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REVIEW

Kinematics Research Progress of Swim-start on the New Start Block

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The new starting block by Omega firstly appeared in Beijing Olympic Games since the FINA (Fédération Internationale de Natation) amended the rule (OSB11, Corgémont, Switzerland). And this new start block gave rise to the researchers and academics focused more on the start techniques on this new start block. The aim of this study is to summarize the current literature regarding the kinematics research progress of swimming start on this new start block and find the proper swim-start to optimize the swimming performance. The aim of this study is to provide insight into the improvement of swimming performance on the new start block by kinematics view for coaches and athletes. Results suggest that the KS is superior to the TS and GS. With the introduction of the OSB11 starting plate, swimmers need to quickly modify and adjust their techniques to take advantage of the new swimming start plate during normal training. The swimmers should not only enhance their speed training and speed training methods but also strengthen the core and lower limb strength to obtain the best take-off forces and horizontal velocity.

Keywords: kinematics; swim-start; new start block

1. Introduction

In swimming race, a swimmer's time that could mostly reflect performance is determined by the time spent on starting, stroking and turning (Guimaraes & Hay, 2010; J. Hay, 1993). The start can account for nearly a quarter of the race time in the big competitive sprint events (Okuno et al.,; S. Slawson, 2010; S. E. Slawson et al., 2011). In sprint swimming races, especially, the short distance swimming race, the performance has been excessive linked to the start performance and took up an increasing part of the total result (Bruce Mason, Alcock, & Fowlie, 2007; Nikodelis & Kollias, 2003) (Lyttle & Benjanuvatra, 2005). In 50m freestyle final events at the Budapest 2017 World Swimming Championships, the swimming performance was within 21s and the raking was determined by milliseconds. That results strengthened the importance of swim-start skill and the start phase of the race to 15m (Cossor, Slawson, Shillabeer, Conway, & West, 2011). And as world records continue to be broken in many swimming events, an effective start as one of the necessary technologies in swimming is excessively important for success.

Since 2008, the FINA passed the proposal that to admit the introduction of a new starting block (OSB11, Corgémont, Switzerland **Figure 1**) characterized by the rear of the platform surface adding an adjustable incline footrest. It was claimed, by Omega, that the block allowed the swimmer to push-off more explosively. With the using of the OSB11 starting block, swimmers need to quickly adopt the rear kick plate with the performance improving during daily training. There has some articles summarized that swim-start strategies differ within the swimmers even among elite swimmers (J Vantorre, Seifert, Fernandes, Boas, & Chollet, 2010), and researchers suggested that the most popular techniques used by the swimmers in the big events were the Grab Start (GS), Track Start (TS) and Kick-Start (KS). The KS, a variation of the TS in 2009, was the last technique of swimming starts (Taladriz Blanco, Blanca, & Arellano Colomina, 2017a). Although previous review almost summarized the swimming start in the way which mixed the starts on the new start block and traditional start block, but it seems unreasonable since adding the new start block, some data might outmoded thus

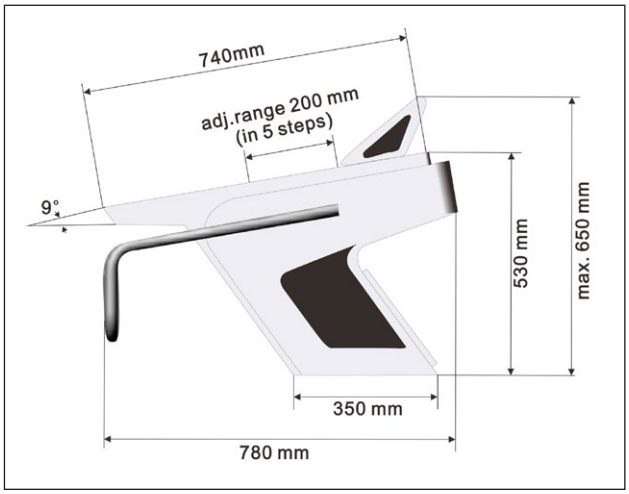

Figure 1: The OSB11 starting block.

has limited implications too current context of the swimming. So in this study we will scope the swimming start about kinematics viewpoint more update from 2008 to 2017. Previous analyses showed that the racing start technique in swimming on the new start remains very debatable among coaches, competitors and researchers. Even though findings of various studies have been inconclusive as to which of these three start techniques is superior. A number of recent study has shown that swimmers should consider using the KS and TS over the GS on the new start block (Murrell & Dragunas, 2013; Vint, Mclean, Hinrichs, Riewald, & Mason, 2009) Welcher, Hinrichs, & George, 2008 (Welcher, Hinrichs, & George, 2008). However, some researchers didn't give priority to the use of one technique over another, declared that the best start technique was the one most practiced by the swimmers (J. Vantorre, Seifert, Fernandes, Vilas-Boas, & Chollet, 2010). The most effective starts were those using the preferred technique due to a practice effect (Cossor et al., 2011). For this reason, the second target of this article is to analyse the comparison of those techniques to evaluate which is the proper swim-start to optimize the performance on the new start block. In this study we will from the kinematics point of view to analysis the characteristics of those techniques by using the kinematic correlation parameters. In order to provide some references for coaches and athletes to know and understand the starting technologies on this new block, and to better serve the teaching and training of swimming.

2. Literature search methodology

Literature were retrieved in Web of Science, Elsevier, and Spring Link databases. The important international congresses and proceedings about kinematics and swimming databases were also searched, mainly from 2008 the new swimming start showed up to November 2017. We screened for studies that performed a kinematics analysis of the start techniques on the new start block. Consequently, the main search term keyword used was "swim-start", "the OSB11 starting block", "swimming" and "kinematics". Reference were all searched from the Google Scholar, and the cited articles and reference lists of all included studies were carefully examined. The articles analyzing swim-starts were restricted to those written in English.

3. Kinematics progress of swim start on the new block

In order to analyse the swimming start in a more detailed and specific way by using kinematics method several related parameters were used. More recent studies have assumed that the start actually begins with the reaction to the start signal and the mark to 15 m (Bishop, Smith, Smith, & Rigby, 2009; Issurin & Verbitsky; B. R. Mason & Cossor, 2001; Vilas-Boas, 2010). And this study accept this conception that the start made out of the water is divided into three phases: the block phase (including the reaction time), the flight phase (including the water entry), and the underwater phase (Arellano, Moreno, Martínez, & Oña, 1994; Counsilman, 1955; J. G. Hay, 1987; B Mason, Cossor, Mason, & Cossor, 2001; Vilas-Boas, 2010).

3.1. The block phase

The block phase is the time elapsed between the time of the swimmer spend to reflect the starting signal and the moment the swimmer's feet leave from the start block. The block phase influences the performance of following periods, therefore, it is important for swimmers to optimize their take-off parameters closely

related to the black. Since 1995 the Olympic committee changed the role that swimmers would be dismissed if they failed once at the swim-start. Then how to improve the stability and the vertical take-off speed on the back plate has confused many researchers and coaches for several years. So we must firstly compare the feet position of the three start techniques to evaluate their stability effect. For the TS technique, the swimmer places one foot at the front of the block and the other towards the rear of the block which leaving more weight over the front/rear foot on the inclined footrest. The KS had a similar starting position adopted in the TS, but rear foot placing on a stable and adjustable surface depending of the swimmers conditions to a more personal way and the feet position had an highly asymmetrical with one foot on the front while the other in the rear oblique edge. In the GS, both feet on the front of the platform. By using the KS, the swimmers can improve the stability through a larger base of support on the rear plate to effectively avoid the foul at the swim-start and attain a successful performance. And other studies have found that the KS using this inclined footrest has faster block times compared to the TS on traditional starting blocks (Biel, Fischer, & Kibele; K. E. Honda, Sinclair, Mason, & Pease, 2010).

The block phase requires a compromise between time and force. In order to take advantage of the decreased resistance compared with water, the swimming starts must be effective to propel athletes into water through the air as quickly and as far as possible. According to previous studies, as a consequence of the asymmetrical position of the KS, swimmers would enhance the force developed on the new block without increasing the block time (K. E. Honda et al., 2010) and even reduce the block time and the response time to the starting signal compared with TS (Biel et al.,; Ozeki, Sakurai, Taguchi, & Takise, 2012) and GS (Taladriz Blanco, Blanca, & Arellano Colomina, 2017b). Higher values of the horizontal take-off velocity might increase the body rotation during the flight phase and leave a steeper water entry at the entry phase (García-Ramos et al., 2015; Houel, Charliac, Rey, & Hellard, 2010), thus would be one of the best kinematic predictors of the start performance (Mclean, Holthe, Vint, Beckett, & Hinrichs, 2000; J Vantorre et al., 2010). Using the KS increased the development of the horizontal and vertical accelerations relative to the TS (Biel et al.,; Ozeki et al., 2012) and significant advantages at 7.5 m. distance than GS (Taladriz Blanco et al., 2017b). Similar to the Omega official claims that the footrest enables the athlete to push-off with a rear knee angle of 90°, the best starts produced a peak vertical force at a rear knee angle of 80°–90° which is beneficial to starting performance, while knee angle of 100°–110° for the best starts to product the peak horizontal force (S. E. Slawson, Chakravorti, Conway, Cossor, & West, 2012). Furthermore another study suggested that developmental level swimmers should choose between a neutral-weighted or rear weighted position on the new OSB11 starting blocks when using KS (Barlow, Halaki, Stuelcken, Greene, & Sinclair, 2014). A narrow stance on this new block was helpful to get larger advantages in the block time and horizontal peak force and a high the centre of mass position to improve swim-start performance (Kibele, Biel, & Fischer, 2016). After limited practice, a neutral or slightly rear weighted KS on the new block would produce the best all round performance (K. Honda, Sinclair, Mason, & Pease, 2012). More interestingly, one research analyzed the effect of the different front leg of the KS, the result suggest that the right in the front position had a negatively effect to the peak vertical jump forces and vertical jump height except for the entry distance, while the peak vertical forces the and horizontal entry distance was relative to the left leg in the front position (Cossor et al., 2011). Swimmers generating higher peak forces were more likely to produce a better overall start performance than those who produced lower forces (Bishop et al., 2009; Connaboy, Coleman, Moir, & Sanders, 2010). It is suggested that swimmers should enhance their lower limb strength training to improve the impulse force on this new start.

3.2. The flight phase

The flight phase is the period after the swimmer's feet leaving the block to the swimmer's head or hand diving into the water. The performance of this phase like time, speed, distance and entry angle, is highly influenced by the front phase. During this phase swimmers need to travel the maximum distance at the high velocity developed during the block phase as soon as possible, and also keep velocity this advantages into the underwater phase. It has been reported that although the KS took advantages in the temporal aspect than TS through the higher take-off vertical velocity but no difference exist in the travelled distances (Beretić, Đurović, Okičić, & Dopsaj, 2013). Peak forces produced by the KS on land was correlated to greater flight distance (Cossor et al., 2011). Narrow stance on the OSB11 block in the KS also was reported to take advantage in flight distance (S. E. Slawson et al., 2011). This result might due to the narrow stance on the new block generated larger horizontal peak force (Kibele, Biel, & Fischer, 2014). Although the current study didn't compare the flight time and distance between KS and GS, but KS seemed to take more advantages

Table 1: Mean and standard deviation for the time variable during the water phase obtained comparing GS, TS and KS techniques.

	Start technique	Time to 15 m (s)
Vantorre et al. (2010)	GS	6.5 ± .3
	TS	6.6 ± .3
Ozeki et al. (2012)	TS	6.92 ± .34*
	KS	6.78 ± .33*

*Significant differences ($p < 0.05$).

than GS in this phase due to the higher velocity and higher force in block phase (Taladriz Blanco et al., 2017b).

At water entry, the body begins to progressively touch the surface of the water, coming along with the drag force increasing. The entry angle influenced the drag force and the average velocity of following phase (M Elipot et al., 2009). Lower hydrodynamic resistance and lower speed decrease at water entry were helpful to an underwater performance improvement (M. Elipot et al., 2009; Holthe & Mclean, 2001; Juergens et al., 1999). Especially, the hip angle in this moment were shown important to the start performance as a consequence of the impact on the water phase. The largest hip angles at water entry seemed to minimize the loss in horizontal velocity as well as a large entry hole by the use of a dolphin-kick after the feet immersion (Kibele & Fischer). Previous studies suggested that similar entry angle effect between the KS and TS or GS (Beretić, Đurović, & Okičić, 2012; Ozeki et al., 2012). But study shown that it was important for start performance to achieve a higher angular momentum and a more concentrated manipulation of the body segments on the block to produce higher angular velocity and more control of inertia body moment in the sagittal plane. Swimmers can choose a flat or volker start to manage the angular momentum and flight track generated during the block phase (J Vantorre et al., 2010; J. Vantorre et al., 2010). But current literature haven't studied the effect of GS and TS as well as GS in this phase.

3.3. The underwater phase

The underwater phase is defined as the interval between head or hand contacting with the water and the head re-surfacing. And the performance of this phase is influenced by the previous phases and is significantly correlated with start time (J Vantorre et al., 2010). The underwater phase between various swimming styles were extremely different in all strokes expect the breaststroke due to FINA rules the 15-m mark the maximum distance a swimmer is allowed to travel before break-out (B. R. Mason & Cossor, 2001). Therefore coaches and swimmers, in practical, should place emphasis on improving the underwater phase fundamental to achieving an effective swim-start (M. Elipot et al., 2009; Elaine Tor, David L Pease, & Kevin A Ball, 2014a). It is important to note the performance during this phase is determined by the variables at the immersion and the speed loss as well as the actions of the knee, the hip and the shoulder (M. Elipot et al., 2009; Cossor, Slawson, Shillabeer, Conway, & West, 2011; Tor et al., 2014b, 2015).

Through a strong synergy between the hip and ankle and an independent action of the knee, high-level swimmers could regulate the leg amplitude and an optimal action of the hip and ankle can increase the leg amplitude without affecting the drag (Elipot, Houel, Hellard, & Dietrich, 2010). One factor that will influence the velocity maintained during the underwater phase is the trajectory the swimmer adopted. Diving too shallow or too depth is negative to the performance, and the trajectory with a maximum depth of –0.92 (±0.16) m during the underwater might be the most effective way to minimize the velocity lost during this phase (Elaine Tor et al., 2014a). At parallel and entirely submerged, the greater impulse during the take-off and its transformation into a fast underwater movement are determinant to decrease the start time (De et al., 2011). There exist strong relationships between gliding and underwater kicking to maintain the velocity (Elipot et al., 2010). Regarding above water surface, a flatter take-off angle may compromise underwater velocity and starting performance (De et al., 2011). Elite swimmers also strive for a high peak toe velocity and a larger caudal momentum to optimize the underwater performance (Connaboy et al., 2010).

One of the most recognized parameters used to assess the overall start and underwater phase performance of different start techniques is the time to 15 m (**Table 1**). Temporal advantages of 0 .14 s by KS was reported in the 15 m compared to TS (Beretić et al., 2013; K. E. Honda et al., 2010; Ozeki et al., 2012). Moreover, significant advantages for KS were also observed in the 7.5 m time relative to the GS (Biel et al.), and in the 7.5 m as well as 10 m compared with the TS (Beretić et al., 2013; K. E. Honda et al., 2010; Ozeki et al.,

2012). These advantages resulted important advantages in the KS performance compared to the TS and GS, with shorter time to 15 m. But various researchers and academics studied the underwater phase without considering the variation of the start technique (Elipot et al., 2010; Elaine Tor, David L. Pease, & Kevin A. Ball, 2014b; E Tor, Pease, & Ball, 2015). From this article's point, in the future's study should better take this variation into consideration and further study their relationships between each other.

4. Conclusions

This study summarized the current literature regarding the kinematics research progress of swimming start on the new start block. And the results demonstrated that the KS is a superior technique compared with the TS and GS due to the larger base of support on the block to improving the stability of start and the larger take-off velocity as well as time advantages in the different start periods. As a consequence of the increased force developed on the block and the time preponderance, the KS has shorter flight time and longer flight distances relative to the GS and TS. Swimming technology and training procedures changing has afforded advantages to swimmers best able to adapt to the new start block and improve their performance. With the introduction of the OSB11 starting block, swimmers also need to quickly modify and adjust their techniques to take advantages of the new plate during normal and season training. During training, swimmers and coaches should focus on the most statistically significant dive performance variables: peak horizontal force and velocity at take-off, block and flight time (Galbraith, Scurr, Hencken, Wood, & Graham-Smith, 2008). The swimmers should enhance their core strength and lower limb strength with different practical methods followed by speed training and speed training methods to obtain the best take-off forces.

Competing Interests

The author has no competing interests to declare.

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