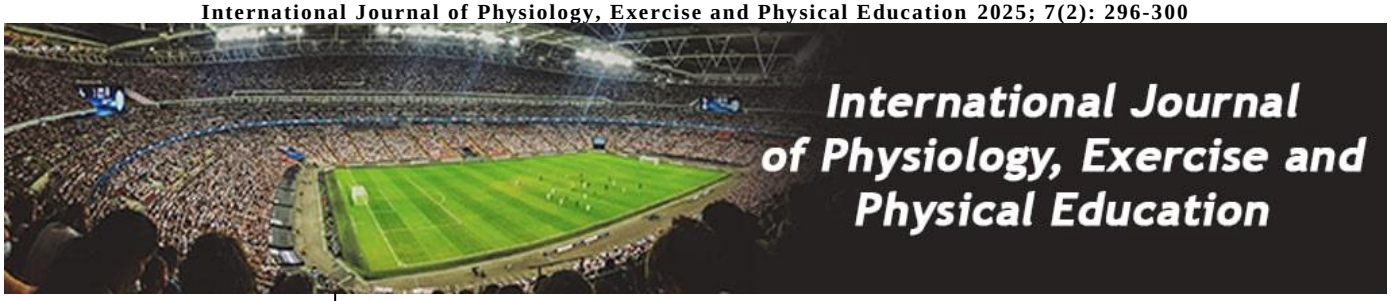

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Correlational analysis of eye-hand coordination and wrist flexibility in relation to backhand short serve accuracy among male badminton players

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Abstract
The sport of badminton involves the acquisition of a diverse set of technical and physical abilities by a player as it is one of the most skillful and quickest races played with a racquet. The accuracy of the backhand short serve is vital particularly when there is competition. This study is analyzing the accuracy of the badminton backhand short serve in relation to two significant physical variables which are the wrist flexibility and eye-hand coordination. Twenty male badminton players of the Lakshmibai National Institute of Physical Education (LNIPE), Gwalior who had participated in the state or intercollegiate levels were considered in the study. The accuracy of the back hand short serve was tested using the French Short Service Test, standardized tests were used to test the flexibility of the wrist and eye hand coordination. Wrist flexibility ($r = 0.606$, $p = 0.005$) and eye-hand coordination ($r = 0.489$, $p = 0.029$) were also observed to have a strong positive relationship with the accuracy of the backhand short serve. These findings have significant implications on coaches and players aiming to be the best in badminton performance as they can mean that specific practice to enhance these two physical aspects can be used to enhance serve accuracy.

Keywords: Physical variables, Backhand short serve, Wrist flexibility, Eye-hand coordination, and Racket sports

Introduction
There is always a search among athletes and coaches to be able to enhance their performance in competitive sports. Badminton is a sport that can be used to illustrate this effort because it is believed to be accurate, fast, and agile. Besides being an Olympic sport, it is a popular hobby that also requires high level of technical skills and physical fitness. As the serve is usually the first shot in a rally and often sets the tone of the rest of the play, it is a tactical shot. The player is required to serve with a backhand short serve where he or she is supposed to serve the shuttlecock a bit more than the net and in the forecourt of the opponent. This will give the player a tactical advantage and will lower the chances of the opponent attacking with great force. To play a backhand short serve effectively and correctly, you have to apply a combination of different and separate physical and neuromuscular elements. Wrist flexibility and eye hand synchronicity are two of the most important aspects that individuals often discuss. In order to hit the racket and the shuttlecock exactly in time, coordination of the hands and eyes the skill to gather whatever you see with what your hands are performing is essential. Neuroimaging studies show that long-term badminton training results in better visuospatial processing and hand-eye coordination which leads to improved performance. On the other hand, the elasticity of the wrist is called the wrist flexibility, which is the scope of motion and the possibility of the joint of the wrist to move freely and not in a stiff way. A flexible wrist will enable a badminton player to manipulate the racket in any number of subtle variations, making the shuttlecock spin, furnish and redirect its path accordingly. Besides increasing ease of technical movements, flexible wrists will also avoid injuries and fatigue in and during long play.
The relevance of these physical factors is highlighted by testimonial evidence as well as the coaching experience, and nowadays the correlation between them and specific badminton skills, such as the short serve when in the backhand, is not well measured empirically. The importance of the knowledge of the effects of the flexibility of the wrist and the eye-hand

synchronization on the accuracy of the serve may influence the way of training, evaluation of talent, or developing skills. Accordingly, the paper attempts to fill this gap through a critical examination of how these two variables relate to the precision of badminton backhand short serve among competitive players of male athletes. It is hoped that the results of the research will contribute to the progress of sports sciences and offer those coaches or athletes who want to achieve better results in badminton the recommendations useful to them.

Methodology

The study sample consisted of 20 LNIPE, Gwalior, male badminton players that were from different universities and were all active participants in inter-university or state competitions. Since the ages of the participants were between 18 and 28, their physical development and experience in competitions were rather similar. Prudent selection of players with high level of skill and a lot of experience in playing was used to enhance the dependability of the results through purposeful sampling. The study adopted the correlational research approach in order to analyse the relationship between wrist flexibility and eye-hand coordination and precision of the backhand short serve in badminton at length. We also used descriptive and correlational statistics to analyse the data that we have acquired. We have used descriptive statistics, i.e. the maximum and minimum values, mean and standard deviation to summarize and describe the performance of each player on each statistic. We then applied the correlational analysis to determine the association between accuracy of the back hand short serve and the flexibility of wrists and eye hand coordination. This approach methodology helped explain the connections between the main variables of the study and created a concise overview of the results observed.

Instruments

The instruments of this research were selected to give a valid and objective assessment of the key variables. All tests were controlled in an indoor setting with minimal external distractions, constant light conditions and the appropriate ambient conditions. Familiarization was done before data collection to ensure that the participants were familiar and experienced with the test procedures.

Ball throwing Test was used to measure eye-hand coordination. In this test, the subjects threw a ball with each underarm and stood at the end of the wall two meters and tried to catch the ball with the other hand. This exercise was beneficial in assessing eye-hand coordination since it entailed visual perception and motor skills to coordinate in this exercise. Analysis was done by counting the number of successful catches of each participant after he/she had three successful catches recorded.

To ascertain the wrist flexibility, we measured the degree of movement in flexion and extension about the wrist joint with the help of a standard goniometer. Respondents sat in a comfortable position with their arms in an appropriate position. The movable and stationary arms of the goniometer were placed along the ulna and the posterior part of the hand, respectively and the axis of the goniometer was put parallel to the styloid process of the ulna. The angles which the participants rotated the wrists to their utmost comfort in each direction were noted. Each participant was subjected to it three times and the average angle was used as a measure of statistics.

The precision of the backhand short serve was measured on the basis of French Short Service Test. To set target zones of this test, arches were drawn on the field, and a rope was passed over the net. Participants were using shuttlecocks as served in an approved location to ensure that they were under the rope and in the suitable scoring areas. All participants had to use ten test serves after two attempts to do so; the overall score was computed by the areas where the shuttlecocks landed.

The evaluation of the key variables that this research examined was similar and sound because of the implementation of such standardized measures and procedures.

Results

Table 1: Descriptive Analysis of Maximum, Minimum, Sum, Standard Deviation, And Mean of Selected Variables

Variables	N	Maximum	Minimum	Sum	Mean	Std. Deviation
Scores of short serves	20	50.00	28.00	764.00	38.20	6.03
Eye-hand coordination	20	36.00	25.00	578.00	28.90	2.82
Wrist flexibility	20	79.70	59.80	1439.50	71.97	4.72

The descriptive statistics of several physical variables and badminton players' scores on the French short service test are shown in Table 1. Eye-hand coordination, wrist flexibility, and French short service test scores averaged 38.2, 28.9, and 71.98 degrees, respectively. The French short service exam, eye-hand coordination, and wrist flexibility scores all had standard deviations of 6.03, 2.83, and 4.72, respectively.

Table 2: Pearson's Product-Moment Correlation Coefficient between wrist flexibility and eye-hand coordination with backhand short serve scores

Variables	N	Pearson's coefficient of correlation	P-value
Eye Hand Coordination	20	.489	.029
Wrist Flexibility	20	.606	.005

The findings show a strong correlation between backhand short serve accuracy and wrist flexibility and eye-hand coordination, respectively. In particular, at the 0.05 level of significance (2-tailed) with 18 degrees of freedom, Pearson's Coefficient of Correlation (r) between backhand short serve and eye-hand coordination was 0.489 ($p = 0.029$), and the correlation between backhand short serve and wrist flexibility was 0.606 ($p = 0.005$). These findings suggest that players who have better eye-hand coordination and wrist flexibility typically execute shorter serves with more

accuracy. According to an earlier study on these parameters, improving wrist flexibility and eye-hand coordination may be helpful for badminton players looking to improve their short serve performance.

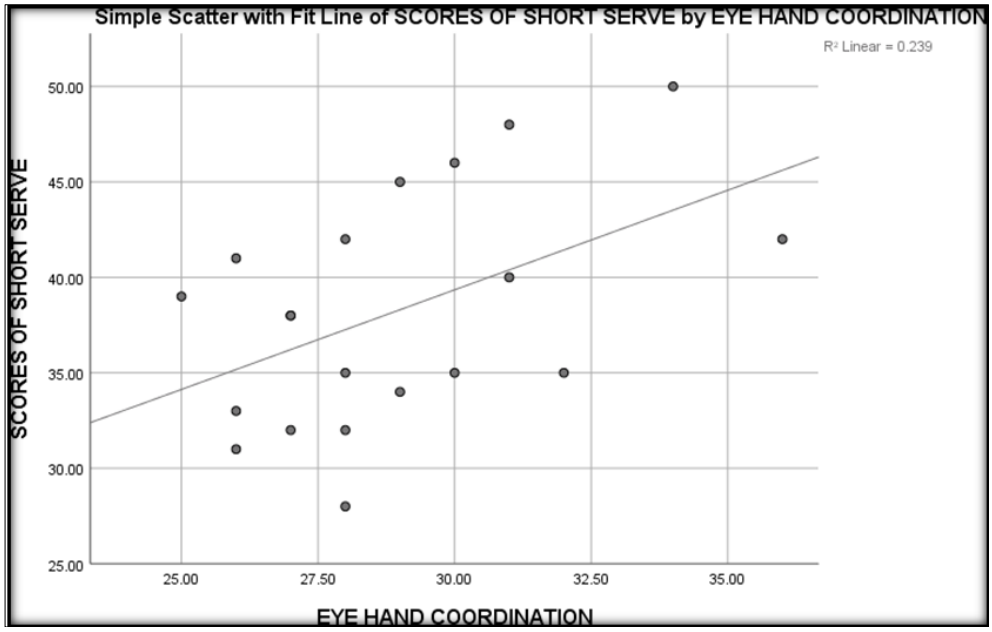

Fig 1: Scatter plot depicting the correlation between accuracy in short serve and eye-hand coordination

The visual representation of the distribution of eye-hand coordination data based on the scores of short serves of the backhand was illustrated in the plot. Since the correlation coefficient between the backhand short serve and the backhand short serve scores was 0.489.

The points on the scatter plot tend to cluster around in a given manner. In the case, the dots in the scatter plot usually would depict a positive sloping line because the higher the short serve skill score, the more participants had better eye-hand synchronization. It was possible to also determine the degree of relationship between eye-hand coordination and short serve ability using the scatter plot. The points of the scatter plot, in this instance, lie close to a linear tendency, which means that the two variables are more correlated.

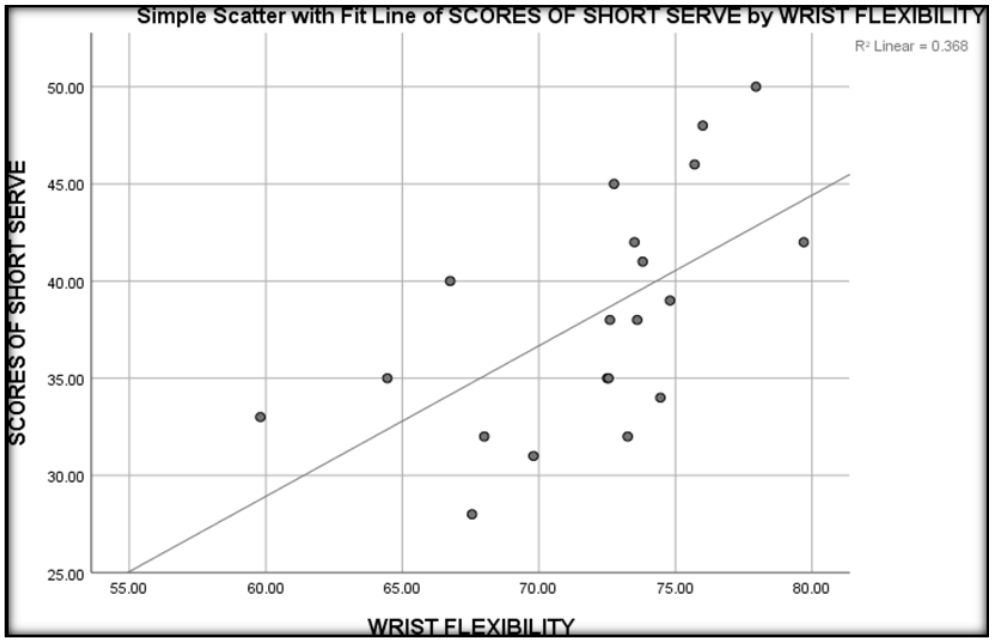

Figure 2: Scatter plot depicting the correlation between accuracy in short serve and wrist flexibility

The correlation coefficient of the graphic representation of the data of the wrist flexibility in the backhand short serve scores is 0.606.

There is a tendency in the points of the scatter plot to cluster together in a certain manner. The scatter plot points would normally create a positive sloping line in this instance, as the participants who have larger wrist flexibility would be on the higher side of the short serve ability scores. The estimate of the strength of correlation between short serve skill and wrist flexibility can be also accomplished with the help of the scatter plot. Here the points of the scatter plot would be clustered closely around a linear tendency and this would signify a higher correlation between the two variables.

Discussion

The paper involved an analysis of the relationship between backhand short serve accuracy in badminton and physical variables, especially the flexibility of the wrist and eye-hand coordination.

The findings of this research revealed that there was a strong correlation with moderate strength of alpha level of 0.05 and 18 degrees of freedom ($p = 0.029$) between the eye-hand coordination and accuracy of the backhand short serve. In addition, the wrist flexibility and short serve accuracy were also found to be highly correlated, moderate strength at equal alpha level and degrees of freedom ($p = 0.005$). Such findings are in line with a previous research article conducted by M. Rachmat Kasmad, Benny Badaru, and Rosmanita (2019), according to which wrist flexibility and eye-hand synchronization significantly affected the proficiency of backhand short serve. The same authors also discovered that wrist flexibility and short-serve in badminton were significantly related (Hikmad Hakim, Sahabuddin, Herman H., Nurul Musfira Amahoru, and Arman Fadillah, 2022) [17]. The results of the current study also confirm the association between short serve proficiency and wrist and eye-hand coordination flexibility.

Accuracy of the backhand short serve is directly related to the flexibility of the wrist and eye-hand coordination, which promotes the significance of the mentioned physical attributes to accurate serving. The eye-hand coordination can be important to coordinate the position of the racket with the shuttlecock and position it close or over the net. Also, the flexibility of the wrist ensures the smooth movement of the wrist and this might enable the accurate placing of the shuttlecock during the serve.

Findings of the research present considerable information on the physical variables that apply to the proper performance of the backhand short serve by the shuttlers. It is however important to note that the study is not causal since it is correlational. The research only examined a single badminton shot; therefore, the results may not be applicable to other shots and other sports.

Conclusion

This study found that the short distance serve in badminton backhand is strongly positively related with the wrist flexibility and eye-hand synchronization among competitive male athletes. Such results imply that such physical qualities might be improved through focused training that would lead to better serve accuracy and performance. To achieve the maximum benefits, trainers and coaches may include certain applicable drills and flexibility exercises in their training programs. It is advised that further studies should be carried out to investigate these relationships among various strategies of badminton, gender and ability.

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