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# Do Isokinetic Strength and Shoulder Mobility Influence Ball Velocity? A Study of Female Badminton Players

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***Abstract***

*The working group of the current study which aims at investigating the relation of isokinetic strength, shoulder mobility and ball velocity at elite female badminton players was made up of 28 female badminton players having the age, body weight and height means; 21,17±3,42 years, 62,47±8,60 kg, 164.31±5.88 cm and volunteering in the study. The data obtained in the study was analysed in the package program of SPSS (Statistical Package for Social Sciences) for Windows 22.0. For all variables in the study, Pearson correlation test was applied. In the research, 60˚/sec. dominant and non-dominant, internal and external isokinetic strength values (nm) were found as 37.05 ± 7.12, 36.95 ± 6.72, 26.87 ± 7.63, 22.27 ± 7.60 respectively. Dominant internal rotation values of the players were found as 57.37 ± 7.20, dominant external rotation values were found as 103.00 ± 8.08, non-dominant internal rotation values were found as 52.00 ± 4.92, non-dominant external rotation values were found as 97.35 ± 7.88. Shuttlecock velocity (km/h) was 238.45 ± 3.20. As a conclusion, upon the investigation of the correlation values between isokinetic strength, shoulder joint mobility and Shuttlecock velocity at elite female badminton players, a statistically direct re-lation was not found between them at the level of significance.*

***Keywords:*** *Badminton, Isokinetic Strength, Shoulder Mobility, Ball Velocity, Racket Sports*

## INTRODUCTION

Badminton can be defined as an irregularly practised racket sport in which repetitive high-intensity games (rallies) are interspersed with short rest periods and a high level of aerobic and anaerobic performance characteristics is important (Faude et al., 2007). According to Yıldıran (Yıldıran, 1997), the precursor of badminton, which dates back to ancient times, can be considered the tepuk game. The games known as tepuk and its variants can be considered as a type of badminton game played with the feet as rackets, both in terms of the playing equipment and the playing technique. XI of the Tepuk game. The game was first played in the 15th century, and games played with rackets were not introduced until the 15th century. Considering that they originated a century later, it is possible that the game is one of the racket-less precursors of badminton. Today, modern badminton is a very popular Olympic sport that is played with rackets. The most effective way to drop the ball and score a point is the smash. Therefore, ball velocity is very important in this game (Gül et al., 2018; Ramasamy et al., 2021).

Badminton is a fast-paced sport, often recognized as the fastest among racquet-based games (Pardiwala et al., 2020). The sport involves various vigorous movements and specific motion sequences that require swift accelerations, sudden decelerations, and frequent explosive directional changes over short distances. All of these movements demand exceptional physical fitness (Rusdiana et al., 2021). It also involves a technical aspect, requiring proficient motor coordination and the mastery of intricate racquet techniques (Indora, 2022). The most traditional and potent offensive technique that players employ to defeat their opponents is the smash. The smash is widely recognized as the primary finishing shot in the game (Asif et al., 2018). The forehand and backhand smashes are utilized in 39.8% of instances (Barreira et al., 2016) with the forehand smash holding significant importance as a critical offensive move in badminton. In international matches, it accounts for 54% of shots, resulting in either an "unconditional winner" or a "forced failure" (Tong & Hong, 2000).

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The shoulder joint, which is the subject of the research, is the most mobile joint in the body. The mechanism of the shoulder joint helps us to adjust the position of the hand in front of the body. In this way, it allows us to perform motor functions by controlling the elbow joint (Jobe et al., 2009).

Strength, which is one of the most important components of the sport for both injury prevention and high performance, has become a very important motor characteristic for badminton. To determine power during dynamic muscle contraction, it is necessary to measure the power and strength generated at a specific angular velocity. These values are determined numerically using an isokinetic dynamometer (Brochu et al., 2002; Yılmaz, 2023). Determining the isokinetic strength profiles of athletes in different sports is of great importance for the fulfilment of the requirements of the sport and the continuity of the athletes' performance at a high level. Badminton is also one of these sports (Magalhaes et al., 2004; Yılmaz et al., 2023).

Nowadays, with the development of technology, science has entered sports, and sports have begun to benefit from scientific data, competition has increased even more, and it has become a process where fractions of seconds compete instead of seconds. Studies in the literature often show that biomechanical and physiological factors directly influence the success of athletes (Bahr & Reeser, 2003). The assessment of dynamic performance and the quantitative representation of its results has therefore become one of the most important topics in sports science. Looking at the international publications in the literature, it can be seen that there are studies investigating the changes in the shoulder joints of athletes who intensively use overhead techniques and the relationships between strengths and angles, while such studies are limited in national publications.

Based on these limited studies, the aim of the study is to contribute to the literature by investigating the relationship between ball velocity, shoulder mobility and shoulder strength, which have important implications in badminton.

## MATERIALS AND METHODS

### Participants

The mean age of the research group of the study is 21.17±4.42 years, body weight is 62.47±8.60 kg and height is 164.31±5.88 cm. The sample consists of 28 elite female badminton players who voluntarily participated in the measurements.

### Data Collection Instruments

### Isokinetic Strength Measurements

The subjects' isokinetic strength measurements were performed by sports physicians using an isomed 2000 isokinetic dynamometer. Prior to the strength measurements, each participant was individually included in a standard warm-up program as far as possible (10-15 minutes). In the warm-up programs, the participants were trained with arm ergometers and stretching exercises. After a special warm-up program, the subjects were led individually to the Isomed device to be measured and the device was set according to their individual anthropometric characteristics. After the subject's body had been fixed so as not to interfere with the test, the personal data was entered into the computer and the test preparations were completed. The axis of the dynamometer was set according to the axis of rotation of the dominant side of the shoulder. Gravity was checked and maximum isokinetic strengths were recorded at angular velocities of 60 d/s, Nm, in a range of joint motion (ROM) of 00-1300, where 00 represents full abduction.

**Figure 1.** Schematic representative for shoulder rotational strength test

### Shoulder Range of Motion (ROM)

Measurements of internal and external rotation were actively performed by experienced physiotherapists using a universal goniometer. The measurements were taken in the supine position with the shoulder in 90 degrees of abduction and the elbow in flexion. During the measurement, care was taken to ensure that the test subjects wore clothing that did not restrict their movements.

### Shuttlecock Velocity

The peak velocity of the shuttlecock was recorded by radar gun (Pocket Radar, Inc. Santa Rosa, California, USA) with an accuracy of ±2 km/h. The radar gun was placed directly behind the net. The shuttlecocks were fed in by the coaches of the national teams. If the coach did not like the shuttlecock thrown, the shuttlecock was repeated. Each athlete had to perform 5 repetitions and the best result was recorded. During the measurements, the athletes were asked not to throw the shuttlecock in the direction of the target, but to drop into the field using all their strength.

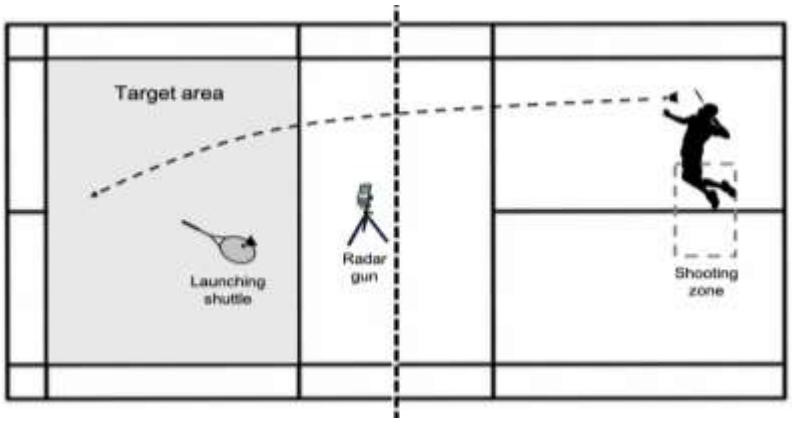


**Figure 2.** The experimental setup for the shuttlecock velocity test

## RESULTS

### Statistical Analyses

The data collected during the study was analyzed using the SPSS (Statistical Package for Social Sciences) program for Windows 22.0. When analyzing the data, the largest value, the smallest value, the arithmetic mean and the standard deviation were used as descriptive statistics. A normality test was carried out for all variables

that were the subject of the study. All variables correspond to the normal distribution at a significance level of alpha=0.05. For this reason, the parametric method of the Pearson correlation test was used for all variables examined.

The demographic data, the isokinetic strength values, the measurements of shoulder joint mobility, the measurements of ball speed and the values of their relationships to each other of the female badminton players who were the subject of the study are shown in tables.

**Table 1. Physical characteristics of females badminton players**

| Variable | n | $\bar{x}$ | sd |
|---|---|---|---|
| Age (year) | 28 | 21,17 | 3,4200 |
| Body weight (kg) | 28 | 62,47 | 8,6014 |
| Height (cm) | 28 | 164,31 | 5,8813 |

**Table 2. Mean and SD of shoulder mobility, strength and shuttlecock velocity**

| Variable | Dominant (Mean ± *SD*) | Non-dominan (Mean ± *SD*) |
|---|---|---|
| *Shoulder ROM* | | |
| IR (degree) | 57.37 ± 7.20 | 52.00 ± 4.92 |
| ER (degree) | 103.00 ± 8.08 | 97.35 ± 7.88 |
| *Shoulder Isokinetic Strength* | | |
| IR strength (Nm) | 37.05 ± 7.12 | 36.95 ± 6.72 |
| ER strength (Nm) | 26.87 ± 7.63 | 22.27 ± 7.60 |
| *Shuttlecock velocity* | | |
| Peak velocity (km/h) | 238.45 ± 3.20 | |

IR = internal rotation range of motion; ER = external rotation range of motion; IR strength = internal rotational strength ; ER strength = external rotational strength.

**Table 3. Correlation values between ROM, isokinetic strength and ball velocity values of female badminton players**

| Variable | | |
|---|---|---|
| | ***r*** | ***p*** |
| IR/ES | 0.372 | 0.182 |
| ER/ IS | 0.083 | 0.762 |
| IS/SV | 0.358 | 0.202 |
| ES/SV | -0.028 | 0.900 |
| IR/SV | 0.097 | 0,725 |
| ER/SV | -0,117 | 0,682 |

IR= internal rotation range of motion; ES=external strength; ER= external rotation range of motion; IS=internal strength; SV= shuttlecock velocity

## DISCUSSION

The aim of the study is to contribute to the literature by investigating the relationship between ball velocity, shoulder mobility and shoulder strength, which have important implications in badminton. In sports science, it is possible for athletes to achieve and maintain their optimal level of performance with properly planned training programs based on scientific data (Macdermid & Stannard, 2012). Considering that smashing accounts for 53.9% of all techniques in badminton (Tong & Hong, 2000), the importance of shoulder strength and movement in badminton becomes clearer. Nowadays, the variables in the game that directly affect success and which skill perfection has the greatest impact on winning are the issues that coaches are most concerned about. When you consider that the average ball velocity of the smash shot recorded in the study is 238.45 km/h, it becomes clear just how important the smash stroke is.

The average age of the female badminton players who are the subjects of this study, which examines the relationship between ball velocity, which directly affects play, and shoulder mobility and shoulder strength in badminton, is 21.17±3.42 years, their body weight is 62.47±8.60 kg and their height is: 164.31±5.88 cm. This seems to be the case.

The isokinetic strength values (Nm) of the badminton players at 60°/sec for the dominant and non-dominant internal and external strength are 37.05 ± 7.12, 36.95 ± 6.72, 26.87 ± 7.63, 22.27 ± 7.60. A look at the literature

shows parallels to the results found in this study. Schmidt et al. (Schmidt et al., 2021) determined dominant and non-dominant values of internal and external isokinetic strength of 54 ± 3.00, 48.00 ± 3.00 and 44.00 ± 3.00, 44.00 ± 3.00, 44.00 ± 3.00 respectively in their study in which they investigated isokinetic force in badminton players at 60°/sec. They determined a value of 00 ± 4.00.

In their study of Swedish female volleyball players, Alfredson et al. (Alfredson et al., 1998) determined dominant external isokinetic strength values of 28.7±6.7 Nm, non-dominant external isokinetic strength values of 29.5±7.3 Nm, dominant internal isokinetic strength values of 28.7±6.7 Nm, and non-dominant internal isokinetic strength values of 40.1±7 Nm and 37.8±9.2 Nm.

When examining the shoulder rotation values of the female badminton players in the study, the dominant internal rotation value was 57.37 ± 7.20, the dominant external rotation value was 103.00 ± 8.08, the non-dominant internal rotation value was 52.00 ± 4.92, and the non-dominant external rotation value was 97.35 ± 7.88. Looking at the literature, the significant excess of external rotation angles over internal rotation angles is also noticeable in these data, which can be observed in the frequently encountered branches with an overhead stop. In the study by Couppé et al. (Couppé et al., 2014), in which they examined the shoulder rotation profiles of elite male and female badminton players, the value of dominant internal rotation was 42.00°±9.00, the value of dominant external rotation was 104.00°±8.00 and the value of non-dominant internal rotation was 42.00°±9.00. The value of non-dominant external rotation was determined to be 51.00°±12.00 and 106.00°±6.00. In their study of male badminton players, King et al. (King et al., 2020) determined a dominant internal and external rotation of the shoulder of 58.7°±12.00 and 102.4°±8.00 respectively. In the study by Forthomme et al. (Forthomme et al., 2005), which examined male volleyball players, the value of the dominant internal shoulder rotation was 47.23°±5.54 and the value of the dominant external shoulder rotation was 103.3°±8.7.

In a study conducted by Herrington (Herrington, 1998) on javelin throwers, it was found that the range of motion of external rotation in the dominant shoulder was greater than the range of motion of internal rotation. Carcia et al (Carcia et al., 2013) reported that this increase in external rotation range developed through repetitive overhead activities. On the other hand, according to Tyler et al. (Tyler et al., 2010) , excessive overhead activities can lead to adaptive changes in shoulder joint mobility and flexibility. These adaptive changes are defined as glenohumeral internal rotation deficit (GIRD), and a restriction of internal rotation is often accompanied by increased external rotation.

If we look at the ball velocity of the badminton players studied after smash stroke, we find that the average ball velocity is 238.45 ± 3.20 km/h. In their study on the biomechanical analysis of overhead shots in badminton, Rusdiana et al. (Rusdiana et al., 2021) determined a ball velocity of 274.00 ± 6.1 km/h after the forehand smash when measuring with the Radar Speed Gun.

When investigating the relationship between shoulder rotations and isokinetic strength values of elite badminton players, a correlation value (r) of 0.083 was determined for the dominant external rotation/dominant internal strength (60°) and a value of 0.372 for the internal rotation/dominant external strength (60°). A linear relationship at the significance level could not be established between the variables.

Correlation values (r) between internal isokinetic strength and shuttlecock speed of female badminton players; while the dominant internal isokinetic strength (60°/sec)/shuttlecock speed was 0.358, the external isokinetic strength (60°/sec) was -0.028; again, no linear relationship at the significance level was found between the variables.

The correlation values (r) between the internal-external rotation and shuttlecock velocity of elite badminton players was 0,097 and -0,117, respectively, but a linear relationship between these variables could not be established at the significance level. In other words, according to the results obtained from the correlation values, an athlete with high strength could not smash faster.

In this study, the relationship between isokinetic strength, shoulder joint flexibility and ball velocity in female badminton players was investigated; when the results were examined based on the research findings, no linear relationship at the significance level was found between isokinetic strength, shoulder joint flexibility and ball

velocity. The literature indicates that there is no statistical significance between isokinetic strength, shoulder joint mobility and ball velocity. Fleck et al. (Fleck et al., 1992) found no statistical significance between isokinetic strength, shoulder rotation and ball velocity in their study of handball players. Although it is assumed that an athlete's smash speed increases to the same extent with a high shoulder internal rotation strength, no statistically linear correlation was found between them.

This could be attributed to other factors during immersion. According to the research, an athlete who only has a high strength score may not be able to smash faster. When examining the literature, factors such as lack of technical components, anxiety, self-confidence, motivation and athletic age are found to affect smash and ball speed in badminton (Akarçeşme et al., 2004; Yarımkaya, 2013).

Studies have shown a negative correlation between excessive shoulder flexibility and strength (Beach et al., 1992; Şahin, 2010). According to the results of this study, an athlete with high external and internal shoulder mobility and thus a flexible shoulder joint did not generate more internal isokinetic strength. Although a very low correlation was found between shoulder mobility, isokinetic strength and ball velocity parameters, it was not found to be statistically significant. This does not mean that external rotation is particularly unimportant. Sufficient joint range of motion allows the shoulder to move with the correct biomechanics to hit the ball with maximum efficiency during the smash stroke. It is also possible that the athlete's performance will increase if the ball is hit correctly. Internal rotation can ensure that the follow-through phase after the ball is longer and that power is better distributed.

In badminton, around 80% of the ball velocity can be explained by the acceleration of the racket. The results showed that ball velocity is not directly related to arm strength and that athletes with a greater range of motion of the shoulder cannot smash faster. In other words, the statistical correlation test showed that ball velocity did not increase in the same direction with increasing strength and joint mobility. For a fast smash in badminton, it is extremely important how fast the forearm moves with supination and pronation movements and how fast the racket hits the ball (Kiang et al., 2009). When studying the stroke mechanics of elite badminton players, it is found that the forearm contracts rapidly during the eccentric phase of the movement (excessive forearm supination), followed by a rapid concentric movement (forearm pronation). This rapid sequence creates a stretch-shortening cycle that increases the efficiency of strength production (Kwan et al., 2011). In other words, it is more important how fast the arm moves than how strong it is.

## CONCLUSIONS

As a conclusion, upon the investigation of the correlation values between isokinetic strength, shoulder joint mobility and ball velocity at elite female badminton players, a statistically direct relation was not found between them at the level of $\alpha = 0.05$ significance.

With this in mind, it would not be wrong for badminton coaches to consider other parameters for an effective smash instead of focusing only on the athletes' strength characteristics. It is assumed that the smash stroke technique in particular has a major influence on the velocity of the ball.

## LIMITATION

When interpreting the study results and the reason why our hypotheses could not be verified, the following limitations must be taken into account. The lack of familiarization may affect the results of the shoulder rotation strength test, and it is also important to consider the strength of other joints, including the trunk, forearm, and wrist, as they may have an effect on shuttlecock velocity. Although the ball throws are performed by an experienced badminton coach, the lack of a standard piece of equipment such as a ball throwing machine may affect players' maximum shuttlecock throwing speed. Finally, the fact that the study was conducted at a single point in time could be the reason why the correlations were not significant. It is necessary to observe the players' stroke velocities during different training sessions and real-time competitions.

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