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Biomechanical Analysis of Ball Trajectory Direction in Free Throw

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Abstract
Basketball game is decided by the most point counted from successful shooting. Moreover, free throw is one of many shooting techniques which is frequently used in basketball game. So, the aims of this research are reviewing the ball trajectory direction to find the formula to increase possibility of successful shooting and decrease shooting error possibility. This is a quantitative study with independent t-test data analysis by SPSS. There are 73 male college physical education students(age : 20 ± 1.2 years) who were categorized based on their height in to 5 groups. Each of them tried to make 3 successful free throw. The result, there are significant different of ball direction, launching angle, maximum elevation, and ball velocity among different height group ($\propto < 0.05$). In the conclusion, the launching angle and maximum elevation among different height group has different characteristic. However, the ball direction and velocity have more similarities among different height group.

Keywords: Biomechanics, Free Throw, Basketball

Introduction
Basketball is an exciting and competitive sport (Ammar et al., 2016). It also contributes positively for health and fitness condition (de Cássia Marqueti et al., 2017). It requires the knee strength (Kabacinski et al., 2018) and an intense physical movement during the exercise and the game (Moanţă, Ghiţescu, & Tudor, 2014). So, it has some injury risks, but it can be prevented by sport science. Moreover, sport science does not only help to decrease injury risk (Muff et al., 2017), but also to estimate the efficient movement (Huston & Grau, 2003).

There are three fundamental skills, such as shooting, passing and dribbling (Ammar et al., 2016). Free throw is part of shooting skill in basketball(Mokou et al., 2016). The best free throw technique has the greatest probability of success(Huston & Grau, 2003). So, in order to increase the successful probability, each player needs to develop theirfree throw technique(Min, 2016). However, it is not easy to understand and develop their free throw technique(Cañal-Bruland, Balch, & Niesert, 2015). As a solution, sport video analysis gives direct feedback and helps to improve all of basketball player performance (Li et al., 2017).

The aims of this research are reviewing the ball trajectory direction to find the formula to increase possibility of successful shooting and decrease shooting error possibility for different height group. There are some components that would influence the distance, such as shooting distance and direction adjustment(Miller & Bartlett, 1994), ball release speed(Miller & Bartlett, 1994), force in our body (Valiant & Eden, 1993), elbow joint, and wrist joint (Lenart & Rzymkowski, 1994). Moreover, the variables in this research are ball direction, launching angle, maximum elevation, and ball velocity. The ball direction were measured by calculating the angle between the maximal ball position with the basket (Fig. 1). The launching angle is the angle between ball direction and the horizontal line (Fig. 2). Ball velocity was measured when the ball just released from the hand (Fig. 2). Then, maximum elevation is the highest position of the ball in the call trajectory line (Fig 2).

Method

Participants

There were 73 male college physical education students(age : 20 ± 1.2 years) who voluntarily participated in this research. Furthermore, they were categorized and named based on their height (Table 1). Each participant needs to make three successful free throws from unlimited attempt. Furthermore, they are also allowed to choose the best three free throws that they did if they have more than thee successful free throws.

Table 1. Sample

Group Name	Height	N	Mean
A	<160	3	157.67 cm
B	161-165	20	162.20 cm
C	166-170	14	166.21 cm
D	171-175	29	172.59 cm
E	176-180	7	177.57 cm
Total		73	

Research Procedures

This is a quantitative research with comparative study.There are four main data in this research, such as ball direction, launching angle, ball velocity, and maximumelevation. The ball direction was recorded by Canon 80D + Canon 18-135 mm STM with HD 50 fps (1280 x 720). The launching angle, ball velocity, and maximumelevation were recorded by GoPro Hero 5 Action Camera with 120 fps (1080 x 720).

Figure 1. The Angle between the maximal ball position with the basket

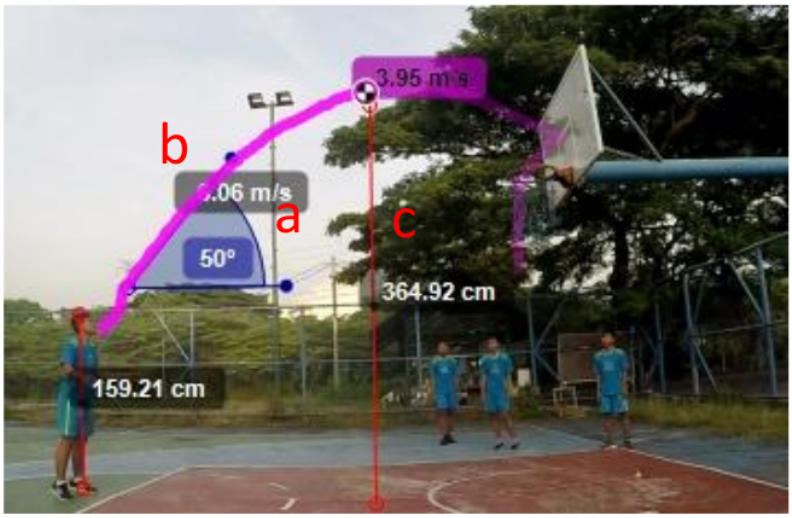

Figure 2. Shooting Launching Angle (a), Ball Velocity (b), and Max. Elevation (c)(Researcher's Document)

Data Analysis

The data was analyzed by 2 dimension kinematic data analysis by Kinovea 0.8.15 computer software. Then, the data was exported in to excel files and tested the normality of distributions by using Kolmogorov Smirnov in SPSS 20.0 program. Furthermore, the data was analyzed the difference based on the height category by one way anova test. Post-hoc analysis was performed to find the particular difference among the height category.

Results and Discussion

The results show that there are significant different ($\propto < 0.05$) among height category in ball direction, launching angle, ball velocity, and maximum elevation (Table 2). Group A has the narrowest ball direction, but the widest launching angle. It means that group A tends to make the launching ball higher with the good precision on the ball direction in order to increase the possibilities of successful shooting. Group B has the highest maximum elevation of the ball trajectory. Group C has the widest ball direction angle and the slowest ball velocity. Group D has the fastest ball velocity. However, this data cannot make the further conclusion about this research. So, it needs to be analyzed by post-hoc.

Table 2. One way anova and mean of ball direction, launching angle, ball velocity, and max. elevation

Group Name	Height	Ball Direction	Launching Angle	Ball velocity	Max. Elevation
A	<160	0.81°	53.00°	5.02 m/s	3.65 m
B	161-165	1.26°	51.50°	5.19 m/s	3.70 m
C	166-170	2.37°	50.36°	4.90 m/s	3.65 m
D	171-175	1.84°	52.62°	6.45 m/s	3.55 m
E	176-180	1.76°	49.14°	5.31 m/s	3.42 m
Significant		.016*	.000*	.024*	.000*

* significant < .05

Post hoc test or multiple comparisons compares each group. Surprisingly, there are only a few significant difference on ball direction and ball velocity among different group. In ball direction, group B has better accuracy than group C. Moreover, group C has slower ball velocity compare with group D. However, there are so many significant differences on launching angle and maximum elevation. It means that every groups has their own different technique on launching angle and maximum elevation.

Table 3. Post hoc data analysis

Group		Significant			
		Ball Direction	Launching Angle	Ball velocity	Max. Elevation
A	B	0.949	0.109	1.000	0.655
	C	0.113	0.001*	1.000	1.000
	D	0.440	0.000*	0.609	0.035*
	E	0.642	0.000*	0.999	0.000*
B	A	0.949	0.109	1.000	0.655
	C	0.018*	0.025*	0.987	0.095
	D	0.278	0.000*	0.076	0.000*
	E	0.783	0.004*	1.000	0.000*
C	A	0.113	0.001*	1.000	1.000
	B	0.018*	0.025*	0.987	0.095
	D	0.485	0.000*	0.040*	0.000*
	E	0.683	0.000*	0.983	0.000*
D	A	0.440	0.000*	0.609	0.030*
	B	0.278	0.000*	0.076	0.000*
	C	0.485	0.000*	0.040*	0.000*
	E	1.000	0.005*	0.487	0.000*
E	A	0.642	0.000*	0.999	0.000*
	B	0.783	0.000*	1.000	0.000*
	C	0.683	0.000*	0.983	0.000*
	D	1.000	0.005*	0.478	0.000*

* significant < .05

Conclusions

Based on the data analysis, there are significantdifferences among different height group on ball direction, launching angle, ball velocity, and maximum elevationare several recommendation for free throw. Moreover, there are specific characteristic on each height group. The height of an athlete determine the launching ball angle. Taller athlete could use narrower launching ball to make the effective trajectory ball. However, shorter athletes need to make a wider and higher ball direction so that can make a perfect parabolic ball trajectory.

Moreover, shorter athletes need to use more power.So they can increase the speed and the maximum elevation of the ball. On other hands, taller players can adjust the ball velocity and maximum elevation easier. However, the most important is the ball direction. The best ball direction should be nearly 0°. So the ball can be directed toward the ring straightly.

There are two limitations of this study. The first is sampling quantity. The sample size may not sufficient enough to represent the whole population. The second is sampling variability. The samples of this research are male. So there could be more findings if the sample variability involves female athletes as well.

Acknowledgments

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Conflict of interest

The authors declare that they have no conflict of interest.

Ethical approval

The research was approved by the local institutional (sport science faculty) review board.

Informed consent

All participants have provided informed consent.

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