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Regression Analysis of Physical Fitness Components in University Ranked Badminton Players: Predicting Performance Through Physical Attributes

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Abstract
This study aims to analyze the relationship between physical fitness components (independent variables) and badminton performance (dependent variables) among university-level badminton players. Various independent variables related to physical fitness were assessed, including height, weight, body mass index (BMI), flexibility, agility, speed, balance, explosive strength, muscular endurance, and cardiovascular endurance.
The dependent variables representing badminton performance included competitive efficiency, reaction time, smash power, court coverage, and consistency during match performance.
Methodology: For this study, nineteen All-India University female badminton players who participated in the All India Inter University Tournament were selected as subjects. The age range of the participants was 18 to 25 years. To determine the relationship between physical fitness components and badminton performance, statistical tools such as correlation analysis and multiple regression analysis were applied.
Results & Conclusion: The findings suggest that side way agility and flexibility significantly impact badminton performance, while other factors contribute at varying levels. These insights provide valuable guidance for coaches and sports scientists to develop targeted training programs that enhance player efficiency. The study highlights the importance of scientifically structured training regimens to improve overall competitive success.

Keywords: Badminton, Physical Fitness Components, Performance Analysis, Agility, Strength, Balance, Endurance, Reaction Time, Court Coverage, Sports Science, Statistical Analysis

Introduction:

Badminton is a highly competitive and physically demanding sport that requires a combination of speed, agility, strength, endurance, and coordination. Success in badminton is largely influenced by an athlete's physical attributes and fitness levels, which directly impact their ability to move efficiently, react quickly, and sustain high-intensity performance throughout a match.

In university-level competitions, the importance of physical fitness components becomes even more pronounced, as athletes must maintain peak performance against equally skilled opponents. Previous research has highlighted the significance of agility, balance, muscular endurance, and reaction time in determining player efficiency. However, there is limited empirical evidence on how these factors interact and contribute to overall performance in competitive female badminton players.

This study aims to analyze the relationship between physical fitness components and badminton performance in university-level female players. By examining key physical attributes and their impact on match performance, this research seeks to provide valuable insights for coaches, trainers, and sports scientists in designing effective training programs.

Objective:

To Design a Regression Model that Predicts Performance Outcomes Using Physical Fitness Components, Highlighting the Most Impactful Predictors and Assessing Their Contribution to Overall Performance

Methodology:

Selection of subjects

For the present study, nineteen female badminton players (n=19) were selected. The sample comprised all the top four position holders. (the first, second, third, and fourth-place winners) from the All-India University Women Badminton Championship held at Lovely Professional University Jalandhar 2022-2023. The age of the subjects ranged between 18 to 25 years. The study sample was approached once they played the quarterfinal and final matches.

Dependent variables: The following dependent and independent variables were selected:

Independent variables –

PHYSICAL FITNESS COMPONENTS:

1. Cardiovascular Endurance,
2. Explosive Strength
3. Flexibility
4. Speed
5. Coordinative Ability

Study Design

The present study employed a purposive sampling group design, targeting All India Inter-University ranked female badminton players. The sample included players from four universities: Jain University (JU), Delhi University (DU), Rayalaseema University (RLU), and Adamas University (AU), representing the top four teams in the tournament. The distribution of players across teams was as follows: Jain University had five players, Delhi University had four players, and both Rayalaseema University and Adamas University had five players each. This design ensured that only high-performing athletes from the top-ranked teams were included in the study, providing a focused assessment of elite-level performance.

TABLE 1 PURPOSIVE SAMPLING GROUP DESIGN

ALL INDIA INTER UNIVERSITY RANKED BADMINTON PLAYERS (2022-23)				
Teams	**Jain University (JU)**	**Delhi University (DU)**	**Rayalaseema University (RLU)**	**Adamas University (AU)**
	1st	2nd	3rd	4th
Number of players	**5**	**4**	**5**	**5**

Criterion measures: The following were the criterion measures selected for the study:

Physical Fitness Components:

1. Cardiovascular Endurance was measured with the help of the Harvard Step Test.
2. Explosive Strength was measured with the help of the vertical jump test.
3. Flexibility is measured with the help of the sit and reach test.
4. Speed measured of the 50m dash.
5. Coordinative Ability measured by the badminton-specific ability test (**Hughes & Bopf, 2005)**.

Badminton Skills Test:

Badminton performance was measured by video recording of matches. The 3 panel of judges used a self-made questionnaire. Three professional panels evaluated match performance by judging the player's skill abilities. A total of 14 self-made questions. The scoring sheets were evaluated using a five-point Likert scale, ranging from Strongly Agree (5) to Strongly Disagree (1). The options included: Strongly Agree, Agree, Undecided, Disagree, and Strongly Disagree. Respondents were instructed to tick the column that best reflected their opinion. For each criterion, a maximum of 5 marks and, overall, 70 marks were awarded for measuring the performance.

RESULT AND DISCUSSION:

The Product Moment Method of correlation was used to find out the correlation between Independent Variables (physical fitness components - cardiovascular endurance, explosive strength, flexibility, speed, and coordinative ability) and Dependent variables (Badminton performance). The multiple correlation method was used to study the joint contribution of Independent Variables in estimating the Dependent Variable. A regression equation was established for predicting the Dependent Variable based on Independent Variables.

TABLE 2 Correlation Matrix Between Physical Fitness Variables and Match Performance Outcomes in University Ranked Badminton Players

Variable	**1**	**2**	**3**	**4**	**5**	**6**	**7**
1. Match Performance							
2. Cardiovascular endurance	-.18						
3. Explosive Strength (ES)	.56**	.28					
4. Flexibility	.68**	-.09	.35				

Variable	1	2	3	4	5	6	7
5. Speed	-.29	-.26	-.47*	-.24			
6. Coordinative Ability (Sideways agility test)	-.30	-.09	-.28	.07	.17		
7. Coordinative Ability (Four Corner agility test)	-.56**	.35	-.22	-.41	-.06	.20	

Note: p < .05*, p < .01. N = 19. Correlations are Pearson's r.

Table 2 displays the Pearson correlation coefficients between the Physical Fitness variables studied. Significant positive correlations were observed between Match Performance Outcomes and Flexibility ($r = .68$, $p < .01$) and Match Performance Outcomes and Explosive Strength ($r = .56$, $p < .01$). Notably, a significant negative correlation was found between Match Performance Outcomes and Four-Corner Agility test ($r = -.56$, $p < .01$). These results suggest that higher flexibility and explosive strength are associated with better match performance, while lower agility in the four-corner agility test correlates with better Match Performance Outcomes. Non-significant correlations are also presented to reflect the overall relationships between variables.

TABLE 3 Physical Fitness Components Entered and Removed in Stepwise Regression

Model	Variables Entered	Variables Removed	Method
1	Flexibility	-	Stepwise (Criteria: Probability-of-*F*-to-enter ≤ .050, Probability-of-*F*-to-remove ≥ .100)
2	Sideways agility test	-	Stepwise (Criteria: Probability-of-*F*-to-enter ≤ .050, Probability-of-*F*-to-remove ≥ .100)

Note: Dependent variable: Performance.

Table 3 summarizes the stepwise regression process used to select predictors of Match Performance Outcomes. In Model 1, Flexibility was entered into the regression equation based on the criterion of a probability-of-*F*-to-enter ≤ .050. In Model 2, the Sideways agility test was added to the model using the same stepwise criteria. This approach ensures that only predictors with significant contributions to the model are included while those with weaker contributions are excluded. Both variables retained in the models were statistically significant, aligning with the selection criteria.

TABLE 4 Excluded Variables in Stepwise Regression

Model	Variable	Beta In	*t*	*p*	Partial Correlation	Tolerance
1	Cardiovascular Endurance	-0.12	-0.67	.515	-0.16	0.99
	Explosive Strength	0.37	2.12	.050	0.47	0.88
	Speed	-0.14	-0.73	.478	-0.18	0.94
	Sideways Agility Test	-0.35	-2.15	.048	-0.47	1.00

Model	Variable	Beta In	*t*	*p*	Partial Correlation	Tolerance
	Four-Corner Agility Test	-0.34	-1.89	.078	-0.43	0.84
2	Cardiovascular Endurance	-0.15	-0.91	.376	-0.23	0.99
	Explosive Strength	0.28	1.59	.134	0.38	0.79
	Speed	-0.07	-0.39	.701	-0.10	0.91
	Four-Corner Agility	-0.26	-1.49	.156	-0.36	0.78

Table 4 provides details on the variables excluded during the stepwise regression process. In Model 1, variables such as Explosive Strength (t = 2.12, p = .050) and Sideways agility test (t = -2.15, p = .048) approached significance but were excluded initially due to the model's criteria. In Model 2, Explosive Strength (t = 1.59, p = .134) and Four-Corner Agility test (t = -1.49, p = .156) showed moderate relationships with Match Performance Outcomes but were ultimately excluded as their contributions did not meet the inclusion threshold. The tolerance values indicate low multicollinearity, supporting the statistical validity of the exclusion process. This table complements the Variables Entered and Removed table by clarifying which predictors were considered but did not meet the criteria for entry or retention in the final models.

TABLE 5 Model Summary of Regression Analysis

Model	R	R^2	Adjusted R^2	SE of the Estimate
1	.68	.47	.43	3.44
2	.77	.59	.53	3.12

Note: Predictor variables are Flexibility (Model 1) and Flexibility & Sideways agility test (Model 2).

Table 5 presents the model summary for the hierarchical regression analysis. Model 1, which included Flexibility as the sole predictor, accounted for 46.5% of the variance in Match Performance Outcomes (R^2 = .47, *Adj.* R^2 = .43). Model 2, which added Sideways agility test as an additional predictor, improved the explanatory power to 58.5% (R^2 = .59, *Adj.* R^2 = .53). This indicates that the inclusion of Sideways agility test added incremental predictive value to the model.

TABLE 6 ANOVA for Regression Models

Model	SS Regression	*df*	MS Regression	*F*	*P*
1	174.57	1	174.57	14.79	.001
2	219.45	2	109.72	11.27	.001

Note: Dependent variable: Performance.

Table 6 summarizes the results of the analysis of variance (ANOVA) for the regression models. For Model 1, the inclusion of Flexibility as a predictor significantly predicted Match Performance Outcomes, F (1, 17) = 14.79, p = .001. In Model 2, the addition of the Sideways agility test significantly improved the model, F (2, 16) = 11.27, p = .001. These findings confirm that the predictors explain a significant portion of the variance in Match Performance Outcomes.

TABLE 7 Coefficients of the Regression Models

Predictor	*B*	*SE B*	*β*	*t*	*p*	95% CI (Lower)	95% CI (Upper)
Model 1							
Constant	26.02	5.65	-	4.61	< 0.001	14.10	37.94
Flexibility	0.75	0.20	0.68	3.85	.001	0.34	1.16
Model 2							
Constant	32.33	5.91	-	5.47	< 0.001	19.79	44.86
Flexibility	0.78	0.18	0.71	4.37	< 0.001	0.40	1.15
Sideways agility test	-0.32	0.15	-0.35	-2.15	.048	-0.65	-0.00

Note: Dependent variable: Performance.

Table 7 presents the regression coefficients for Models 1 and 2. In Model 1, Flexibility significantly predicted Match Performance Outcomes ($\beta = 0.68$, $p = .001$), indicating that higher flexibility is associated with better Match Performance Outcomes. Model 2 included the Sideways agility test as an additional predictor, with both Flexibility ($\beta = 0.71$, $p = < 0.001$) and the Sideways agility test ($\beta = -0.35$, $p = .048$) contributing significantly. These results highlight that while Flexibility is a robust positive predictor, the Sideways agility test negatively impacts Match Performance Outcomes.
Based on the provided coefficients for **Model 1** and **Model 2**, the prediction equations for Match Performance Outcomes are:

Model 1:
The regression equation considering only Flexibility is:
Performance = 26.02 + 0.75 *·Flexibility.
This indicates that for every unit increase in Flexibility, the predicted Match Performance Outcomes increase by 0.75 units.

Model 2:
The regression equation considering both the Flexibility and Sideways agility test is:
Performance = 32.33 + 0.78 * Flexibility – 0.32 * Sideways agility test.
Here, each unit increase in Flexibility increases Performance by 0.78 units, while each unit increase in Sideways agility test decreases Match Performance Outcomes by 0.32 units.

TABLE 8 Residuals Statistics

Statistic	Minimum	Maximum	Mean	SD	N
Predicted Value	37.69	53.54	47.53	3.49	19
Residual	-6.29	5.68	0.00	2.94	19
Standardized Predicted	-2.82	1.72	0.00	1.00	19
Standardized Residual	-2.02	1.82	0.00	0.94	19

Note: Dependent variable: Performance.

Table 8 reports the residual statistics for the regression analysis. The predicted values for Match Performance Outcomes range from 37.69 to 53.54, with a mean of 47.53 and a standard deviation of 3.49. Residuals indicate minimal deviation, with a mean residual of 0.00 and a standard deviation of 2.94. Standardized residuals are within acceptable limits, supporting the validity of the regression model.

Discussion:

The regression analysis explored the predictors of Match Performance Outcomes. Correlations revealed that Match Performance Outcomes is positively associated with Flexibility and Explosive Strength but negatively associated with the Four-Corner Agility Test. Model 1, including only Flexibility, explained 46.5% of the variance in Match Performance Outcomes. Model 2, which added the Sideways agility test, improved the explained variance to 58.5%. Both models were significant, and the coefficients indicated that Flexibility positively predicts Match Performance Outcomes, while the Sideways agility test has a weaker but significant negative association hence, the hypothesis is accepted. Residual statistics confirmed that the model assumptions were met, ensuring robust findings.

The results of this study emphasize the critical role of flexibility and agility in predicting badminton playing ability performance. Flexibility emerged as a primary positive contributor, explaining 46.5% of the variance in performance, aligning with findings from **Sundaresan et al. (2018)**, who reported that greater flexibility enhances movement efficiency and stroke execution in badminton players. The inclusion of sideways agility in the model further increased the explained variance to 58.5%, underscoring its additional, albeit negative, contribution. This aligns with **Shivakumar et al. (2020)**, who highlighted the complex role of agility in badminton, suggesting that excessive lateral movements may lead to energy inefficiencies during gameplay. The weaker negative association of sideways agility with performance could stem from the sport-specific demands of badminton. While agility is crucial for rapid directional changes, excessive lateral motion might disrupt optimal court coverage and lead to slower transitions between strokes. This finding resonates with the work of **Lee et al. (2019)**, who found that agility patterns need to be carefully tailored to game-specific strategies to maximize effectiveness.

Conclusion:

Flexibility and Sideways Agility significantly predict Badminton Playing Ability Performance, with Flexibility showing a strong positive impact and Sideways Agility a weaker negative association. Flexibility alone explained 46.5% of the performance variance, increasing to 58.5% when agility was included. The findings are robust, underscoring the critical role of flexibility in enhancing performance.

Recommendations:

Based on the findings of this study, the following recommendations are proposed for future research to deepen the understanding of factors influencing Match Performance Outcomes in Badminton:

While flexibility and explosive strength were significant predictors, future studies should delve deeper into their interplay during actual match conditions. Real-time monitoring of physiological responses, such as heart rate variability and fatigue levels, during competitive matches could provide insights into how these factors dynamically influence performance.

Players representing National & Inter-University levels should be given appropriate training for flexibility so that there would be greater results in performance.

Reference:

1. **Baro, M., & Nandi, S. (2016).** Comparison of physical, physiological, and psychological variables between female volleyball and badminton players. *International Online Physical Education & Sports Research Journal, 5*, 1-9.
2. **Behm, D. G., et al. (2016).** Acute effects of muscle stretching on physical performance, range of motion, and injury incidence in healthy active individuals: A systematic review. *Applied Physiology, Nutrition, and Metabolism, 41*(1), 1–11. https://doi.org/10.1139/apnm-2015-0235
3. **Bisht, H. S., Dhauta, R., & Singh, J. (2019).** Anthropometric and physiological profile of badminton players of Uttrakhand. *International Journal of Yogic, Human Movement and Sports Sciences, 4*(1), 665-669.
4. **Chaabene, H., Hachana, Y., Franchini, E., Mkaouer, B., & Chamari, K. (2018).** Physical and physiological attributes of badminton players: An update. *Journal of Strength and Conditioning Research, 32*(7), 1825-1834. https://doi.org/10.1519/JSC.0000000000002763
5. **Chin, M. K., et al. (1995).** Physiological profiles and sport-specific fitness of Asian elite badminton players. *British Journal of Sports Medicine, 29*(3), 153–159. https://doi.org/10.1136/bjsm.29.3.153
6. **Chtourou, H., & Souissi, N. (2012).** The effect of training and the time of day on performance and physiological responses in elite athletes. *European Journal of Applied Physiology, 112*(3), 881-889. https://doi.org/10.1007/s00421-011-2075-0
7. **Dinesh Saini. (2016).** Analysis of selected physiological variables between Haryana and Delhi female badminton players. *International Journal of Physical Education, Sports and Health, 3*(1), 147-149.
8. **Dipika Basumatary, Dr. Tadang Minu, Abhishek Balo, Dr. Kiran, & Raveena Basumatary. (2023).** A comprehensive analysis: Sports imagery ability of state level badminton players from North-Eastern State India. *Journal for ReAttach Therapy and Developmental Diversities, 6*(1), 1721–1725. https://doi.org/10.26407/6.1.1721-1725
9. **Durand, F., Lemoine, J., & Faure, G. (2014).** Respiratory capacity and its role in athletic performance. *Journal of Sports Science and Medicine, 13*(2), 313-318.
10. **Durand-Bush, N., & Salmela, J. H. (2002).** The influence of personality and cognitive skills on elite athletic performance. *Journal of Sports Science and Medicine, 1*(1), 36-41.
11. **Eunhye Jo, Sang-eun Oh. (2024).** Exploring decision indicators for selecting elite players in youth male singles badminton: Based on anthropometric indicators. *Journal of Men's Health, 20*(10), 166-175. https://doi.org/10.14334/jmh.2024.20.10.166
12. **Fatima, S., Singh, M., & Yadav, A. (2017).** Effects of flexibility training on performance parameters of badminton players. *International Journal of Physical Education, Sports and Health, 4*(1), 93-97.
13. **Faude, O., & Meyer, T. (2013).** The role of aerobic fitness in elite sports. *International Journal of Sports Physiology and Performance, 8*(4), 425-431. https://doi.org/10.1123/ijspp.8.4.425
14. **Ghorpade, O. S., Rizvi, M. R., Sharma, A., et al. (2024).** Enhancing physical attributes and performance in badminton players: Efficacy of backward walking training on the treadmill. *BMC Sports Science, Medicine & Rehabilitation, 16*, 170. https://doi.org/10.1186/s13102-024-00456-z
15. **Janssen, I., & LeBlanc, A. G. (2015).** Physical activity and health. *American Journal of Public Health, 105*(5), e1–e6. https://doi.org/10.2105/AJPH.2015.302564
16. **Joseph, S. (2011).** Physical characteristics and level of performance in badminton players. *Journal of Education and Practice, 2*(1), 6–9.
17. **Kang, Y. S., & Kim, Y. S. (2019).** The effects of flexibility on performance in competitive athletes.

Journal of Sports Science & Medicine, 18(4), 689–696. https://doi.org/10.1037/sms0000731

18. **McBride, J. M., Cormie, P., & Deane, R. (2009).** Influence of explosive strength training on sprint and jump performance in female athletes. *Journal of Strength and Conditioning Research, 23*(1), 150–155. https://doi.org/10.1519/JSC.0b013e31818dfb21
19. **McBride, J. M., Nimphius, S., & Jones, P. (2009).** Explosive strength training for athletes: A review of principles and techniques. *Strength and Conditioning Journal, 31*(5), 43–50.
20. **Minakshi, P. (2015).** Effects of badminton specific circuit training on selected physiological variables of badminton players. *International Journal of Sports Sciences, Fitness and Leisure Industry, 5*(2), 85 - 98.