMJ (cm)	46.67 ± 3.66	46.00	40.00	55.00	NA
CMJ (W)	2996.02 ± 321.09	3004.01	2329.95	3617.37	Normal
t-test (s)	11.40 ± 0.96	11.74	9.44	12.44	non-normal

* *SD: Standard Deviation; NA: Not Applicable; BMI: Body Mass Index (kg/m2); BF: Body Fat (%); SM: Skeletal Whole Body Muscle (%); CMJ: Countermovement Jump (cm) & (W*

Table 2 presents a correlation test between age, height, body mass, and body composition on agility performance. The results show no significant correlation between agility and other variables (p > 0.05). However, there is a very weak correlation (r < 0.1) with age (r = 0.088), height (r = 0.133), body mass (r = 0.133), BF% (r = 0.141), and SM% (r = 0.053).

Meanwhile, the correlation between independent variables showed that BF%

had a strong positive correlation with body mass (r = 0.763, p < 0.01, large), as well as a significant negative correlation with SM% (r = –0.498, p < 0.01, medium). SM% also showed a significant negative correlation with body mass (r = –0.506, p < 0.01, large), indicating that greater relative muscle mass is associated with a decrease in both body fat and total body mass.

Table 2. Spearman Correlation Coefficient Between Age, Body Composition, and Agility Performance in Women's Badminton

Variables	1.	2.	3.	4.	5.	6.
1. Age	-	.587**	.737**	.422*	-.455*	.088
2. Height		-	.513**	.135	.011	.133
3. Body mass			-	.763**	-.506**	.133
4. BF (%)				-	-.498**	.141
5. SM (%)					-	.053
6. Agility						-

**p < 0.05 ; **p < 0.01. BF: Body Fat (%); SM: Skeletal Whole Body Muscle (%)*

Table 3 displays the correlation results between lower-limb power, measured using CMJ (W), and agility. The results showed no significant correlation between the two variables (p = 0.8843) and a very weak correlation (r = -0.040).

Table 3. Spearman Correlation Coefficient Between Lower-Limb Power and Agility Performance of Female Badminton Athletes

Variables	1.	2.
1. CMJ	-	-0.040
2. Agility	-0.040	-

**p < 0.05 ; **p < 0.01. CMJ: Countermovement Jump (W)*

Table 4 presents the data from the hierarchical multiple regression analysis to predict the agility of female badminton athletes based on lower-limb power (phase III), after controlling for the age variable (phase I), followed by BF% and SM% in (phase II).

Table 4. Summary of Hierarchical Regression Analyses with Lower-Limb Power Predicting Agility After Controlling for Age And Body Composition of Badminton Athletes

Variables	Agility		
	Phase I (β)	Phase II (b)	Phase III (β)
Age	0.306	0.350	0.424
BF (%)	-	0.191	0.248
SM (%)	-	0.256	0.238
CMJ (W)	-	-	-0.182
R^2	0.093	0.154	0.174
ΔR^2	-	0.061	0.019

F Change	2.579	0.829	0.508
Say. F Change	0.121	0.449	0.483

**p < 0.05 ; **p < 0.01. BF:Body Fat(%); SM: Skeletal Whole Body Muscle(%); CMJ: Countermovement Jump (W); R2: nilai R; ΔR2: Change R2from the previous phase*

In (phase I) age, entered as a predictor resulted in an R^2 value of 0.093, indicating that age accounts for approximately 9.3% of the variance in agility. On the other hand, this contribution was not significant in statistics (p = 0.121). Phase II added body composition (BF% and SM%), increasing the R^2 to 0.154, but this change remained insignificant (ΔR^2 = 0.061 and p = 0.449). Phase III, CMJ (W) was added to the phase, and the R^2 increased to 0.174. Despite the slight increase, the additional contribution of CMJ (W) to the prediction of agility was also not statistically significant (ΔR^2 = 0.019 and p = 0.483).

DISCUSSION

This study examine the correlation between lower-limb power, body composition, and agility in female badminton athletes. The results indicated no significant correlation between age, body composition (BF% and SM%), or lower-limb power measured by CMJ (W) on agility performance, either through correlation or hierarchical regression.

Contrary to a number of prior research (France et al., 2024; Lee et al., 2022) which states that BF% shows a significant positive correlation with sprint and agility. This indicates that the higher the BF%, the slower the sprint and agility times.

In this study, BF% did not have a significant correlation with agility, although the correlation trend was positive and weak. In line with research conducted by Akdogan et al. (2022) there is no significant correlation between body composition and sprint performance in female athletes. Research by Akdogan & Guven (2021) in female adolescent volleyball athletes showed that although some regional body fat parameters (leg and trunk) were negatively correlated with agility, not all body composition parameters showed a consistent and significant correlation. This indicates that the effect of BF% on agility is complex and not always linear, especially in female adolescent athletes.

The correlations between the independent variables in this study indicate a logical and interrelated pattern. BF% has a very strong positive correlation with body mass, clearly indicating that an increase in BF% directly contributes to an increase in total body weight. The negative correlation between SM% and both body mass and BF% indicates that an increase in muscle proportion is associated with a decrease in BF%, which in theory could support performance (Lockie et al., 2021; P.T., 2014). However, these findings do not provide a strong enough basis to draw applicable conclusions about agility performance.

The lower-limb power variable also did not show a significant correlation with agility (r = -0.40, p = 0.884). This is consistent with studies on female basketball athletes by Spiteri et al. (2014) which showed that lower-limb power was not associated with agility or change of direction (r = –0.19 to –0.46). This study emphasized that eccentric strength contributes more to change of direction ability, while explosive power alone is insufficient to describe complex agility performance.

On the other hand, this research contrasts with several studies in other sports. A study of 164 adolescent soccer players showed that lower-limb explosive strength was a key determinant of sprint and agility performance, even after adjusting for age and body composition, contributing 36-37% of the variance (France et al., 2022). The study conducted by Kabacinski et al. (2022) showed that the correlation between muscle strength, vertical jump, and agility was at a low to moderate level when measurements were taken early in the season. This indicates that muscle power alone is not necessarily the primary determinant of agility, unless tailored to the specific context of the movement. A study comparing power training between Percentage-Based Resistance Training (PBRT) and Velocity-Based Resistance Training (VBRT) resulted in improvements in lower-limb power and footwork in badminton athletes, but VBRT resulted in greater improvements (Lu et al., 2025). This confirms that the type of training stimulus, not just the magnitude of power, plays a crucial role in transferring explosive ability to agility.

Further regression analysis showed that age explained only a small portion of the variation in agility performance. Similarly, when BF% and SM% were added (R^2 increased to 15.4%) and CMJ (W) (to 17.4%), these changes did not produce significant improvements. These results suggest that factors other than age, body composition, and lower-limb power may be more dominant in defining agility performance in female badminton athletes.

It should be noted that there are some limitations to this study. First, the sample size was relatively small (n = 27), which may have contributed to the non-parametric distribution of the agility data not meeting the assumption of normality. Second, the cross-sectional design limits generalizability to a broader population. Third, other factors that may influence agility, such as maturation status, types of exercise, flexibility (Zwierko et al., 2022; Paul et al., 2016; Hegishte & Kumar, 2023). Fourth, this study only uses agility t-test as a measuring tool, although t-test it is a valid measuring tool. Future research can add other types of agility tests that are specific and resemble badminton footwork (Cheng et al., 2025; Huang et al., 2019).

This research, supported by various findings from previous studies, provides insight into the integration of several variables to manage body composition, while supporting agility and power performance in badminton athletes. Appropriate dietary intake, regular body composition checks in the training environment, and lower-limb power have also been shown to be important predictors of agility and speed (Samanipour et al., 2025; McEwan et al., 2020; França et al., 2024). Several types of training are also recommended to support this performance, such as core strength training, which has been shown to improve dynamic balance and agility in adolescent badminton athletes, and visual reaction training, Velocity-Based Resistance Training (VBRT), which improves lower limb power and footwork movement speed (Ozmen & Aydogmus, 2016; Kuo et al., 2022; Lu et al., 2025). Lower-limb power, plyometric, and isokinetic training have been shown to improve neuromuscular adaptation, power, and change of direction (COD) ability, which are key components of agility (Hammami et al., 2018; Kabacinski et al., 2022; Ramírez-delaCruz et al., 2022).

CONCLUSION

This study found no significant correlation between lower-limb power and body composition (BF% and SM%) on agility performance in female badminton athletes. Hierarchical regression analysis also showed that the contribution of these three variables to agility was very small and not statistically significant. This finding suggests that agility may be more influenced by other unmeasured factors, beyond lower-limb power and body composition.

Among the limitations of this study are the small sample size, cross-sectional design, involving only one agility test instrument, and not measuring other factors that may influence agility.

Recommendations for further research are suggested to use a larger sample size and consider additional variables such as maturation, eccentric strength, flexibility and cognitive responses that may influence agility performance.

Within the context of a training program, a multidisciplinary approach should be considered. Lower-limb training, core strength training, plyometrics, visual reaction training, and velocity-based resistance training (VBRT) have demonstrated effectiveness in enhancing power and footwork speed. Furthermore, regular body composition monitoring and appropriate nutritional strategies are recommended to maintain a performance-supportive physique.

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