# Analysis of Swimming Start Angle to the Sliding Ability of Man Crawl Swimming Style Viewed from Biomechanical Study

1st Rumi Iqbal Doewes
*Sebelas Maret University*
*Solo, Indonesia*
king.doewes@staff.uns.ac.id

2nd Sapta Kunta Purnama
*Sebelas Maret University*
*Solo, Indonesia*
saptakunta_p@yahoo.com

3rd Islahuzzaman Nuryadin
*Sebelas Maret University*
*Solo, Indonesia*
mase.ior2004@gmail.com

4th Manshuralhudlori
*Sebelas Maret University*
*Solo, Indonesia*
manshur87@gmail.com

*Abstract*— **The study purpose was determined the starting angle which has a further jump distance viewed from Dartfish analysis in swimming sports. The research method was used quantitative method with descriptive analysis approach. The study sample was swimming athletes totaling 3 people. The jump results from the start performed by athletes with 3 experiments were analyzed by statistical analysis and motion analysis using Dartfish software. The conclusions are (1) there are significant differences in the experiments carried out by swimmers with different starting angles resulting in different jump distances; (2) motion analysis shows that swimmer 3 in the second experiment with knee angle of 109°, slope angle of 100°, repulsion angle (elevation) of 22°, entry angle of 39° with travel time 0.33 seconds in air reaches the farthest jump distance which is 3.78 meter.**

*Keywords*— *Swimming, Start angle, Crawl style, Biomechanics*

## I. INTRODUCTION

Swimming is a situation where swimmers should float on water to compete (Azizi 2011: 1626). In freestyle swimming numbers, athletes are usually uses the crawl style when competing because the crawl style was considered the fastest swimming style than other styles. In swimming, the start becomes the beginning of the race. The start was intended to give the swimmer an initial push to cut the mileage and provide a strong slide when swimming. A good start will contribute to the boost that swimmers can use, especially on short distance race numbers. According to George, et al. (2008: 100) "start is contributes 10% of the total time in the 50 meters race number, and about 5% in the 100 meter race number". Given the size of the contribution given by the start, the start must be more studied so that the start has several rules in how to do it.

In the start there are several stages, including at start block, floating in the air, and sliding. Each of these stages has its own time and distance to be taken. When in the start block (block time) swimmers prepare to jump towards the pond, during the preparation the swimmer will position his body with the angle of the foot arranged to facilitate the cancellation of equilibrium and still be able to do strong jumps so that at this stage swimmers can make repulsion strongly and quickly. When the swimmer makes a repulsion before the flight time, the swimmer will make repulsion with a certain elevation angle to get a long jumping distance with a fast time, in the flight time stage the maximum height can be seen when the swimmer is in

the air, the distance taken before entering the water, and the speed at which after repelling until the swimmer enters the water (water time). When entering into the water (water time) the swimmer will position his body to form an angle, from this angle will affect the depth of the swimmer in the water, the speed of the slide, and also the distance traveled when sliding.

To find out the good angles in several stages of the start, the role of biomechanics is very important. Biomechanical analysis at each stages can be seen every angle made by the swimmer and the results obtained from that angle. In block time, can be seen the swimmer's foot angle with the speed when you start until when the foot is released from the start block, in the flight time stage you can see repulsion elevation angle and initial speed of the block time stage with maximum height, maximum distance and speed during takeoff until the body into the water, while the water time stage can be seen the initial velocity of flight time stage and angle into the water with a maximum depth results swimmers, distance, and speed while sliding.

In this study, to determine the effectiveness of the start movement carried out by an athlete that cannot be seen with the naked eye, this study uses the help of the start video recording that was demonstrated by the athletes.

## II. RESEARCH METHODOLOGY

### A. Place and Time of Research

This Research Was Performed at the Elite Swimming Club Surakarta regular practice at the Tirtamaya Jebres swimming pool located at Jl. Kolonel Sutarto No.142, Jebres, Surakarta City, Central Java. The research was conducted during a regular exercise schedule and implemented before exercise routine of Elite Swimming Club Surakarta on Sunday of December 9th, 2018 at 14.00 pm.

### B. Research Design

The research design was used a quantitative method with a descriptive analysis approach. According to Sugiyono (2005: 21) "descriptive method is a method used to describe or analyze the research results but not used to make broader conclusions".

## C. Research Subject

The research subjects were male athletes group who joined the Elite Swimming Club Surakarta amounted to three swimmers.

## D. Data Collection Technique

Record the swimmer's start movement with different start angles used digital camera, then analyzed with Dartfish especially to determine the jumping distance, time, and movement.

## E. Data Analysis Technique

Data analysis was carried out by t test to determine the significant difference between the swimmers' starting angle. In addition to the t-test, the analysis also carried out motion analysis using Dartfish software. Dartfish software is a tool for measurement. Motion analysis was focused in the position of gestures when refusing, slide and enters to the water.

## III. RESULTS AND DISCUSSION

## A. Data Description

TABLE I.    THE RESULTS OF JUMP DISTANCE MEASUREMENTS AT VARIOUS ANGLES

|  | Swimmer 1 | | | Swimmer 2 | | | Swimmer 3 | | |
|---|---|---|---|---|---|---|---|---|---|
| Knee angle | $95^0$ | $94^0$ | $104^0$ | $108^0$ | $101^0$ | $101^0$ | $106^0$ | $109^0$ | $108^0$ |
| Slope | $103^0$ | $103^0$ | $102^0$ | $107^0$ | $109^0$ | $107^0$ | $99^0$ | $100^0$ | $98^0$ |
| Time to move | 0.64 s | 0.72 s | 0.63 s | 0.64 s | 0.72 s | 0.72 s | 0.83 s | 0.86 s | 0.86 s |
| Elevation angle | $25^0$ | $25^0$ | $23^0$ | $27^0$ | $25^0$ | $22^0$ | $21^0$ | $22^0$ | $22^0$ |
| Time in the air | 0.40 s | 0.40 s | 0.36 s | 0.44 s | 0.36 s | 0.32 s | 0.33 s | 0.33 s | 0.36 s |
| Jump distance | 3.43 m | 3.43 m | 3.37 m | 3.58 m | 3.58 m | 3.48 m | 3.64 m | 3.78 m | 3.71 m |
| Entering angle | $42^0$ | $34^0$ | $32^0$ | $38^0$ | $39^0$ | $40^0$ | $37^0$ | $39^0$ | $37^0$ |
| Time to slide | 4.92 s | 4.48 s | 5.04 s | 3.56 s | 3.44 s | 3.64 s | 3.45 s | 3.40 s | 3.47 s |
| Total time | 5.96 s | 5.60 s | 6.04 s | 4.64 s | 4.52 s | 4.68 s | 4.57 s | 4.60 s | 4,70 s |

Table 1 explains the experiment of the start angle performed 3 swimming athletes which produce different jump distances.

## B. T-Test (Different)

TABLE II.    TABLE 2. T-TEST RESULTS

**Paired Samples Test**

|  | Paired Differences | | | | | | | Sig. (2-tailed) |
|---|---|---|---|---|---|---|---|---|
|  | Mean | Std. Deviation | Std. Mean Error | 95% Confidence Interval of the Difference | | t | df |  |
|  |  |  |  | Lower | Upper |  |  |  |
| Pair 1  Experiment2 - Experiment3 | .7667 | .202082 | .01202 | .02496 | .12838 | 6,379 | 2 | .24 |

Based on the t-test it can be seen that $t_{count}$ is 6.379 while $t_{table}$ is 2.919. The results of $t_{count} > t_{table}$ means that there are significant differences in the experiments carried out by

swimmers with different angles resulting in different jump distances.

TABLE III.    DESCRIPTION OF JUMP DISTANCE DATA

**Descriptive Statistics**

|  | N | Minimum | Maximum | Mean | Std. Deviation |
|---|---|---|---|---|---|
| Experiments | 3 | 3.43 | 3.78 | 3.5967 | .17559 |
| Experiment3 | 3 | 3.37 | 3.71 | 3,5200 | .17349 |
| Valid N (listwise) | 3 |  |  |  |  |

Based on table 3, it can be seen that the farthest distance made by the swimmer is 3.78 meters.

## C. Analyzer of Dartfish Software

## 1. First Swimmer

## a. First experiment



Fig. 1.    Knee angle and slope of 1st swimmer of 1st experiment

In the first experiment the swimmer conduct grabs start by forming a knee angle of 95° with a slope of 103°. With this start angle the swimmer starts to move until the entire body was separated from the start block takes 0.64 seconds.



Fig. 2.    The repulsion angle of 1st swimmer of 1st experiment

The swimmer repulsion with an angle of 25° and is in the air within 0.40 seconds.

Fig. 3.   Swimmer entry angle 1 experiment 1

The swimmer enters the water at a distance of 3.43 meters and enters the water with an entry angle of 42°. After that the swimmer slides in the water to a distance of 10 meters with a time of 4.92 seconds. The time needed by the swimmer in the first experiment starting from the beginning of the move up to a distance of 10 meters is 5.96 seconds.

*b. Second experiment*



Fig. 4.   Knee angle and slope of 1st swimmer of 2nd experiment

In the second experiment the swimmer perform grab start by forming a knee angle of 94° with a slope of 103°. With this angle the swimmer starts to move until the entire body was separated from the start block takes 0.72 seconds.



Fig. 5.   Swimmer repulsion angle 1 experiment 2

The swimmer perform repulsion with an angle of 25° and in the air within 0.40 seconds .



Fig. 6.   Entry angle of 1st swimmer at 2nd experiment

The swimmer enters to the water at a distance of 3.43 meters and enters the water with an entry angle of 42°. After that the swimmer slides in the water to a distance of 10 meters with a time of 4.48 seconds. The time needed by the swimmer in the second experiment starting from the beginning of moving to a distance of 10 meters is 5.60 seconds.

*c. Third experiment*



Fig. 7.   Knee angle and slope of 1st swimmer of 3rd experiment

In the third experiment the swimmer perform grab start by a knee angle of 104° with a slope of 102° . With this angle the swimmer starts to move until the entire body is separated from the start block takes 0.64 seconds.



Fig. 8.   The repulsion angle of 1st swimmer of 3rd experiment

Swimmers make repulsion at an angle of 23° and in the air within 0.36 seconds



Fig. 9. The entry angle of 1st swimmer at 3rd experiment

The swimmer enters the water at a distance of 3.37 meters and enters the water with an entry angle of 32°. After that the swimmer slides in the water to a distance of 10 meters with a time of 5.04 seconds. The time needed by the swimmer in the third experiment starting from the beginning of the move up to a distance of 10 meters is 6.04 seconds.

*2. Swimmer 2*
*a. First experiment*



Fig. 10. Knee angle and slope of 2nd swimmer at 1st experiment

In the first experiment the second swimmer perform a grab start by a knee angle of 108° and slope of 107°. By this angle, the swimmer starts to move until the entire body was separated from the start block takes 0.64 seconds.



Fig. 11. Repulsion angle of 2nd Swimmer at 1st experiment

Swimmers make repulsion at an angle of 27° and in the air within 0.44 seconds



Fig. 12. The entry angle of 2nd swimmer at 1st experiment

The swimmer entering the water at a distance of 3.58 meters and enter the water with an entry angle of 38°. After that the swimmer slides in the water to a distance of 10 meters with a time of 3.56 seconds. The time needed by the swimmer in the first experiment starting from the beginning of the move up to a distance of 10 meters is 4.64 seconds.

*b. Second experiment*



Fig. 13. Knee angle and slope of 2nd swimmer at 2nd experiment

In the second experiment the swimmer perform a grab start by knee angle of 101° and slope of 109°. With this angle the swimmer starts to move until the entire body is separated from the start block takes 0.72 seconds.



Fig. 14. Repulsion angle of 2nd swimmer at 2nd experiment

Swimmers make repulsion at an angle of 25° and in the air within 0.36 seconds

Fig. 15. The entry angle of 2<sup>nd</sup> swimmer at 2<sup>nd</sup> experiment

The swimmer enters the water at a distance of 3.58 meters with an entry angle of 39°. After that the swimmer slides in the water to a distance of 10 meters with a time of 3.44 seconds. The time needed by the swimmer in the second experiment starting from the beginning of moving to a distance of 10 meters is 4.52 seconds.

*c. Third experiment*



Fig. 16. Knee angle and slope of 2<sup>nd</sup> swimmer at 3<sup>rd</sup> experiment

In the third experiment the swimmer perform grab start by a knee angle of 101° with a slope of 107°. With this angle the swimmer starts to move until the entire body is separated from the start block takes 0.72 seconds.



Fig. 17. The repulsion angle of 2<sup>nd</sup> swimmer at 3<sup>rd</sup> experiment

Swimmers make repulsion at angle of 22° and in the air within 0.32 seconds.



Fig. 18. The entry angle of 2<sup>nd</sup> swimmer at 3<sup>rd</sup> experiment

The swimmer enters the water at a distance of 3.48 meters with an entry angle of 40°. After that the swimmer slides in the water to a distance of 10 meters with a time of 3.64 seconds. The time needed by the swimmer in the third experiment starting from the beginning of the move up to a distance of 10 meters is 4.64 seconds.

*3. Swimmer 3*
*a. First Experiment*



Fig. 19. Knee angle and slope of 3<sup>rd</sup> swimmer at 1<sup>st</sup> experiment

In the first experiment the swimmer perform a grab start by a knee angle of 106° with a slope of 99°. With this angle the swimmer starts to move until the entire body is separated from the start block takes 0.83 seconds.



Fig. 20. The repulsion angle of 3<sup>rd</sup> swimmer at 1<sup>st</sup> experiment

Swimmers make repulsion angle at 21° and in the air within 0.40 seconds.

Fig. 21. The entry angle of 3rd swimmer at 1st experiment

Swimmers entered into the water at a distance of 3.64 meters and get into the water with the entry angle of 37°. After that the swimmer slides in the water to a distance of 10 meters with a time of 3.45 seconds. The time needed by the swimmer in the first experiment starting from the beginning of moving to a distance of 10 meters is 4.57 seconds.

*b. Second experiment*



Fig. 22. Knee angle and slope of 3rd swimmer at 2nd experiment

In the first experiment the swimmer perform a grab start by knee angle of 109° with a slope of 100°. With this angle the swimmer starts to move until the whole body is separated from the start block takes 0.86 seconds.



Fig. 23. The repulsion angle of 3rd swimmer at 2nd experiment

Swimmers make repulsion angle at 22° and in the air within 0.33 seconds.



Fig. 24. The entry angle of 3rd swimmer at 2nd experiment

The swimmer enters the water at a distance of 3.78 meters with an entry angle of 39°. After that the swimmer slides in the water to a distance of 10 meters with a time of 3.40 seconds. The time needed by the swimmer in the 2nd experiment from the beginning of moving to a distance of 10 meters is 4.60 seconds.

*c. Third experiment*



Fig. 25. The knee angle and slope of 3rd swimmer at 3rd experiment

In the first experiment the swimmer perform a grab start by knee angle of 108° and slope of 98°. With this angle the swimmer starts to move until the whole body is separated from the start block takes 0.86 seconds.



Fig. 26. The repulsion angle of 3rd swimmer at 3rd experiment

Swimmers make repulsion angle at 22° and in the air within 0.36 seconds.

Fig. 27. The entry angle of 3rd swimmer at 3rd experiment

Swimmers entered into the water at a distance of 3.71 meters with the entry angle of 37°. After that the swimmer slides in the water to a distance of 10 meters with a time of 3.47 seconds. The time needed by the swimmer in the third experiment starting from the beginning of moving to a distance of 10 meters is 4.70 seconds.

### D. Discussion

From the research results, it can be seen that there are significant differences in the calculation results given by the jump distance in 3 swimmers with 3 time experiments. Which gives a better value is jumping technique of third swimmer. Result of motion analysis was shown that the jumping distance is 3.78 meters. This is because the third swimmer has an entry angle of 39°, while first swimmer has an entry angle of 34° with jumping distance of 3.43 and the second swimmer has an entry angle of 39° with a jumping distance of 3.58. To achieve longest jump, an ideal angle is needed, because in theory, the 45° angle will produce maximum air time and the horizontal speed. So from that third swimmer's angle is closer to the ideal angle than other swimmers.

The other factors affecting the jumping results at start are the size of the repulsion angle. The first swimmer has a repulsion angle of 25° with travel time in air of 0.40 seconds, second swimmer has a repulsion angle 25° with travel time in air of 0.36 seconds , and third swimmer has a repulsion angle of 22°° with travel time in air of 0.33 seconds . The smaller the repulsion angles smaller the obstacles when floating in the air. So that the obstacles in the air are small, it will also produce maximum time in the air and obtained further jumping distance. In addition, the knee angle and slope angle also affect the next movement in the swimming start. The greater the angle of the knee and the greater the slope angle, the smaller the resistance to move to the next movement.

Based on the research results it can be concluded that the knee angle of 109°, slope angle of 100°, repulsion angle (elevation) of 22°, entry angle of 39° with travel time of 0.33 seconds produces a jumping distance of 3.78 meters.

## IV. CONCLUSION

### A. Conclusion

There were significant differences in the experiments carried out by swimmers with different starting angles resulting in different jump distances.

Motion analysis shown that 3rd swimmer in the second experiment with knee angle 109°, slope angle of 100°, repulsion angle (elevation) of 22°, entry angle of 39° with travel time in the air of 0.33 seconds reaches the farthest jumping distance of 3.78 meters.

### B. Suggestion

Given that the start contributes to the swimming race, especially the short number, the start analysis is to find out the best knee angle, the take-off angle, and entry angle into the water and able to release the maximum potential of each athlete.

Athletes should know the knee angle, forward slope, takeoff angle, and the most effective entry angle for themselves considering that each athlete has their own angle.

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