

นิพนธ์ต้นฉบับ (Original article)

ชีวกลศาสตร์ทางกีฬา (Sports Biomechanics)

**THE VELOCITY OF THE JOINT ROTATION EFFECT TO BALL SPEED IN SEPAKTAKRAW  
SOMERSAULT KICK**

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**ABSTRACT**

As smash skills, the sepaktakraw somersault kick indicated by the angular velocity of any joint rotation, has been being used most and is much more efficient than other skills. The exclusivity of this skill is having a different trunk rotation from others. In addition, the effective ball speed after kicking can occur by leg length. **Objectives:** To study the correlation between angular velocity of the joints rotation in the extremity (trunk, pelvis, hip, knee, and ankle) and the ball speed. To study the contribution of the angular velocity of the joints (trunk, pelvis, hip, knee, and ankle) at ball contract and the ball velocity in the sepaktakraw somersault kick. And to study the correlation between leg length and the ball speed. **Method:** Ten male spike players with experience  $7.2 \pm 2.86$  years competed in the university games of Thailand and Thailand league (age;  $22.5 \pm 2.59$  years, body weight;  $63.8 \pm 5.22$  kg, and height;  $171.5 \pm 3.3$  cm), were recruited in this study. Each participant performing three somersault kicks was allowed to fix individual ball-height position. Three-dimensional system from 10 high resolution video cameras with the frequency of 200 Hz was used to record the data. And Low-pass Butterworth digital filter at a cut-off frequency of 7 Hz was used to smooth data. The statistical significance analysis used Pearson correlation coefficients test set at  $p < 0.05$ . **Results:** There were no significant correlation between the angular velocity of trunks, pelvises, hips, knee, and ankles rotation and ball speed. However, the angular velocity of hip adduction showed significantly negative correlation with ball speed. ( $p = 0.04$ ). The highest angular velocity of the trunk (295.46 deg/s) and the highest angular velocity of the hip (422.17 deg/s) at ball contract affected the maximum ball velocity (19.87 m/s). In addition, the correlation between leg length and ball speed was not found. **Conclusion:** The contribution of the higher angular velocity of multi-joints could produce a greater ball speed in sepaktakraw somersault kick.

**Keywords:** Velocity of the joints / Ball speed / Somersault kicks / Trunk and lower extremity / 3D analysis

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## ความเร็วของการหมุนข้อต่อที่มีผลต่อความเร็วลูกตะกร้อในการเดบแบบเต็มรอบของกีฬาเชป์ตะกร้อ

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### บทคัดย่อ

การทำคะแนนหน้าตาข่ายของเชป์ตะกร้อพบว่ามีการใช้ท่าขัมเมอร์คลื่นหรือการเดบแบบเต็มรอบมากที่สุด ซึ่งเป็นท่าที่มีความเร็วของลูกตะกร้อมากกว่าท่าอื่น เนื่องจากมีความเร็วเชิงมุ่งที่ลูกส่งจากการหมุนของหลายข้อต่อโดยเฉพาะมีการหมุนของลำตัวที่ต่างจากท่าอื่น และยังพบว่าความพยายามของขาอาจจะส่งผลต่อความเร็วของลูก วัตถุประสงค์ของการศึกษา: เพื่อศึกษาความสัมพันธ์ระหว่างความเร็วเชิงมุ่งในการหมุนข้อต่อลำตัว กระดูกเชิงกราน สะโพก หัวเข่า และข้อเท้ากับความเร็วของลูกตะกร้อในการเดบแบบเต็มรอบ เพื่อศึกษาความสัมพันธ์ระหว่างความพยายามข้ากับความเร็วของลูก ในการเดบแบบเต็มรอบ วิธีการดำเนินวิจัย: ผู้เข้าร่วมคือนักกีฬาเชป์ตะกร้อชายระดับมหาวิทยาลัยและระดับไทยแลนด์ ลีกจำนวน 10 คน พบร่างสักกีฬามีประสบการณ์ในการเดบแบบเต็มรอบ  $7.2 \pm 2.86$  ปี อายุ  $22.5 \pm 2.59$  ปี น้ำหนัก  $63.67 \pm 5.22$  กิโลกรัม และส่วนสูง  $172 \pm 3.3$  เซนติเมตร โดยทำการเดบแบบเต็มรอบคนละ 3 ครั้ง บันทึกข้อมูลในรูปแบบ 3 มิติ ด้วยกล้องวิดีโอกับความเร็วสูง 200 ภาพต่อวินาที จำนวน 10 กล้อง โดยข้อมูลได้ถูกนำมาตัดสัญญาณรบกวนโดยใช้ Butterworth digital low-pass filter ที่ 7 Hz และวิเคราะห์ทางสถิติโดยใช้ Pearson correlation coefficients test ที่ระดับความเชื่อมั่น  $p < 0.05$  ผลการศึกษา: ความเร็วเชิงมุ่งของการหมุนของลำตัว กระดูกเชิงกราน สะโพก หัวเข่า และข้อเท้า ไม่มีความสัมพันธ์กับความเร็วของลูกตะกร้อ แต่อย่างไรก็ตามมีเพียงความเร็วในการหุบข้อต่อโพกที่มีความสัมพันธ์ในทางลบกับความเร็วของลูกตะกร้อ ( $p = 0.04$ ) ในด้านความเร็วในการหมุนลำตัวจะระทบบคลื่นค่าสูงสุด 295.46 องศาต่อวินาที ด้านความเร็วในการหมุนข้อต่อสะโพกจะระทบบคลื่นค่าสูงสุด 422.17 องศาต่อวินาที มีผลให้ลูก ตะกร้อที่เตะมีความเร็วสูงสุดเท่ากับ 19.87 เมตรต่อวินาที นอกจากนี้ยังพบว่าความพยายามของขาไม่มีความสัมพันธ์กับ ความเร็วของลูกตะกร้อ ( $p = 0.47$ ) สรุปผลการศึกษา: ความเร็วเชิงมุ่งของการหมุนของข้อต่อเดียวๆ ไม่มีผลต่อความเร็ว ของลูกตะกร้อ ทั้งนี้ต้องอาศัยความเร็วในการหมุนของข้อต่อร่วมกันหลายๆ ข้อต่อที่เพิ่มมากขึ้นจึงส่งผลให้ความเร็วของลูก ตะกร้อในการเดบแบบเต็มรอบเพิ่มขึ้น

**คำสำคัญ :** ความเร็วในการหมุนของข้อต่อ/ ความเร็วบล็อก/ การเดบแบบเต็มรอบ/ ลำตัวและรยางค์ส่วนล่าง/ การวิเคราะห์แบบ 3 มิติ

## INTRODUCTION

Three main skills require using as basic technics in sepaktakraw such as serving, setting, and smash. From these skills, the smash is the skill which makes a score most consisted of many types including sunback, half-roll spike, and somersault kick. The sepaktakraw somersault kick has been used most due to all of smash skills. From previous evidence revealed that the sepaktakraw somersault kick skill is more effective than other skills<sup>24</sup>. The technic of the sepaktakraw somersault kick performs similarly to acrobatic activation which has to gesticulate in the air<sup>5</sup>. Exclusivity of this skill, the subject performs higher trunk rotation which led to the contribution of many joints rotation in the sepaktakraw somersault kick players.

The contribution of the joint rotation is considered by the angular velocity of many joints.<sup>17</sup> Smash is one of sepaktakraw skill using the contribution of angular velocity of the joints, which includes the angular velocity of trunk, pelvis, hip, knee, and ankle.<sup>14</sup> In addition; the effective ball speed is involved with leg length. The previous study recommended that the sepaktakraw players can do somersault kick effectively, due to having the kinematics components including the leg length and leg muscle power, the speed of body rotation, body height, leg flexibility and ability.<sup>5</sup> The linear velocity determines as kicking (e.g. radius is length of the legs, linear velocity is speed for foot, angular velocity is the angular velocity of the joints). If the angular velocity is constant, the speed of foot is varied with length of legs affected on the ball speed.<sup>16</sup>

The sepaktakraw somersault kick is the motion which use in several country especially in competition games. There are limited researches of sepaktakraw somersault kick, especially in the major of biomechanics. The pilot study does not explain the variables of kinematics which affect the ball speed in doing the sepaktakraw somersault kick. In this study the researcher focused on the kinematics 3D of trunk and lower extremities including pelvis, thigh, shank, and foot, as doing the sepaktakraw somersault kick related with the ball speed.

## OBJECTIVES

To study the correlation between the angular velocity of the joints rotation extremity (trunk, pelvis, hip, knee, and ankle) and the ball speed in the sepaktakraw somersault kick.

To study the contribution of the angular velocity of the joints at contact ball including trunk and lower extremity (pelvis, hip, knee, and ankle) affects the ball speed in the sepaktakraw somersault kick.

To study the correlation between leg length and the ball speed in the sepaktakraw somersault kick.

## METHODS

### Subjects

Ten male spike players with experience  $7.2 \pm 2.86$  years competed in the university games of Thailand and Thailand league (age;  $22.5 \pm 2.59$  years, body weight;  $63.8 \pm 5.22$  kg, and height;  $171.5 \pm 3.3$  cm), were recruited in this study

### Experimental Procedure

All subjects signed an informed consent form before measuring anthropometry, and marking of landmark for marker placement. Then all subjects wore sepaktakraw shoes and black bodysuit which is no reflective materials. The general characteristics of the subjects consisted of height and body weight. All subjects were asked to warm up for approximately 12 minutes including dynamic stretching for 5 minutes and static stretching for 7 minutes. Subjects' physical performance test as follows: leg strength with Back & Leg dynamometer, vertical jump with video cameras (BTS Smart DX 500 systems), and leg's flexibility (sit and reach) with Multi-box. Then each subject is placed the retro reflective markers at 44 sites of the body (Figure 1), accorded by the LJMU lower limb and trunk model on anatomical landmark where made before.



Figure 1: Reflective marker 44 sites

Recording the static trial is followed by performing subjects' anatomical position by standing on the center of the volume. Recording left-right functional hip joint is followed by performing subjects' hip flexion and external rotation which the hip joint has a range of motion (approximately 45 degrees) at least 5 cycles (1 second per cycle). Recording left-right functional knee joint is followed by performing subjects' knee flexion which the knee joint goes through its full range of motion (approximately 90 degrees) at least 5 cycles (1 second per cycle). Due to these subjects' performing was transferred from the placed marker position to the center of the joints. Then the subjects performed Somersault kick for 2 minutes in order to produce the familiar and determine the position of a ball height, recording dynamic trial was followed by performing subjects' somersault kick. A ball height was defined by his performance, where they can perform potentially. We measured a ball height before data collection by each subject performed somersault kick with their defined ball height in amounts of 3 times. The data was used by the best performing.

### Data Processing

Low-pass Butterworth digital filter at a cut-off frequency of 7 Hz was used to smooth data. The statistical significance analysis used Pearson correlation coefficients test set at  $p < 0.05$ .

The ball speed was calculated using vector equation. The two reflective markers of ball were calculated the center (between with two reflective markers). We calculate the ball speed by speed formula and formula of locating points in space. Speed divides a distance of movement by the movement time.<sup>20</sup>

$$\text{The ball speed} = \sqrt{\left\{ \frac{(x_2 - x_1)}{t} \right\}^2 + \left\{ \frac{(y_2 - y_1)}{t} \right\}^2 + \left\{ \frac{(z_2 - z_1)}{t} \right\}^2}$$

### Statistical Analysis

The SPSS for Windows (Version 17.0, Chicago, IL, USA) used for all statistical procedure. Shapiro-Wilk test used testing of normal distribution of the data. The data is normal distribution use Pearson correlation coefficients test relationship between leg length extremity and speed ball, and angular velocity of joints and ball speed. Significant level was set at  $p < 0.05$ .

## RESULTS

The study showed the highest angular velocity of joints acted by knee extension ( $1368.3 \pm 159.97$ ) and the mean of ball speed ( $17.393 \pm 2.357$ ) (Table 1). However, the correlation between the angular velocity of almost all joints and ball speed had not found. There was only the correlation between the angular velocity of hip adduction and ball speed that showed negative significance.

The values of the maximum angular velocity of the joints and the peck percentage of spike time at contact ball were found in different subjects (Table 2). S2 found at trunk and hip relation was 295.46 deg/s, 422.17 deg/s and 37.23%, 71.28%, respectively. S3 found at pelvis relation was 235.73 deg/s and 79.35 %. S1 found at knee relation was 1558.33 deg/s and 97.80 %. And S6 found at ankle relation was at 575.86 deg/s and 100 %. Therefore, the maximum angular velocity of trunk and hip rotation affected the maximum ball speed (19.87 m/s) showed in S2.

Dominant leg length of the subjects was  $1.166 \pm 0.027$ m (Table3). When found the correlation between dominant leg length and ball speed, it did not show the correlation.

Table 1: Test correlation between the angular velocity of the joints and ball speed

Angular velocity of joints (mean $\pm$ SD)		Ball speed (mean $\pm$ SD)	P-value	Correlation
Trunk posterior rotation (deg/s)	424.28 $\pm$ 46.36	17.393 $\pm$ 2.357 (m/s)	0.172	0.335
Trunk right transverse rotation (deg/s)	289.47 $\pm$ 73.11		0.146	-0.371
Pelvis posterior rotation (deg/s)	239.78 $\pm$ 142.35		0.151	-0.363
Pelvis right transverse rotation (deg/s)	323.37 $\pm$ 60.03		0.069	0.503
Hip flexion (deg/s)	356.55 $\pm$ 138.37		0.245	-0.248
Hip internal rotation (deg/s)	295.34 $\pm$ 97.84		0.143	-0.375
Hip adduction (deg/s)	301.43 $\pm$ 90.93		0.038*	-0.585
Knee extension (deg/s)	1368.3 $\pm$ 159.97		0.32	-0.17
Ankle dorsiflexion (deg/s)	343.37 $\pm$ 76.51		0.348	-0.142

\*Significant correlation between angular velocity of joints and ball speed ( $p < 0.05$ ).

Table 2: The contribution of the angular velocity of the joints at ball contact and ball velocity presented in each subject

Subject	Angular velocity of contract (deg/s)					Ball velocity (m/s)
	Trunk	Pelvis	Hip	Knee	Ankle	
S1	233.47 (24.18)	223.1 (87.91)	221.57 (59.15)	1558.33* (97.80)	303.61 (100)	19.26
S2	295.46* (37.23)	216.75 (78.72)	422.17* (71.28)	1274.41 (95.75)	378.92 (100)	19.87*
S3	120.38 (29.35)	235.73* (79.35)	266.51 (68.48)	1368.29 (95.65)	171.94 (100)	18.54
S4	200.58 (40.71)	161.61 (81.42)	336.24 (75.22)	970.50 (94.69)	160.85 (97.35)	16.31
S5	140.57 (34.44)	138.47 (74.44)	373.40 (65.56)	1154.01 (93.33)	536.05 (100)	16.04
S6	186.91 (34.31)	156.90 (80.39)	240.31 (68.63)	957.41 (95.1)	575.86* (100)	18.59
S7	165.15 (33.68)	155.96 (80)	97.56 (71.58)	1072.03 (95.79)	304.68 (100)	18.33
S8	178.22 (50.44)	150.03 (82.3)	250.94 (82.3)	1184.17 (95.58)	359.42 (100)	12.43
S9	50.67 (33.7)	178.33 (73.91)	201.79 (63.04)	1087.88 (95.65)	459.08 (100)	15.15
S10	189.13 (49.04)	218.77 (83.65)	286.11 (77.88)	1107.77 (95.19)	320.55 (100)	19.41
mean	176.05 (36.71)	183.56 (80.21)	269.66 (70.31)	1173.50 (95.45)	357.10 (99.74)	17.39

\* Maximum angular velocity compared between subjects (among the subjects).

**Table 3:** Test correlation between dominant legs length and ball speed

Dominant legs length (mean $\pm$ SD)	Ball speed (mean $\pm$ SD)	P-value	Correlation
1.166 $\pm$ 0.027 (m)	17.393 $\pm$ 2.357(m/s)	0.469	-0.029

\*Significant correlation between dominant legs length and ball speed ( $p<0.05$ )

## DISCUSSION

The main purpose of this study is finding the correlation between angular velocity and ball speed. However, we did not find the correlation in this study. Angular velocity of hip flexion affects increasing of angular velocity of knee extension which correlates with increasing of ball speed.<sup>17</sup> In the present study found angular velocity of hip flexion about  $356.55 \pm 138.37$  deg/s which affects knee extension about  $1368.3 \pm 159.97$  deg/s. When observed in S2 found that the maximum hip flexion and high knee extension affected the maximum ball speed. However, it was not found the correlation between angular velocity of the joints and ball speed. There was some study demonstrated that height of the ball at contact ball effects on ball speed but we did not control the subject about this factor. In addition, the high angular velocity of multi-joints showed in S2 may also involve with increasing ball speed. The study result was corresponded to the previous study which studied about multi-joints kinetic chain analysis of knee extension during the soccer instep kicks.<sup>17</sup> Therefore, the effectiveness of ball speed occurs with multi-joints function.

In constant angular velocity of the joints, the factor that affect ball speed is leg length.<sup>5, 16</sup> The average of dominant leg length in the present study measured in 10 male subject is  $1.166 \pm 0.027$  m which was not correlated with ball speed. It's possible that angular velocity of the joint was not in constant state.

## CONCLUSION

In the present study, angular velocity of each joint and dominant leg length from somersault kick were not correlated with ball speed. However, there were some subject' result that showed the high angular velocity value of multi-joints which affected a higher ball speed compared to other subjects. Therefore, from these results can conclude that one of them angular velocity or dominant leg length cannot expect the value of ball speed. It also needs the contribution of multi-joints which depends on each Sepaktakraw player's skill.

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