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The Analysis of Shuttlecock Velocity of Indonesia Home Industry Products Based on the Field Test Method

Ucup Yusup[1]*, Agus Rusdiana[2]

[1]Prodi Pendidikan Kepelatihan Olahraga, Universitas Pendidikan Indonesia
[2]Prodi Ilmu Keolahragaan, Universitas Pendidikan Indonesia

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Abstract

One of the main components of badminton games is shuttlecock. The shuttlecock home industries in Indonesia mainly employ for about 20-40 freelance workers. The workers in the home industries are able to produce 500-100 slops of shuttlecock daily. The guarantee of the shuttlecock quality produced by home industries, either through the laboratory tests or field tests, is rarely conducted formally. Therefore, we are interested in conducting an academic study on the velocity of the shuttlecocks produced by the workers of the shuttlecock home industries that have been distributed in Indonesia markets. There are eight widely distributed shuttlecock brands produced by the home industries in Indonesia, including Taiso, Saporate, Netra, Arjuna, Kuda Mas, Rivals, Purnama, and Spin. The purpose of this study was to examine the quality of aerodynamics rate of the shuttlecock produced by home industries by comparing the rate of motion of the shuttlecock in different distances started from the initial velocity to the final velocity when the shuttlecocks impact to the ground. The method used in this study was a descriptive qualitative study. The instruments used were three high resolution handy cams, a set of calibration, and the 3D motion analysis system software (Frame Diaz IV). The result of this study showed that the average velocity of the shuttlecock, started from the initial velocity to the final velocity with 5 meter distance, reached 85.0 m/s., while the average final velocity reached 29.8m/s at 5 meter distance. From all of the shuttlecock types tested in the field test for their velocity, it was found that the Spin brand moved with a high velocity with 12.8% of percentage. Meanwhile, the lowest velocity of the shuttlecock was found in the Taiso brand where the percentage was 15.3% in 9 meter and12 meter distances. The study concludes that the average of various shuttlecock brands' speeds are in the normal category except for the Taiso and Spin brands.

✉ Correspondence Address : Jln. Dr. Setiabudhi 229. Bandung. Indonesia
E-mail : ucuppkofpok@gmail.com

INTRODUCTION

Shuttlecock production has been widely spread in different cities in East and Central Java in Indonesia. Some cities become the centers of the shuttlecock production, including Solo, Nganjuk, Lamongan, Surabaya, Sidoarjo, and Malang. Unlike Tegal, Solo has been known for the production of quill shuttlecock. Meanwhile, Tegal and other cities produce shuttlecock from goose feather which is the international standard material of shuttlecock. Badminton game is widely known as the most popular sport in Indonesia. Through this sport, Indonesia achieves the popularity in International level through the championship the athletes won over other countries. For instance, the badminton club started from the amateur to professional are growing in almost every city. One of the main components of the badminton game is shuttlecock. As a popular game in society, the demand of the shuttlecock will keep growing since the nature of shuttlecock as a disposable material (Rusdiana & Mustari, 2017).

The Sport Science Study Program is a non-educational study program under The Faculty of Sport and Health, Universitas Pendidikan Indonesia. The learning outcome of the study concerns on the understanding of the sciences of sport and the precise mastery and application of the science and technology, especially in sport. Moreover, they are required to be able to comprehend the basic concept and theory of a set of supporting disciplines that focus on the natural science in supporting and understanding the sport phenomena in society. In addition, the graduates are demanded to be able to develop a special expertise in sport to improve the health degree of human as a whole through human resource development by activity.

Therefore, the development of academic culture, the development of the relevance and competitiveness of the curriculum, the improvement of the internationally representative sport science laboratory, and the improvement of the lecturers' competences, as the result of the strong demand of the ability in communicating science and technology through international language, become the main focus in developing the Study Program nowadays. The result of research published in an indexed international journal with a good reputation are significantly escalating. However, the impacts of the result of the study for the society are still limited. Therefore, this article is expected to give beneficial impacts for the coach knowledge and athletes in the field. The result of the study was the discovery of a new method in analyzing the shuttlecock aerodynamics. Besides that, by the implementation of the method, analyzing the shuttlecock products that have been widely used in the formal international tournament and the new product from nylon and plastics is becoming probable. The problems of the shuttlecock production in home industry level include:

The production of shuttlecock in Indonesia, especially in Surakarta city, is still conducted traditionally. The scientific test for the products related to the aerodynamics characteristics of the shuttlecocks is rarely taken.

The coordination and the collaboration between universities and industries is still need improvement.

The quality of the home industry shuttlecock product requires improvement to meet the requirement of the formal tournament in both national and international, gradually and continuously.

MATERIAL AND METHODS

The method employed in the society service based on the result of this research was a descriptive qualitative study. Several brands and types of shuttlecock will be tested by comparing them with tested shuttlecocks that have been widely used in international tournaments. The participants of this research consisted of 12 university badminton players who had a sufficient overhead smash technique skill. Each player did the smash for 10 times with different shuttlecock where the schedule was adjusted with the player's time of recovery. The instruments used in the study were three 3 high resolution handycams, a set of calibration, and the 3D motion analysis system software (Frame Diaz IV). Meanwhile, the analysis of research indicators implemented in this study are as follows:

a) The Initial Velocity Analysis

In this analysis phase, at the time right after the contact between the racket and shuttlecock happens, the velocity was measured through the regression analysis approach (Rusdiana & Mustari, 2017).

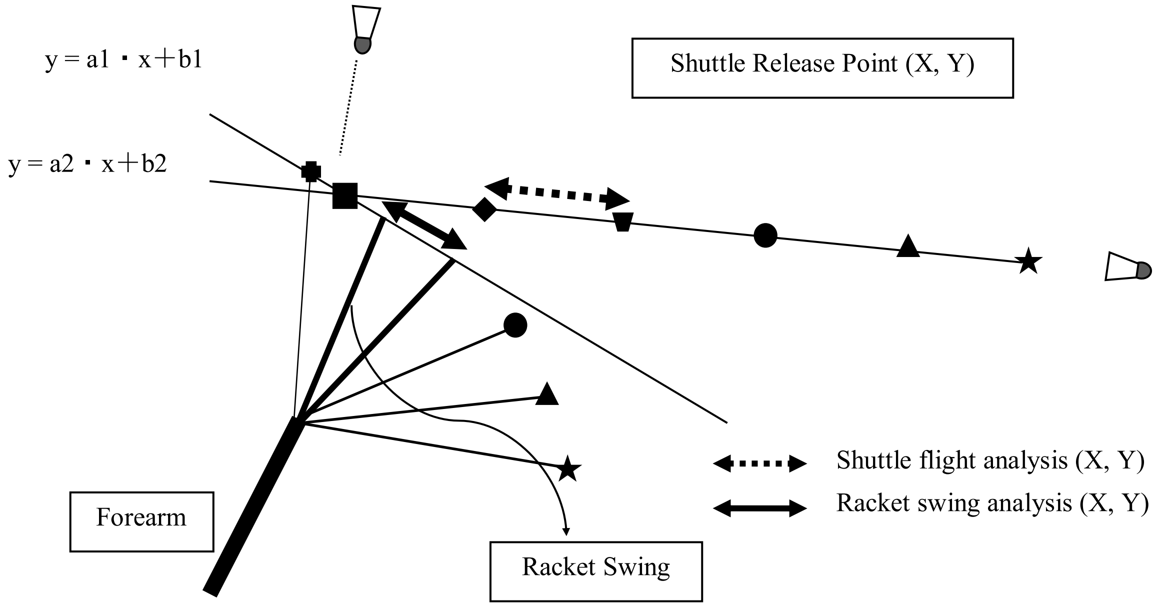


Figure 1. The formula to compute the initial velocity of the shuttlecock in the black colored box is the shuttlecock release point. The dashed line is the rate of the shutllecock after the impact point, while the straight line is the rate of the racket.

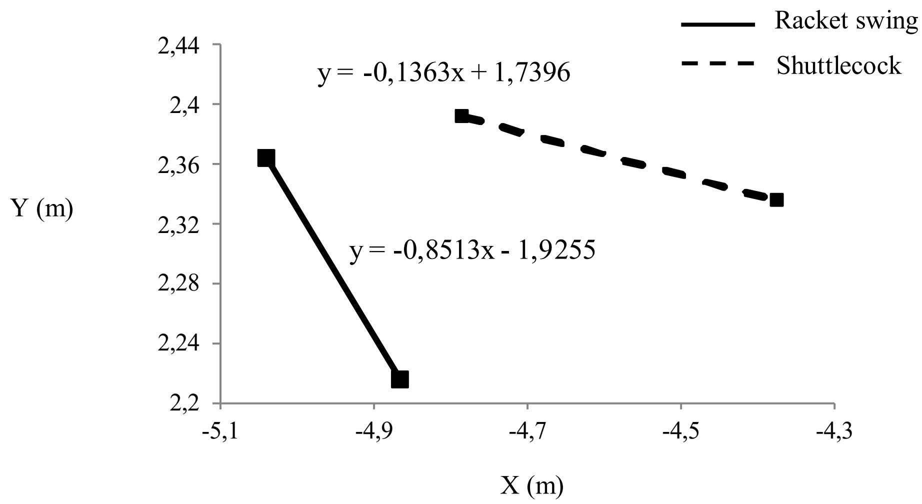


Figure 2. The formula to decide the point of the initial velocity of the shuttlecock during smash

The The explanation of the two Figures above, assisted by statistical least-square method, the equation of the straight line with the symbol (⟷) for the shuttlecock and (⇠⇢) for the racket are as follows:

$$y_1 = (a_1)x_1 + (b_1) \quad 1$$

$$y_2 = (a_2)x_2 + (b_2) \quad 2$$

The number 1 is the representation of the shuttlecock position and number 2 is the racket position. The position of the object – 1 (shuttlecock) can be mathematically stated as follow:

$$x_1(t) = -\frac{1}{2}a_{1x}t^2 + v_{1x}t + x_1(0) \quad 3$$

$$y_1(t) = -\frac{1}{2}a_{1y}t^2 + v_{1y}t + y_1(0) \quad 4$$

$$x_2(t) = -\frac{1}{2}a_{2x}t^2 + v_{2x}t + x_2(0) \quad 5$$

$$y_2(t) = -\frac{1}{2}a_{2y}t^2 + v_{2y}t + y_2(0) \quad 6$$

The impact time between the racket and the shuttlecock can be assumed with t = 0 s with the assumption that the acceleration of each material is zero, thus the equation above will change into (Jian-she, 2018):

$$x_1(t) = v_{1x}t + x_1(0) \quad 7$$

$$y_1(t) = v_{1y}t + y_1(0) \quad 8$$

$$x_2(t) = v_{2x}t + x_2(0) \quad 9$$

$$y_2(t) = v_{2y}t + y_2(0) \quad 10$$

Substitute t between equation 7 and 8 and between equation 9 and 10, the result are the equations below :

$$y_1(t) = \left(\frac{v_{1y}}{v_{1x}}\right)x_1(t) + \left(y_1(0) - x_1(0)\left(\frac{v_{1y}}{v_{1x}}\right)\right) \quad 11$$

$$y_2(t) = \left(\frac{v_{2y}}{v_{2x}}\right)x_2(t) + \left(y_2(0) - x_2(0)\left(\frac{v_{2y}}{v_{2x}}\right)\right) \quad 12$$

By using the data of the racket and shuttlecock position in a period of time, t, the value of m1, b1, m2, and b2 are obtained. Therefore, the equation for the dashed line as shown is Figure 4 is gained (Bankosz, Nawara, & Ociepa, 2013). By finding out the intersection of both lines, the intersections of both lines are discovered, including the point of impact between the racket and the shuttlecock namely point that are equal to , since both of the materials, racket and shuttlecock, are in the same point at t = 0 s namely point P (Chan & Rossmann, 2012).

Since

$$x_1(0) = x_2(0) = x(0) \;;\; y_1(0) = y_2(0) = y(0)$$

Thus

$$a_1 = \left(\frac{v_{1y}}{v_{1x}}\right) \;;\; a_2 = \left(\frac{v_{2y}}{v_{2x}}\right)$$

$$b_1 = \left(y(0) - x(0)\left(\frac{v_{1y}}{v_{1x}}\right)\right) \;;\; b_2 = \left(y(0) - x(0)\left(\frac{v_{2y}}{v_{2x}}\right)\right)$$

The results are 4 equations with 4 unknown parameters, they are :

$$V_{1x}, V_{1y}, V_{2x}, dan\ V_{2y}$$

Hence, those four parameters are gained which explained that the velocity of the racket and shuttlecock at t = 0 s at P point can be found (Dong, Lyu, Hart, & Zhu, 2018).

b) Final Velocity Analysis

The final velocity of the shuttlecock is one of the analysis parameters to examine the motion quality of the shuttlecock. To find out the final velocity of the shuttlecock, the slow motion high speed camera that could reach 1000 fps was used (Le Personnic, Alam, Le Gendre, Chowdhury, & Subic, 2011).

c) Deceleration of Shuttlecock Analysis

The analysis of deceleration is the subtraction of the final velocity subtracted by the initial velocity of the shuttlecock. The shuttlecock made from plastics has a tendency to have a high velocity compared to the shuttlecock made from feather (Cao, Qiu, Zhang, & Shi, 2014).

d) Drug Force Shuttlecock

The analysis of the drug force is a force component that is parallel with the direction of wind. The lift is a force that is perpendicular to the direction of wind. For the wind energy, the lift is used more than the thrust (Lin, Chua, & Yeo, 2013).

e) Shuttlecock Trajectory Analysis

One of the most important aspects in the shuttlecock motion is the data that describe the trajectory and velocity of the shuttlecock (Cao et al., 2014). There are some techniques that can be used to obtain the data, one of those is by using the image processing technique, such as videography or optoelektronics (Alam, Chowdhury, Theppadungporn, & Subic, 2010). The problem that occurred during developing the system was that in the reality, the shuttlecock moves in a 3 dimension media, while the camera only captures the two dimension picture. Therefore, the epipolar geometry stereo vision method which is optimized by the Kalman filter based camshift algorithm was employed (Bankosz et al., 2013).

Figure 3. The brands of home industry shuttlecock (1.Taiso, 2. Saporate, 3. Netra, 4. Arjuna, 5. Kuda Mas, 6. Rivals, 7. Purnama, 8. Spin.)

RESULT AND DISCUSSION

The data describe that the shuttlecock velocity, started from the initial velocity to the final velocity at 5 meter distance, indicates that the average initial velocity reached 85.0 m/s., while the average final velocity reached 29.8m/s at 5 meter distance. From all of the type of shuttlecocks tested at the field related to their velocity, it was found that the Spin shuttlecock moved with a high velocity that reached 37.5%. The shuttlecock with the lowest velocity was the Taiso shuttlecock with 32.5% percentage.

The data obtained from the shuttlecock velocity analysis started from the initial velocity to the final velocity at 9 meter distance depict that the average of the initial velocity reached 85.0 m/s., while the average final velocity reached 11.8m/s at 9 meter distance. From all the type of shuttlecock tested at the field for their velocity, the data indicated that the Spin shuttlecock moved in a high velocity with 12.8% of percentage. Moreover, the lowest velocity of the shuttlecock was found in the Taiso shuttlecock where the percentage reached 15.3%.

Table 2. The result of the initial velocity and the final velocity of various shuttlecocks in 5 meter distance.

Shuttlecock Number	Distance (m)	Time (S)	Initial Velocity (m/s)	Final Velocity (m/s)	Diff. (%)
1	5.0	0.10	92.1	30.1	32.7
2	5.0	0.10	92.1	33.3	36.2
3	5.0	0.12	78.9	26.5	33.6
4	5.0	0.10	88.6	33.2	37.5
5	5.0	0.11	77.9	27.8	35.7
6	5.0	0.10	86.3	31.2	36.2
7	5.0	0.11	75.2	27.6	36.7
8	5.0	0.10	88.9	28.9	32.5
Average	5.0	0.10	85.0	29.8	35.1

Table 1. Size dimension, length, weight, and diameter of the shuttlecocks

	The Characteristics of Various Type and Model of Shuttlecock							
Shuttlecock Dimension	Taiso	Saporete	Netra	Arjuna	Kuda Mas	Rivals	Purnama	Spin
Skirt diameter, d (mm)	66	65	66	64	66	65	65	66
Length of shuttlecock, H (mm)	89	87	88	87	87	88	86	88
Cork diameter, dn (mm)	27	26	28	27	27	26	27	27
Length of cork, I (mm)	26	28	27	28	27	28	27	27
Mass, m (gram)	5	5	5	5	5	5	5	5

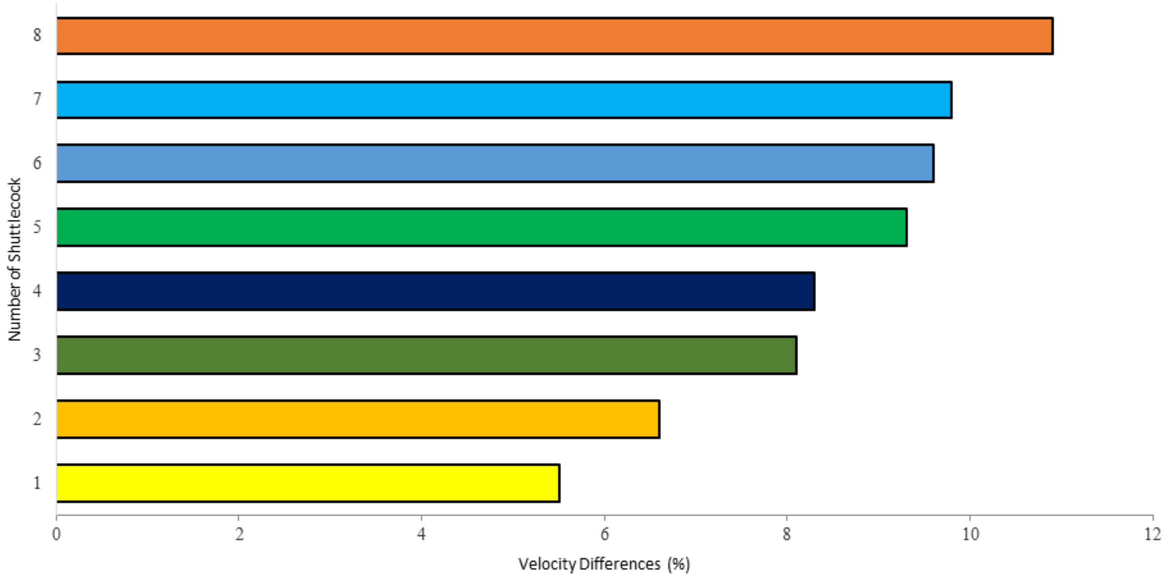
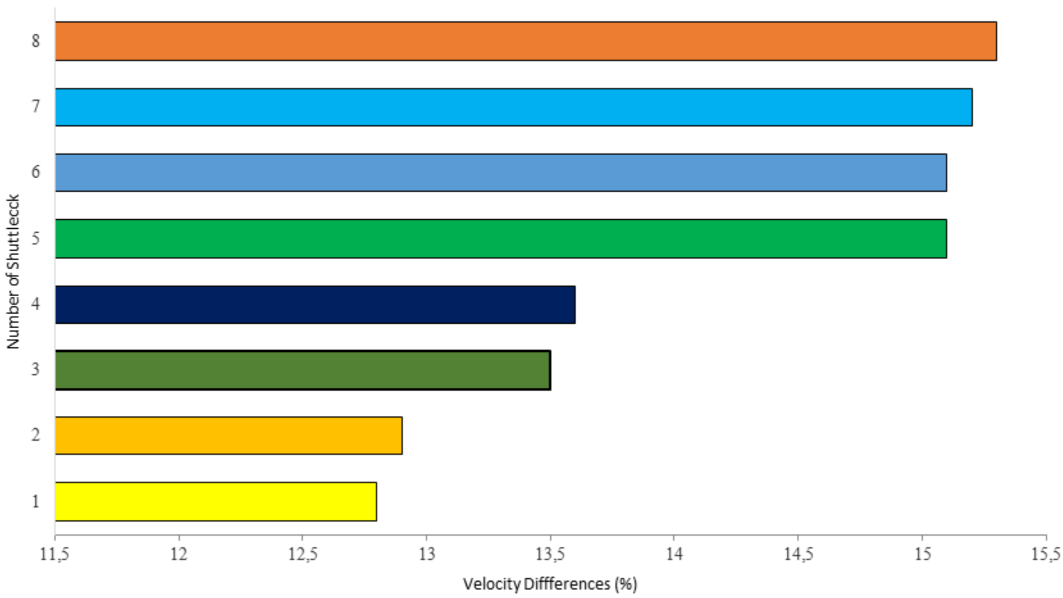


Table 3. The result of the initial velocity and the final velocity at 9 meter distance

Shuttlecock Number	Distance (m)	Time (sec)	Initial Velocity (m/s)	Final Velocity (m/s)	Differences (%)
1	9	0.42	92.1	11.8	12.8
2	9	0.37	92.1	12.4	13.5
3	9	0.45	78.9	10.7	13.6
4	9	0.36	88.6	13.6	15.3
5	9	0.40	77.9	11.8	15.1
6	9	0.40	86.3	11.8	15.1
7	9	0.44	75.2	11.1	12.9
8	9	0.40	88.9	11.4	15.2
Average	9	0.40	85.0	11.8	14.2



The data analysis of the average velocity of the shuttlecock started from the initial velocity to the final velocity at 12 meter of distance presents that the average of the initial velocity reached 85.0 m/s., while the average of the final velocity was 7.0m/s. From all of the shuttlecocks tested at the field for their velocity, it was found that the Spin shuttlecock moved with a high velocity where the percentage was 10.9%. Meanwhile, the shuttlecock with the lowest velocity was Taiso shuttlecock with the percentage obtained 5.5%.

CONCLUSION

The field test, by conducting several times of smash, on the home industry shuttlecocks in Indonesia, especially in Java, the study concludes that the velocity of the Taiso shuttlecock (too fast) and the Spin shuttlecock (too slow) has a significant characteristics differences. Meanwhile, the velocity of other brands of the tested shuttlecock, according to the analysis in various distances, are still in the normal category.

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