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3D KINEMATIC ANALYSIS OF STANDING AND JUMPING SMASH TECHNIQUE OF INDONESIAN BADMINTON NATIONAL ELITE ATHLETES

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The lack of sport technology application and experts in sport science is one of the weaknesses that leads to inadquate analysis and research in sports, specifically analyses of badminton games. This problem contributes to a significant decrease in the performance of Indonesian badminton teams when competing in international games. The purpose of this research is to measure the maximum velocity of a shuttlecock in smash techniques and to analyse the characteristics of the mechanics of smash techniques, mainly the upper limb joint movements. The research subjects were 6 Indonesian Badminton Association athletes that included: Greysia Polli and Meiliana Jauhari (women's double) Ricky Karanda and Marcus Fernaldi (men's double) and Irfan Fadilah and Weni Anggraeni (mixed double). The velocity of the shuttlecock and the sequence of smash techniques were captured using a digital video camera and motion analysis system software (FRAME Dias IV, Japan). The final result showed that the velocity of the shuttlecock in jumping smash is higher than in standing smash. The angular velocity of the shoulder joint in internal-externalshoulder rotation, the flexion-extension wrist rotation, and the forearm joint in supination-pronation movement gave a significant contribution to the velocity and momentum of the shuttlecock.

Keywords: biomechanics analysis, overhead smash, shuttlecockvelocity, elite athletes

INTRODUCTION

Technological advances, specifically in sports, are integral to the improvement of the study and performance of athletes in this modern time. In developed countries, sport science laboratories have been built and equipped with high-tech testing and measurement tools, supported by experts. In the laboratory, experts from various sport fields cooperate and collaborate to diagnose, analyse, evaluate and give knowledge to trainers and athletes of their weaknesses and abilities. They also give information about the opponents so the athletes can achieve more. Sport science covers different aspects of analysis, such as coaching, games analysis, sport nutrition, sport and exercise physiology and psychology, mental training and sport biomechanics/human movement analysis. In East Asia, mainly in Japan, China and South Korea, they have built this kind of laboratory and in Japan they named it JISS (Japan Institute of Sport Science) in 2002.In Australia there is the AISS (Australia Institute of Sport Science), KISS (Korea Institute of Spot Science) in South Korea, BISS (Beijing Institute of Sport Science) and many others. It is not surprising then if the development of sports in these East Asian countries is more advanced than other Asian countries. The real significant achievement was when

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China collected the most medals in the 2008 Beijing Summer Olympics, beating the United States, Russia and Germany that usually dominated the competition. Other Asian countries, such as South Korea and Japan, were in the top five.

The loss of the Indonesian Thomas and Uber teams against the Japanese teams has marked a new point in the decreasing performance of Indonesian badminton teams, taking away the chance to get into the semi-final. Previously, Indonesian teams had always achieved good results. There are many factors surrounding this problem, and one of them is the slow process of regeneration in coaching young athletes, which then creates a major achievement gap between senior and junior players.The very limited infrastructure and facilities, such as badminton courts and other supporting equipment, also affect the development of young athletes, especially those who live in remote areas in Indonesia. Another factor is the lack of application and use of highly-developed modern sport technology. This creates significantly inadequate knowledge in sports, especially among coaches in analysing and evaluating the weaknesses and advantages of the athletes or their opponents. The lack of experts in sport science also contributes to the lack of analysis and research in sports, especially in the case of badminton.

In the game, a smash can be categorised into two types: standing smash and jumping smash. The velocity of the shuttlecock can reach more than 300 km/h. Chinese male doubles player, Fu Haifeng, was recorded to reach the velocity of around 332 km/h when doing a smash during the Sudirman Cup in 2005. It was measured by a radar gun device and was recorded as the world's fastest shuttlecock's velocityrecord (Tsai, 2000). In men's single competition, Indonesia's Taufik Hidayat recorded a shuttlecock velocity of 305 km/h during the 2006 World Tournament. At the end of 2011, Yonex's laboratory did a trial of a new racquet (ArcSaber Z-Slash), tested by elite athlete from Malaysia, Tan Boon Heong. In the trial, a high-velocity video camera with a shutter speed of 20,000 frames per second recorded the shuttlecock velocity of 421 km/h.

PURPOSE

The purpose of this research is to discover the difference between the maximum velocity of a shuttlecock in an overhead forehand smash and jumping smash. Another purpose is to analyse the characteristics of the mechanical sequence of both smash techniques, mainly the upper limb joint angular velocity of the Indonesian Badminton athletes in training.

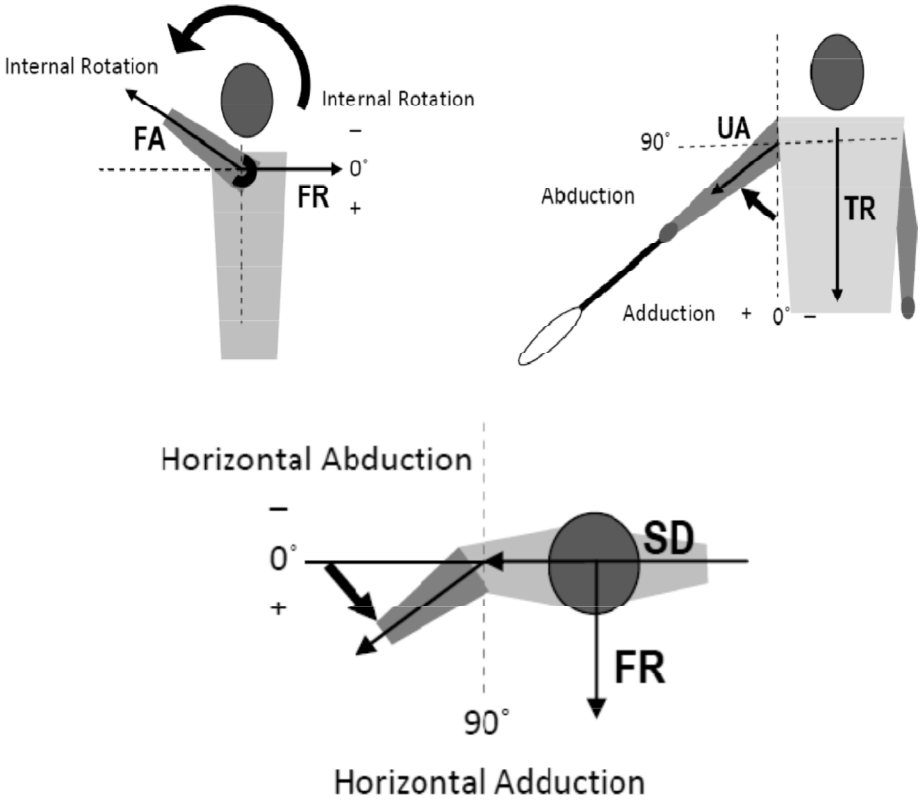
METHOD

The method applied in this research is descriptive qualitative, because the data was only collected once, i.e. for the overhead forehand standing smash and jumping smash. The data was then analysed in order to see the difference level of the shuttlecock's velocity and how dominant factors, such as the shoulder,

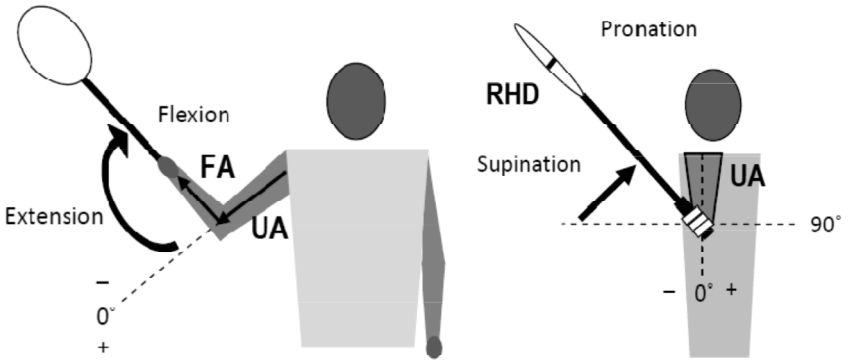
elbow, forearm and pelvis rotation, affect the momentum/velocity of the shuttlecock.

The research subjects were 6 Indonesian badminton athletes in training: Greysia Polli and Meiliana Jauhari (women's double), Ricky Karanda and Marcus Fernaldi (men's double), and Irfan Fadilah and Weni Anggraeni (mixed double). The velocity of a shuttlecock and the sequence of smash techniques were captured using a digital video camera and motion analysis system software (FRAME Dias IV, Japan).

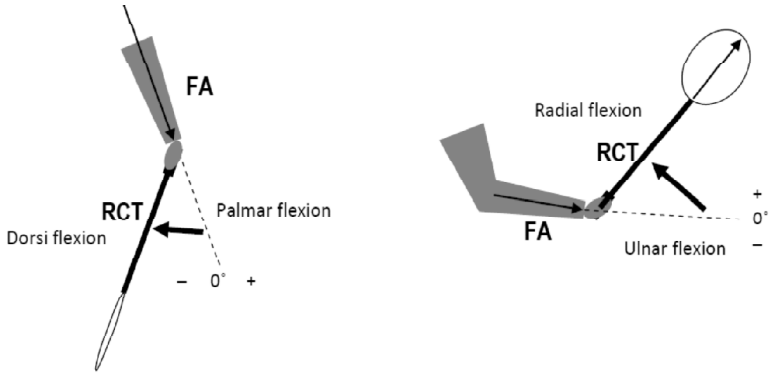
Meanwhile, to discover the characteristics of the mechanics of a smash sequence, a model was made according to the principles of anatomical movements. In the shoulder joint,there are three characteristics of movement, which are: internal and external shoulder rotation, abduction-adduction shoulder movement and horizontal abduction-adduction shoulder movement.



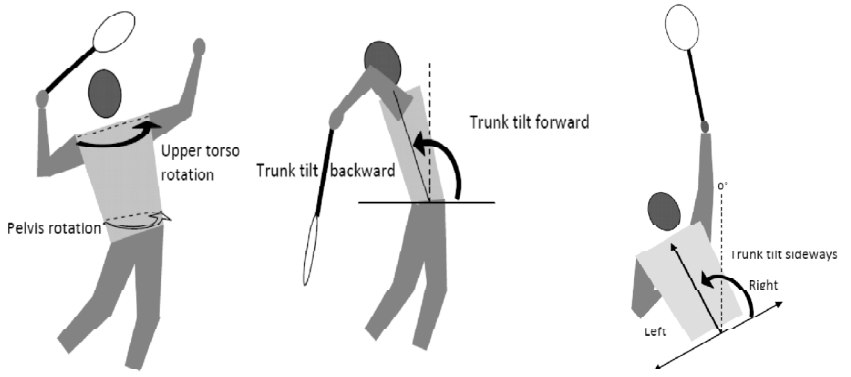
In the elbow joint, there are two characteristics of movement, i.e.: flexion-extension and pronation-supination.



In the wrist joint, there are two characteristics of movement, i.e.: palmar flexion-dorsi flexion and radial flexion-ulnar flexion.



And then there are the upper torso rotation and pelvis rotation, and trunk tilt forward and backward in the hip joint and also trunk tilt left and right sideways.



Picture 1: The characteristics of movements in the upper limb joints

RESULTS

The velocity of shuttlecocks

Based on the results shown in Table 1, there is a significant difference of momentum/ velocity of the shuttlecock during an overhead forehand smash and jumping smash (each was conducted 10 times with maximum strength), especially for Greysia Polii, Ricky Karanda, Marcus Fernaldi and Irfan Fadhilah.

TABLE 1: THE AVERAGE VELOCITY RESULT OF THE SHUTTLECOCK DURING SMASH AND JUMPING SMASH (EACH PARTICIPANT MADE 10 HITS)

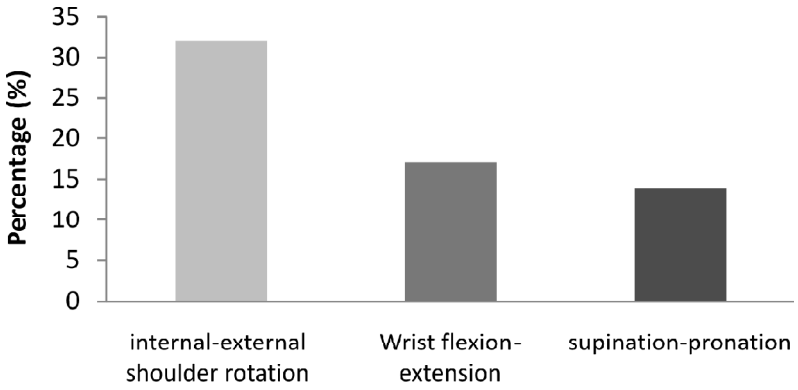
No	*Names*	*Category*	*The velocity of the shuttlecock (m/s)*	
			Smash	*Jump Smash*
1	Greysia Polii	Women's Double	67.2	72.1*
2	Meiliana Jauhari		64.9	67.4
3	Ricky Karanda	Men's Double	79.6	85.7*
4	Marcus Fernaldi		74.3	84.9*
5	Irfan Fadhilah	Mixed Double	76.8	83.2*
6	Weni Anggraeni		61.9	65.5

*significant difference on 0.05 level

The Contribution of the Velocity of the Upper Limb Rotation to the Velocity of the Shuttlecock

Based on the analysis of the shuttlecock's velocity and characteristics of smash techniques, mainly in the upper limb joints, it was found that the dominant movement contributing to the shuttlecock's velocity was the shoulder joint rotation, i.e. the internal-external shoulder rotation, as much as 35%. The flexion-extension wrist joint rotation contributed 17% to the velocity and the pronation-supination wrist joint rotation contributed 14%. More details can be seen in the following table.

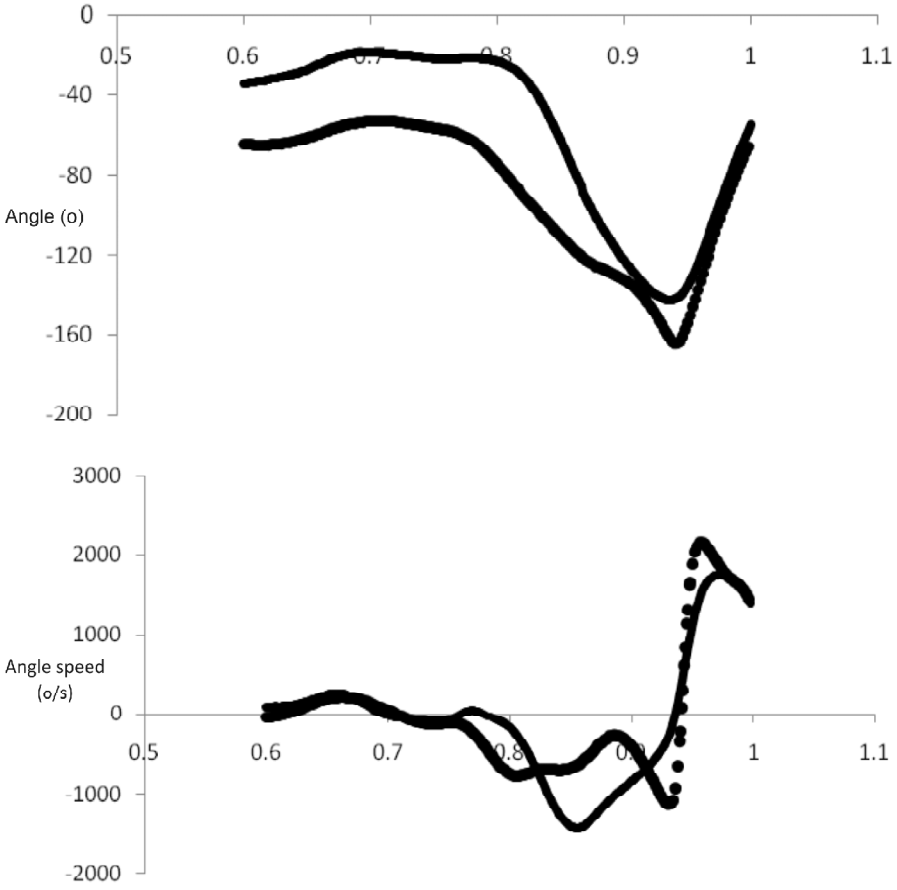
TABLE 2: DOMINANT CONTRIBUTION OF VARIOUS JOINTS' ANGULAR VELOCITY TO THE SHUTTLECOCK'S VELOCITY



ANGULAR VELOCITY OF THE UPPER LIMB JOINTS

Internal-External Shoulder Joint

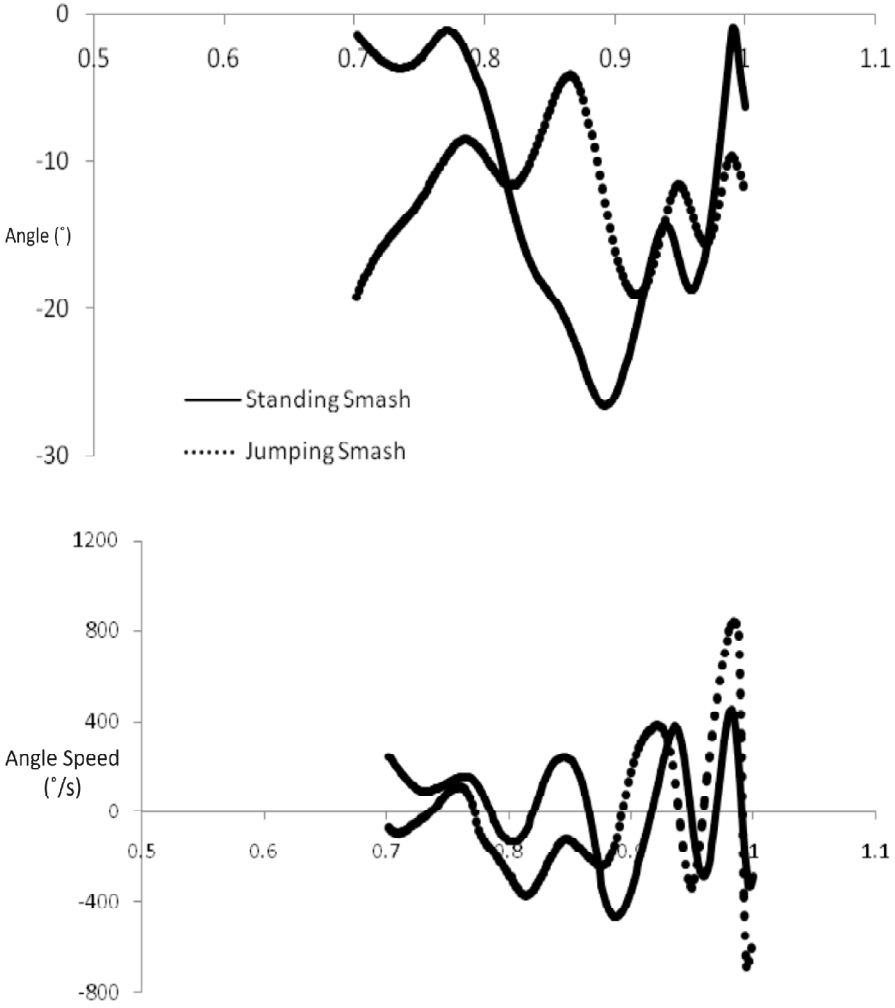
The duration of the overhead standing and jumping smash is around 1 second. The chart below shows the internal and external shoulder joint rotation during both smash techniques.



Picture 2: The change in rotational angle and velocity in the shoulder joint (internal-external angular rotation)

The result shows that there was a significant difference in the maximum angle movement (165^0 vs 134^0) and the velocity of joint rotation (2161^0/s vs 1715^0/s). This result showed that the fast angle change and high velocity shoulder joint rotation in jumping smash technique caused a high momentum's velocity of the shuttlecock.

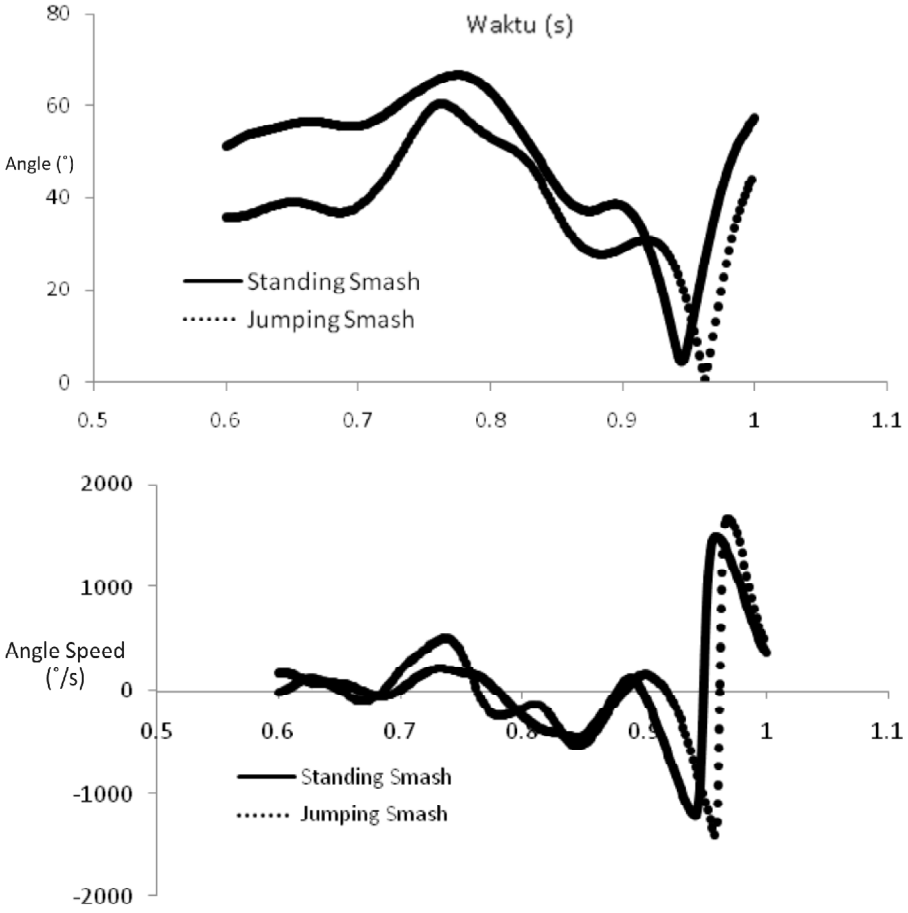
Flexion-Extension Wrist



Picture 3: The change in rotational angle and velocity in the wrist joint (flexion-extension wrist angular rotation)

Based on the picture above, the result showed a significant difference in the change of maximum angle movement (-30^0 vs -18^0) and the velocity of joint rotation (849^0/s vs 536^0/s). This shows that the fast angle change and high velocity wrist joint rotation in jumping smash technique caused a high momentum's velocity of the shuttlecock.

Supination-pronation in forearm joint



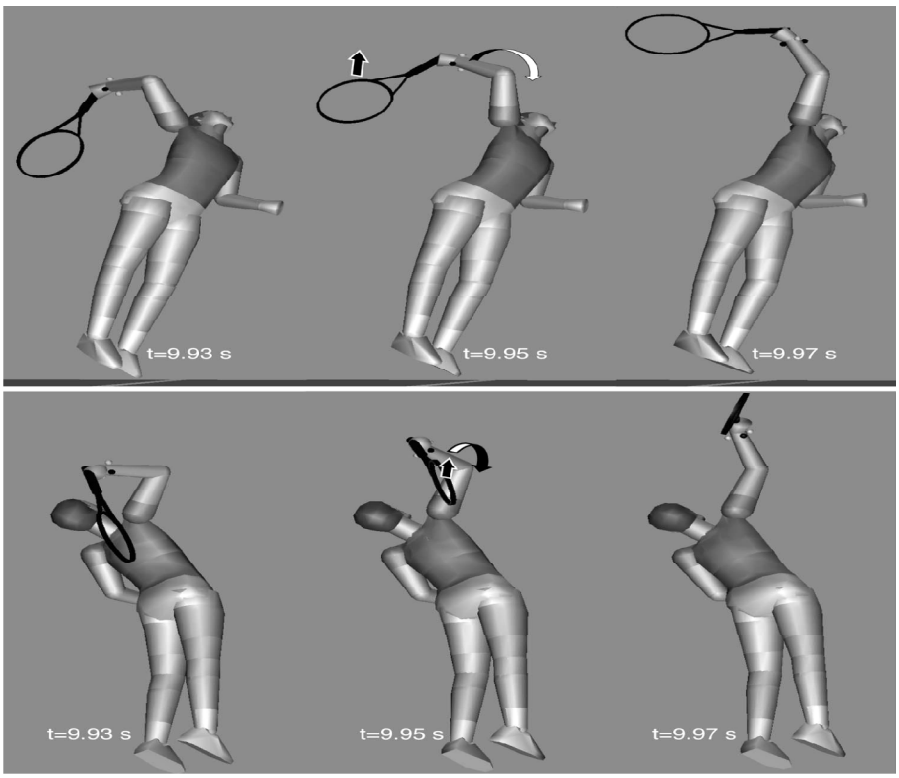
Picture 4: The change in rotational angle and velocity in the forearm joint

Based on the picture above, the result showed a significant difference in the change of maximum angle movement (4^0 vs 2^0) and the velocity of joint rotation (1684^0/s vs 1332^0/s). This shows that the fast angle change and high velocity forearm joint rotation in jumping smash technique caused a high momentum's velocity of the shuttlecock.

DISCUSSION

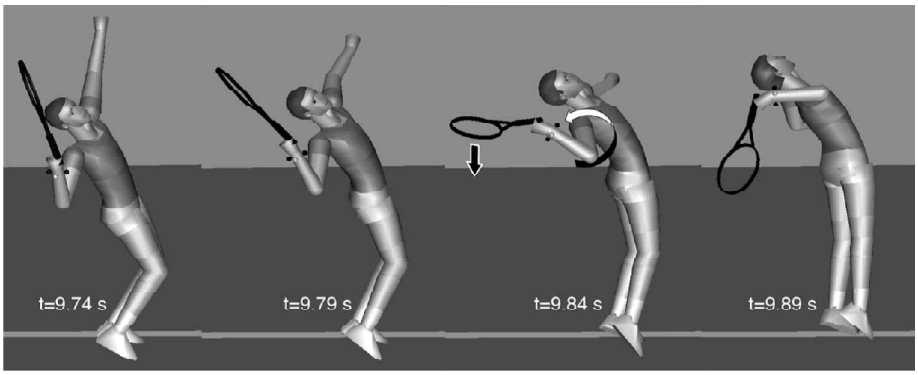
The movement pattern sequence of a smash involves velocity and linear and circular acceleration of the body, shuttlecock and racquet movement. There is very limited research in badminton games that explains the movement of forehand overhead

strokes, mainly the standing and jumping smash. However, according to Brian J.G. (2006), he analysed the contribution of angular velocity of each upper limb in a tennis serve and concluded that the maximal external shoulder rotation is the beginning phase to produce a faster internal shoulder angular velocity that increases the velocity of the tennis ball. This is explained in the images below.

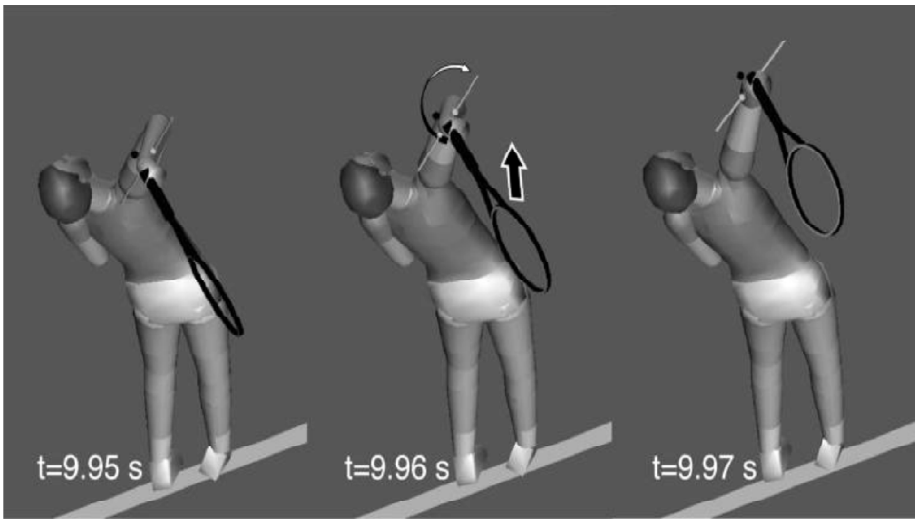


Picture 5: The contribution of maximal external shoulder rotation (Source: Brian J.G., 2006)

The next movement that contributed significantly was the elbow's flexion-extension. The faster this movement goes, especially the extension, the more powerful the upper arm and swing of the racquet forward will be before the impact moment with the shuttlecock. The research results showed that the flexion and extension in the wrist joint reached 40% of the velocity of racquet swing. It means that the faster the flexion movement of the upper arm and racquet goes towards the back side of the body, the stronger the next impulse will be (i.e. the extension movement). Picture 6 illustrates the movement of the flexion and extension elbow joint that contributed to the velocity of the racquet.



Picture 6: Flexion-extension elbow joint movement (Source: Brian J.G., 2006)



Picture 7: Pronation-supination in radio ulnar joint movement long before the impact (Source: Brian J.G., 2006)

CONCLUSION

Based on the results and discussion above, it can be concluded that the velocity of the shuttlecock in a jumping smash is faster than a standing smash. The angular velocity of the shoulder joint in internal-external shoulder rotation, flexion-extension wrist rotation and supination-pronation forearm movement contributed significantly to the momentum/velocity of the shuttlecock.

After further analysis of the data, based on the smash technique characteristics of the 6 players, it was found that, regarding the quality, the smash technique didn't have any significant mistakes in the mechanical sequence of the movement.

Therefore, it is recommended that the athletes are given special weight training for their shoulder joints, especially the internal-external shoulder rotation, flexion-extension wrist rotation and pronation-supination elbow joint movement. The purpose of this weight training is to increase the local muscle endurance and power in the shoulder, elbow and wrist joint. There are several weight training programs adequate for strengthening smash movement characteristics.

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