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Original empirical article

INFLUENCE OF THE BACK PLATE ON KINEMATICAL STARTING PARAMETER CHANGES IN ELITE MALE SERBIAN SWIMMERS

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Abstract. *The aim of this study was to find the differences in kinematical parameters between different types of swimming start performance, one from a starting block with a new incline back plate platform and the other from a starting block without the back plate. Twenty-seven elite male swimmers completed three dive and 10m maximum swim effort starts using the back plate and three traditional track starts without the back plate. A repeated measure analysis of variance (ANOVA) was utilized to determine the significant difference for each kinematical variable. The results indicated that the start with a back plate was significantly faster than the start without a back plate on the 10m sprint F=4.28, p=0.04; Significant differences were determined for the size of the rear leg knee joint angle at set position F=15.27, p=0.00; rear foot ankle joint angle at set position F= 5.38, p=0,02; reaction time F=8.42, p=0.00; and also flight time F=5.17, p=0.02. It is recommended that the values in the angle of the rear knee joint at the set position in a start with the back plate could be slightly higher, and a further improvement of starting speed should be in the direction of increasing those angle values. As a result, the Center of Mass should be moved forward slightly, allowing even faster reaction time, significantly shorter flight time duration without sacrificing a significant reduction in flight distance.*

Key words: *swimming start, track start, kick start.*

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INTRODUCTION

The requirements for a superior start include a fast reaction time, significant jumping power, a high take-off velocity and a decrease in drag force during entry. A low resistance streamline position during underwater gliding to minimize the loss of horizontal velocity as well as an increase in propulsive efficiency during the transition stage can assist in a superior start (Schnabel and Kuchler, 1998). Over the last 40 years, the swim start technique has continued to evolve, from the conventional or arm swing start to the grab start and the track start. The track start has one foot at the front edge of the block, the other placed towards the back of the starting platform with hands grabbing the front edge of the block. Due to these changes in the swimmers foot placement, the track start employs a wider base of support than the grab start, resulting in greater stability for the swimmer (Breed and McElroy, 2000). Studies have been carried out on styles of set position, such as the grab, track, handle, and so on (Welcher, Hinrichs, and George, 2008). It was determined that there was no significant difference in start time among the grab start, the track start, and the handle start. Furthermore, 94% of the variance in the start time was explained by water time, the duration of the period from the first contact with water to a distance of 9 m (Guimarães and Hay, 1985). In 2009 a new starting technique was developed with the introduction of an incline or "kick" plate mounted onto the start platform. This newly designed start block by Omega (OSB11, Corgemont, Switzerland), has the international governing body for swimming 'FINA' approval and has allowed the development of the kick start. The kick start is essentially a modified track start that allows the rear foot to be raised off the platform and placed upon a kick plate. The kick plate is angled at 30 deg from the surface of the block and can be moved through five different locations on the starting platform. Omega claims that "tests undertaken by top level swimmers showed faster races versus a standard block". A group of researchers (Honda, Sinclair, Mason, and Pease, 2010; Nomura, Takeda, and Takagi, 2010) found significant differences between two types of the start (kick start vs. track start) and supported Omega's claims that using the back plate proved advantageous during the start, both suggesting that time and effort would be necessary for athletes to achieve these improvements. The purpose of this study was to determine the effects of the new angled start platform i.e. kick start on performance relative to that of the traditional track start on a group of elite competitive swimmers.

THE METHOD

This study involved 27 elite competitive swimmers (Height = 188.5±10.3 cm, Weight = 81.6±8.4 kg, Age = 21.1±4.3 yrs), members of the National Serbian Youth and Senior Swimming Team. The experimental procedure was approved by the Serbian Expert Advising Committee. The participants completed a warm up, based around their pre-race routine which consisted of some sprint and dive drills to ensure the athletes were ready to perform at their maximal capacity. The participants performed three track starts in each of the two conditions. Three starts during the first trial started from the conventional platform without a back plate (TRS) track start. The three starts during the second trial started from the platform with the back plate (KCS) kick start. There was a 5 min rest after each start attempt. The best i.e. the fastest attempt in each trial was analyzed. Normal competitive starting procedures were used for each trial. The participants were instructed

to perform a maximal effort dive and maximal swim to the 10 meter mark. The starting block specifications were as follows; Height from the surface of the water was 0.70m. The starting platform was 0.5m in width × 0.6m in length, with a 10º slope. As a back plate, a pedal was used, set at 0.44m from the front edge of the platform, and with a 30º slope from the platform. The reaction time plate (Alge Swim Time - Austria) was attached onto the starting platform for obtaining reaction time results. The timing plate (Alge Timing - Austria) was set on the 10m mark attached on one side on the lane line and on the other side to the swimming pool lateral edge. The start was recorded in the sagittal plane, and the camera used for recording and obtaining 2-D kinematic data was a "Basler, high speed, GigE" with a frequency of 50 frames per second. The information obtained from the recording starts was the analyzed using the "Kinovea 0.8.15" computer software . The main indicators for assessing the differences between the track and kick start after recording and processing by means of the computer software were: (FFA) the angle of the front foot ankle joint – at set position (in degrees); (FKA) the angle of the front leg knee joint - at the set position (in degrees); (RFA) the angle of the rear foot ankle joint - at the set position (in degrees); (RKA) the angle of the rear leg knee joint – at set position (in degrees); (RCT) reaction time - the time span from the starting signal to take-off from the block (in 0,01 s); (TOA) the Take-off Angle – the angle between the horizontal line and the line which connects the body centre of mass (CM) with the referential spot on the foot, at the moment of the last contact of the foot with the starting block (in degrees); (BEA) the Body Entry Angle - the angle between the horizontal line and the line which connects the body centre of mass with the referential spot on the hand, at the moment of the first contact of the fingers with the water (in degrees); (FLD) Flight distance – the horizontal distance from the swimming pool wall to the first contact of the swimmer's fingertip with the surface of the water (in 0,01 m); (FLV) Mean flight velocity - during the flight phase (in m/s); (FLT) Flight time – the time span from the starting signal to the first contact of the swimmer's fingertip with the surface of the water(in 0,01 s). (T10) Time at 10m – the time span from the starting signal to the moment when the swimmer touches the timing plate at 10m (in 0,01 s). A repeated measure analysis of variance (ANOVA) was utilized to determine the significant differences for each variable between the track start and kick start. Statistical calculation was done by means of the Statistics software SPSS 15.0.

RESULTS

The descriptive statistics of the calculated kinematic parameters and the results of the repeated measure analysis of variance (ANOVA) are presented in Table 1. For the (FFA) angle of front foot ankle joint at set position and (FKA) angle of front leg knee joint at the set position, significant differences were not found ($p=0.58$) and ($p=0.59$). A statistically significant difference between the start from the conventional platform without a back plate and the start from the platform with a back plate can be found in the (RFA) angle of the rear foot ankle joint at the set position and (RKA) the angle of the rear leg knee joint at the set position. The rear foot ankle joint at the set position was 10.97 degrees smaller during the kick start than the track start ($p=0.02$) and the rear leg knee joint angle was 11.37 degrees smaller during the start from the platform with a back plate than the start from a conventional platform without a back plate ($p=0.00$).

Table 1. The differences between the obtained results of the two different types of start.

Variable	Mean TRS	SD TRS	Mean KCS	SD KCS	F	p
FFA	112.19	10.75	110.63	9.86	0.30	0.58
FKA	134.63	10.58	136.19	11.04	0.27	0.59
RFA	104.78	9.74	93.81	7.09	5.38	0.02
RKA	107.44	11.08	96.07	10.28	15.27	0.00
RCT	0.76	0.05	0.73	0.04	8.42	0.00
TOA	43.96	8.29	40.37	7.63	2.74	0.10
BEA	42.41	3.24	42.22	5.66	0.02	0.88
FLD	2.41	0.15	2.37	0.15	1.04	0.31
FLT	1.07	0.06	1.02	0.07	5.17	0.02
FLV	2.28	0.19	2.33	0.22	0.94	0.33
T10	3.99	0.22	3.84	0.27	4.28	0.04

There is a statistically significant difference in reaction time (p=0.00) where the reaction time for the kick start is 0.03s faster than for the track start. In 3 of the kinematic parameters (TOA, BEA, FLD), no significant difference between those two types of start were found. A higher mean numeric value was obtained for the take-off angle (TOA) in the track start than for the kick start, where the difference of 3.59 degrees was not statistically significant (p=0.10). The difference in the body entry angle (BEA) was 0.19 degrees in favor of the track start, but was not statistically significant. Also, flight distance (FLD) during the track start was 0.04 m longer than in the kick start and the difference in flight velocity was 0.05 m/s higher for the kick start than the track start, but was not statistically significant. A significant difference was determined in flight time, i.e. flight time duration in the kick start was 0.05s shorter than in the track start (p=0.02). The difference in time at 10m (T10) was 0.15s, the kick start was faster than the track start and it was statistically significant (p=0.04).

DISCUSSION

In the back plate condition, the rear knee joint angle had a value close to 90 degrees. The knee joint angle of the rear leg was recommended to be 90 degrees by the manufacturer of starting blocks with a back plate that was approved by FINA, which is in accordance with the results of this study where the rear leg knee joint angle at the set position in the kick start was significantly smaller than the one for the track start (96.07 degrees vs. 107.4 degrees p=000). However, studies have shown that the isometric force-angle relationship of knee extension reported a higher force production at 105 degrees to 120 degrees than in other joint angle conditions (Lindahl, Movin, and Ringqvist, 1969). The force exhibited a peak when the foot position was at 80-90% of the leg length (Yamauchi, Mishima, Fujiwara, Nakayama, and Ishii, 2007). If this ratio was angle converted, it had a value of approximately 106 degrees to 128 degrees. The angle of the rear foot ankle at the set position was significantly lower with the back plate (93.81 vs. 104.78) allowing a higher heel position. The results are in agreement with the study of squatting-to-standing movement where it was determined that heel elevation primarily influenced postural adjustment as the anterior displacement of the hip (Sriwarno, Shimomura, Iwanaga, and

Katsuura, 2008). Reducing the size of the rear leg angle knee joint and rear foot ankle joint should initiate the stretching of the front thigh muscles and lower leg muscles at the set position, which affects the muscles to react eccentrically and to be more active during the stretch which should enhance performance during the concentric action (Komi, 2000). The new block allows the kick start to achieve an average on block time of 0.73s compared to the track start of 0.76s. This was significant ($p=0.00$) as the kick start had a shorter off-block time by 0.03 s, which is in accordance with the results of Honda et al. (2010), where during the kick start the average on-block time was 0.77s compared to that of the track start of 0.80s. This was significant ($p<0.01$) as the kick start had shorter off-block times by 3 hundreds of a second. Breed, and McElroy (2000) have previously found a 3-hundredth of a second difference in on-block time between the grab and the track start to be insignificant, as the variance between their starts was high (0.06s and 0.07s standard deviations for the grab and track start respectively). Their study included novice swimmers, whereas the present study was conducted with elite swimmers. Thus, the variance was smaller than that of both the kick and track starts by 0.04 and 0.05s. In the study of Nomura, Takeda, Takagi, (2010), a significant difference was found ($p<0.05$) in the take-off angle between KCS and TCS, in which the KCS take-off angle was more close to the horizontal line and smaller than that in the TCS. Jorgić, Puletić, Stanković, Okičić, Bubanj, S. and Bubanj, R. (2010) found a significant difference in the angle of take-off the ($p=0.04$) between the grab and the track start where the angle of take-off was smaller in the track start. In this study the take-off angle in the KCS was insignificantly smaller than that in TCS (40.37 vs. 43.96). The advantage in faster reaction time which was provided by the kick start over the track start was able to be carried through 10m, where it held a significant 0.15 second gain at this distance between the KCS and TCS (3.84 vs. 3.99 $p=0.04$). This difference indicated the improvement was mainly established on the block and not greatly enhanced thereafter regarding the fact that no significant differences were found in the body entry angle, mean flight velocity and flight distance. It also indicated that having the kick plate allowed block time to be reduced without sacrificing a significant reduction in flight distance ($p=0.31$), which coincides with the results obtained in the study by Honda et al. (2010), and enabling a significantly shorter flight time duration (1.07 vs. 1.02 $p=0.02$). Prior studies have not found the track start to be significantly faster than the grab start for a set distance ranging from 5m to 11m (Breed and McElroy, 2000). The fact that the obtained results in the T10 were statistically different indicated that the kick start showed its superiority compared to the track start for the 10m ($p=0.04$).

CONCLUSION

The kick start showed a significantly faster time for the 10m swim than the traditional track start without a back plate. The values in the angle of the rear knee joint at the set position in the kick start regarding the results and recommendations of other studies (Lindahl, Movin, and Ringqvist, 1969; Yamauchi et al. 2007) should be slightly higher, and further improvement of starting speed should be directed at increasing those angle values. As a result, the center of mass should be moved forward slightly, i.e. into a comparatively anterior position, allowing even faster reaction time, significantly shorter flight time duration without sacrificing a significant reduction in flight distance.

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UTICAJ STARTNE PLATFORME NA PROMENE U VREDNOSTIMA KINEMATIČKIH PARAMETARA PRILIKOM STARTA KOD VRHUNSKIH SRPSKIH PLIVAČA

Igor Beretić, Marko Đurović, Tomislav Okičić

Cilj ove studije bio je da se utvrde razlike u vrednostima kinematičkih parametara prilikom različito sprovedenog starta u plivanju, najpre skokom sa startnog bloka tj., platforme postavljene pod određenim uglom i najzad skokom sa startnog bloka uobičajenim startom (bez promene ugla platforme). Dvadeset sedam vrhunskih plivača izvelo je po tri skoka navedenim načinima sa preplivanjem deonice od 10m maksimalnim intezitetom. Kod utvrđivanja statistički značajnih razlika za svaku kinematičku varijablu, korišćena je analiza varijanse (ANOVA) za ponovljena merenja. Rezultati su ukazali da je start sa startne platforme postavljene pod uglom sa preplivanjem 10m maksimalnim intezitetom, brži u odnosu na start i preplivanje sa platforme uobičajenim načinom. Statistički značajne razlike utvrđene su u veličini ugla zgloba kolena i skočnog zgloba zadnje noge u startnom položaju, vremenu reakcije, kao i vremenu leta. Preporuka je da bi ugao u zglobu kolena zadnje noge u startnom položaju prilikom skoka sa startne platforme postavljene pod određenim uglom, trebalo da bude nešto veći, a dalje poboljšanje startne brzine bi trebalo da bude posledica pomeranja težišta tela unapred, što će omogućiti kraće vreme reakcije i značajno kraće vreme leta plivača, bez smanjenja dužine leta.

Ključne reči: *start u plivanju, trak start, kik start.*