Is Staggered Greater Than Parallel Feet Placement?
Kinematic Analysis for the Start of Backstroke-Swim Style

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Abstract: Most athletes have minimal speed in terms of starting compared with their cyclic movement whereas a good start contributes to the swimming performance. So, the purpose of this research is to know the more effective and efficient placement of leg position and efficient for the start of backstroke-swim style. The samples were eight swimmers (average age, weight, and height: 18.9 years old, 62kg, 174cm) from Aquatic Student Activity Unit at UPI who became participants of this study, using purposive sampling technique. The swimmers' starting movement was recorded with 60Hz camera, and then applied into movement analysis software: kinovea. The analyzed reaction components were (1) initial angle, (2) angular velocity, and (3) reaction time between the placement of parallel and staggered leg positions. The results of t-test analysis showed that there is no difference in the initial angle, angular velocity, and the reaction time between the placement of parallel and staggered feet placements on the bottom starting of backstroke-swim style ($p > 0.05$).

1 INTRODUCTION

Swimming performance in short-range competitions is measured by the amount of time of the following four components: start, swim, reversal, and finish (Blanksby, Nicholson and Elliott, 2002; Theut and Jensen, 2006). The success of the start is said to be an important element in the swimming competition. The start consists of several phases: block, flight, entry, glide, leg kicking and swimming (Arellano et al., 2000; Vantorre, Chollet and Seifert, 2014). The study mentions, from the total length of swimming time in a pool of 25 yards, the start can contribute 25%. On the 50 yard distance, the start can contribute 10%, and 5% at 100 yard distance (Kilan i, Al-Tuieb and Kilani, 2013). Previously, the grab start method was considered the fastest compared to other start methods. The results of the temporal analysis of kinetic and speed measurements show that grab start produces better vertical impulses and take off speeds than the track start, while the track start is faster when leaving the start block (Benjanuvatra et al., 2004). Currently, many world-class swimmers use the track start method. Track start that resembles running start is used because it has advantages compared to grab start. First, swimmers can enter the water more quickly because the center of gravity will run almost straight forward until it reaches its maximum point to fall into the water. Second, the swimmer's feet can lead to better forward resistance when the swimmer has twice the strength. Because the back feet do the first repulsion to push the foot forward, there is a movement of momentum, which is then followed by the forceps of the front foot (Badruzaman, 2011). At the start of backstroke-swim style with parallel and imparallel placement of legs (one below and one above), there was no difference ($p > 0.05$) of average speed and horizontal distance, and no difference in leg movement during start (Theut and Jensen, 2006). Parallel feet placement, in which the feet are dipped into the water when hand-off and take-off positions are at the body mass center position, and the speed of the horizontal body mass center, are better than the placement where the feet are not dipped into the water. As for the placement of parallel feet position that are not dipped in water shows better results in the component of contact time with the wall, and the center speed of the horizontal and vertical body mass on the phase flight. There is no difference in water range (horizontal), back angle and start time of 5 m from both placement of the foot (de Jesus et al.,

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2013). Placement of feet above the water surface is also better in terms of speed start (p <0.01) in, and take-off horizontal (p = 0.01) in comparison with the placement of feet under the water, but have a smaller horizontal peak power (p = 0:02) (Nguyen et al., 2014).

The mechanical principle of movement at the start of swimming is associated with the action-reaction principle (Third Newton 'Laws). If there is any change of state from static to motion, or from motion to static, there must be cause or influence. The influence or cause is the style. At the bottom start of the backstroke-swim style, there is a force called propulsive force (Stager and Tanner, 2005). The force works when the foot does repulsion against the block starting wall, causing the body to have back repulsion. When the force occurs, an angle formed by the shin, knee joint, and thigh bone is formed. If the resulting angle is smaller and the body is more inclined forward, in other words the horizontal distance from the point of the body should be minimized, or the weight point near to the side of the pedestal, it will produce an increased movement speed to a direction. The principle of action-reaction also explains that to produce a large reaction, a strong support is needed. A strong pedestal will produce good power (Grimshaw and Burden, 2007; McGinnis, 2013).

Using the basis of movement mechanical principle, the aim of this study is to compare the repercussions between the parallel and staggered feet placements, in which their repulsions consist of the following components: initial angle, angular velocity, and reaction time. Therefore, the hypothesis of this research are as follows: (1) Is there an initial angular difference between parallel and staggered foot placements? (2) Is there a difference in angular velocity between parallel and staggered feet placements? (3) Is there any difference in reaction time between parallel and staggered feet placements?

2 METHODS

The samples in this study were eight athletes of backstroke-swimming style from the Aquatic SAU at UPI (Average age: 18.9 years old, weight: 62kg, height: 174cm). Samples were set based on the characteristics of the swimmer's ability by using purposive sampling.

The used research method used was experimental method with one-shot case study design (Fraenkel, Wallen and Hyun, 2012). The experiment was conducted three times for each feet position (staggered and parallel). Both of the feet position were placed on the surface of the water (Emerson) with consideration to avoid water resistance and slippage. All three experiments were recorded using a digital video camera placed at a distance of 5 meters (Vantorre et al., 2010; Vantorre, Chollet and Seifer t, 2014; de Jesus et al., 2015) and operated at a frequency of 60Hz (underwater camera nikon coolpix aw110) . Next, the video image is processed by kinovea software to see the swimmer's movements during the start of repulsion. Measurable components using this software are distance, angle, coordinate point, and speed (Kinovea, 2015).

Figure 1: Parallel (a) and staggered (b) feet placements.

3 RESULTS AND DISCUSSION

Table 1 shows descriptive data from the results of parallel and staggered foot placement repulsions for three trials. The average angle formed early in the first experiment is smaller than experiments 2 and 3 both for positioning of parallel (44.87 º ± 5.92) or staggered (45.88 º ± 9.57) feet, so is with angular velocity which shows better numbers in the first experiment (parallel = 286.36º / s ± 26.83; staggered = 281.43º / s ± 64.60). This can happen because in the first experiment the sample had not experienced fatigue. There is a causal relationship between muscle fatigue and high intensity exercise. High intensity exercise with anaerobic metabolism can lead to decreased contractile function (Westerblad, Allen and Lännergren, 2002). In this case the athlete was in maximum capacity to produce power or power output (Vøllestad, 1997). The average angle of initial angle and angular velocity (table 1a) of the two feet's in each experiment indicates that there is conformity with the presumption of the mechanical movement described previously, that if the formed initial angle is small, it will result in a velocity change in a large direction and vice versa (Grimshaw and Burden, 2007; McGinnis, 2013). As for the reaction time of each experiment, they only show difference of 0.01 seconds to 0.02 seconds, in which the parallel feet placement was 0 .02 seconds faster than the staggered. However, it does not indicate that parallel feet placement is better than staggered because the difference is only slightly (see at table 1b). The staggered feet placement allows swimmers to reach water further (because foot in lower position pushed earlier and is then followed by the other foot) so it takes a little longer for the swimmer to do entry phase. It can also be caused by internal factors of the athletes themselves, for example the athletes‘ habits in using the feet parallel position when starting the backstroke-swim style.

Reaction time in the start of swimming is the reaction time generated when the start sign is sounded, where a foot repulses the repulsion board and the head streams the water until the beginning of the glide/stroke movement is performed. There are several factors that influence reaction time that are associated with human performance, including: (1) the number of stimulus-response alternatives, (2) the stimulus-response match, (3) the stereotyped population, and (4) the number of exercises (Schmidt and Lee, 2014). In some cases, stimulus-response compability and the number of exercises are the main factors affecting reaction time. With so much practice, the stimulus-response process gets closer to the automation reaction. So, the more often the muscle is trained, the better the reaction will be generated when faced with a stimulus or stimulation of movement.

Table 1: Results of starting repulsion on backstroke-swim style (initial angle, angular speed, reaction time) on each trial (mean ± sd).

	Initial Angle(°)	Angular Velocity(°/s)	Reaction Time(s)
Parallel 1	44.87±5.92	286.36±26.83	0.72±0.92
Parallel 2	52.75±15.17	255.11±41.89	0.71±0.06
Parallel 3	48.12±11.58	276.20±44.16	0.72±0.10
Staggered 1	45.88±9.57	281.43±64.60	0.78±0.14
Staggered 2	46.75±10.96	258.40±61.06	0.76±0.15
Staggered 3	49.12±9.61	245.99±49.76	0.80±0.16

Table 2: Differences in the average of repulsion results between parallel and staggered feet placements

Variable	Parallel (mean±sd)	Staggered (mean±sd)	t	p value
Initial Angle (°)	48.58±9.23	47.25±9.24	0.289	0.777
Angular Velocity (°/s)	272.56±27.67	261.94±33.20	0.695	0.498
Reaction Time (s)	0.72±0.08	0.78±0.09	-1.504	0.155

From the results of the difference test analysis (table 1b) between parallel and staggered feet placements for the initial angle component (p = 0.777), angular velocity (p = 0.498), and reaction time (p = 0.155), each had p> 0.05. This means that there is no significant difference in starting angle, angular velocity, and reaction time between parallel and staggered feet placements. It is different to what happens at the start of track start method that is considered more effective and efficient, because it allows swimmers to reach the water further at a horizontal distance, and faster because of the pedestal area is in a unstable state so that will cause the forward movement more quickly. However, at the start of the mechanical back force, the movement is strongly influenced by the projection point of the center of gravity. The center of gravity is one of the important factors determining movement because the center of gravity can affect one's stability and balance. At the bottom start, the center of gravity is just under water and beyond the pedestal field. Therefore, the swimmer must have a grip as well as strong hands and muscles to support the body in order not to fall into the water or slip before take-off start.

4 CONCLUSIONS

In this study, the parallel and staggered feet placements have (initial angle, angular velocity, and time reaction) relatively similar repulsion results. This means that no feet position has been found to be more effective and efficient for swimmers when starting the backstroke style. This study needs to be updated by looking at other factors that may affect the swimmer's start results, such as athlete's experiences, the condition or duration of training, muscle flexibility, platform conditions, fatigue, and athlete's nutrition. In addition, the use of more samples is strongly recommended to be able to generalize the results of the study.

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